Post-Print Technical Solution for High-Definition Broadcasting Construction of Yanggu Media Convergence Center

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Date: 2025-09-19T15:52:12+00:00

Abstract

Purpose: With the rapid development of information technology, county-level converged media centers must be equipped with high-definition broadcasting technology to improve program broadcasting quality, enhance user visual experience, and also promote the deep integration of radio and television with multiple platforms such as the Internet and mobile terminals. Method: This paper analyzes the key points of high-definition broadcasting system construction, selection of critical equipment, system integration, and multi-platform dissemination capabilities by elaborating on the high-definition broadcasting technology solution of Yanggu Converged Media Center. Result: It provides technical reference for the construction of high-definition broadcasting systems in county-level converged media centers. Conclusion: This technical solution features simple design, powerful functionality, easy operation, and cost savings.

Full Text

Preamble

Technical Solution for High-Definition Broadcasting Construction at Yanggu Media Convergence Center

(Yanggu County Media Convergence Center, Yanggu, Shandong 252300)

Abstract

[**Objective**] With the rapid development of information technology, county-level media convergence centers must be equipped with high-definition broadcasting capabilities to enhance program quality, improve viewer visual experience, and facilitate deep integration between radio/television broadcasting and multiple platforms such as the internet and mobile terminals. [**Method**] This

paper analyzes the construction of a high-definition broadcasting system for Yanggu Media Convergence Center, covering key architectural considerations, equipment selection, system integration, and multi-platform dissemination capabilities. [**Result**] The solution provides a technical reference for high-definition broadcasting system construction at county-level media convergence centers. [**Conclusion**] The proposed technical solution is simple in design yet powerful in function, easy to operate, and cost-effective.

Keywords: media convergence center; high-definition broadcasting; technical solution; multi-platform dissemination; equipment selection
CLC Number: G222
Document Code: A
Article ID: 1671-0134(2025)08-145-04
DOI: 10.19483/j.cnki.11-4653/n.2025.08.032
Citation Format: Meng Xianlu. Technical Solution for High-Definition Broadcasting Construction at Yanggu Media Convergence Center [J]. China Media Technology, 2025, 32(8).

As digital technology continues to advance, traditional media faces fierce competition from emerging platforms such as the internet and social media. In this context, the construction of media convergence centers has become critical for enhancing the competitiveness of traditional radio and television media, accelerating media integration, and meeting diverse audience demands. Yanggu Media Convergence Center' s high-definition broadcasting solution strictly follows provincial bureau requirements, closely integrates with the center's actual conditions, and employs internet thinking to achieve resource integration and efficient collaboration. The solution aims to enhance high-definition broadcasting capabilities, enable intelligent business management for converged media production, and build a comprehensive content data platform that is data-driven, mobile, personalized, and intelligent [1], providing an efficient and reliable standardized technical platform and framework for creating a fused production ecosystem encompassing content, channels, platforms, operations, and management, while also offering interfaces for future standard expansion and extension [2].

1. Background and Requirements for Yanggu Media Convergence Center' s High-Definition Broadcasting

Mobile Device Compatibility. With the proliferation of smartphones, tablets, and other mobile devices, high-definition broadcasting must not only support traditional television terminals but also ensure smooth playback across various mobile devices, adapting to different screen resolutions and network bandwidth conditions.

Multi-Platform, Multi-Terminal Support. High-definition content requires efficient and stable playback across different dissemination platforms. Yanggu Media Convergence Center needs to support simultaneous broadcasting across multiple channels and terminals, including radio and television, internet

video platforms (such as live streaming and video-on-demand platforms), and social media. High-definition broadcasting has become a core requirement of modern media technology. For Yanggu Media Convergence Center, it not only improves program production quality but also demonstrates its competitiveness and influence. With the popularization of high-definition television (HD) and ultra-high-definition (4K) technology, the center must have at least 1080p (Full HD) broadcasting capability, with plans to gradually transition to 4K broadcasting based on actual conditions. This ensures programs can present higher quality, clearer images, and enhanced visual effects and user experience—particularly important for news reporting and cultural programming, where accurate information presentation can improve program credibility and influence. High-quality audio support is equally essential. Beyond high-quality video, high-definition broadcasting requires high-quality audio output, especially for news live broadcasts, talk shows, and cultural entertainment programs, where surround sound and stereo support can create a more immersive viewer experience. Audio must be clear, noise-free, and highly intelligible. The use of audio processing equipment, particularly for audio clarity enhancement in complex environments, is crucial for ensuring program quality. Simultaneously, the high-definition broadcasting system must ensure precise audio-video synchronization to avoid lip-sync issues or delays that could negatively impact the viewing experience.

2. Construction Content and Objectives

Yanggu Media Convergence Center is constructing a new HD/SD-compatible digital broadcasting platform for two channels, employing primary-backup broadcast servers with hardware decoding and four sets of broadcast control stations (two per channel) to achieve separation of broadcast and control functions with hot backup for multiple layers of safety assurance. The database and storage systems feature dual redundant hot backup to ensure data and storage security in the production and broadcasting network [3]. The system is equipped with internal/external network gateway isolation, two review workstations, one technical review system, independent playlist editing for two channels, Beidou dual-mode time calibration, and independent logo/titling systems for each channel, with core broadcast control equipment operating in primary-backup hot backup mode.

The objectives of this high-definition broadcasting solution are to: (1) enhance program quality by achieving high-quality video and audio effects that make programs more vivid, clear, and realistic; (2) strengthen media dissemination capabilities by optimizing production, storage, and transmission workflows to improve efficiency and quality, expanding audience reach through multi-platform, multi-channel content distribution; (3) promote media convergence construction and interactivity by providing cross-platform content publishing and interactive features that increase audience engagement and satisfaction; and (4) optimize resource allocation and cost control by leveraging decreasing equipment costs to

build high-definition broadcasting systems at relatively low investment, improving management efficiency while laying the groundwork for future technological upgrades [5]. The overall system architecture is illustrated in Figure 1 [Figure 1: see original paper].

The overall signal flow diagram is shown in Figure 2 [Figure 2: see original paper].

3. Main Equipment and Functional Characteristics

The high-definition broadcast server system primarily consists of broadcast servers, broadcast control computers, storage management servers, database servers, migration servers, playlist workstations, review workstations, technical review workstations, and transcoding/import workstations. The system diagram is shown in Figure 3 [Figure 3: see original paper], with the following functional characteristics:

(1) Reliable, Safe, and Stable Broadcasting. The system implements separation of production and broadcasting with no single point of failure, ensuring that multi-channel broadcasts do not interfere with each other. The broadcast control network operates independently, unaffected by external interference or viruses, ensuring stability and security. With primary-backup broadcasting, primary-backup control, primary-backup databases, primary-backup switching, NAS storage, and dual switches with dual network dual data streams, the system offers high security. Control computers do not affect broadcasting when the database is closed or the network is disconnected. The system supports expandable serial port capacity, with the ability to control up to eight external devices, offering good stability and free port configuration. It supports 24-hour uninterrupted broadcasting; once launched, the system automatically rolls filler content, ensuring the video server always has program output. When playlist timing logic errors occur, such as gaps between programs, the system automatically inserts filler clips to prevent black or blue screen accidents [6]. Professional FTP transmission ensures data security and strong scalability. The system features comprehensive permission management with detailed access control for all broadcast operations (loading, editing, configuration, playback) and password protection for operations that could interrupt broadcasting. All server operations and broadcasts are logged in detail for complete process tracking and troubleshooting [7]. Technical review functions support multi-module technical review of audio/video files with primary and auxiliary review modes. Optional AFD information markers enable automatic aspect ratio control for HD/SD conversion. The system automatically monitors the readiness of VTRs, materials, and primary-backup programs, checks material consistency between primary and backup, monitors host/slave status and equipment status, and provides audio alarms via sound cards and speakers when faults are detected, with red flashing indicators on the broadcast interface. The software provides various optimization and detection functions, including automatic timing and error correction for playlists [8].

(2) Advanced and Reliable Architecture. The system features automatic time calibration, open architecture, and dual hot backup broadcasting. The software offers flexible configuration for different environments, scales, and requirements, supporting several mainstream imported server primary-backup architectures [9]. Multiple emergency measures are provided, such as program advance, program delay, and emergency backup signal sources. NAS storage operates independently without relying on storage servers, supporting multiple protocols (CIFS/NFS/FTP/HTTP/ISCSI) for direct connection to switches, providing more stable bandwidth through multi-network card aggregation, with 12-36 disk bays for easy expansion. The system controls various broadcast equipment with real-time monitoring, recording, and alarm capabilities for broadcast status. It provides system lock functions to improve broadcast switching precision [10]. Intelligent real-time automatic migration of disk materials enables seamless connection with production networks for integrated production and broadcasting, and supports seamless integration with the company' s media asset management system.

(3) Simple and Convenient Operation. The system features a full Chinese interface with simple operation. A single server supports 1-4 channel broadcasting with HD/SD compatibility. It provides multiple broadcast modes including sequential, insert, timed, relative timed, follow-insert, and manual trigger. It supports mixed broadcasting from VTRs, video servers, and live programs, with primary-backup simultaneous emergency insert capability [11]. The server provides manual emergency operation capabilities. It offers automatic material and equipment checking functions—after playlist loading, it automatically checks video server status and material upload/backup status, providing audio-visual alarms for faults. It includes program logic checking functions that automatically perform secondary logic checks on loaded playlists to detect gaps and overlaps. Playlist time logic checking can identify timing gaps and collisions, with prominent alerts for any issues.

(4) Applicable and Precise Information Query and Display Functions. The system provides secure and convenient material management, query, and verification functions to meet broadcast safety and overall material management workflow requirements. It offers broadcast status query functions showing current channel status, pre-roll status, network connection status, database connection status, disk space usage, and CPU/memory status information. The material library supports quick queries, providing materials most relevant to channel broadcasting according to predefined rules to improve search efficiency, with manual query capabilities based on custom rules [12]. The video server supports automatic startup. The control computer supports relay and primary-backup signal dual switching, can control various switchers and matrices, displays the status of connected switcher mixers in real time, and provides analog control panels.

4. Main Equipment and Specifications

4.1 HD/SD Server Broadcast System (Two Channels)

Two-Channel HD/SD Broadcast Servers (Primary-Backup) -2 Sets
Server: Inspur or DELL R740 or equivalent brand with identical configuration: Intel Xeon Silver 4208 2.1GHz, 8C/16T, 9.6GT/s, 11M cache, Turbo, HT (85W); DDR4-2400; 16GB RDIMM, 3200MT/s memory; 2$\times$600GB10$KSAS$2.5"$hot-swap$harddrivesin$RAID$1; $RAIDcontroller$; 4$GigabitEthernetports$; $redundant$550$Wpowersupply$; 2$Urack-mountfixedrails.**Ultra-High-SpeedNASStorage$–$1$Unit**4$Urack-mount$, 24$hot-swapSATA/SASbays$; $Intel$64$-bitquad-coreprocessor$; 16$GBcache(upgradeableto$64$GB)$; 4$\times$4 $gradeSATAdrivesin$RAID$5; 4$\times$10/100/1000$MBadaptiveEthernetports(RJ-45)$, 2$\times$\$10 Gigabit Ethernet interfaces [13].

Broadcast Control Computers -4 Units (Primary-Backup)
4U professional industrial chassis or brand computer: Intel i5-12400 processor; 8GB DDR4; system drive: 250G M.2; 23.8-inch monitor; USB optical mouse/keyboard.

Master/Backup Database and Secondary Storage Migration Servers -2 Units (Primary-Backup)
Server (H3C): Intel Xeon Silver 4208 2.1GHz, 8C/16T, 9.6GT/s, 11M cache, Turbo, HT (85W); DDR4-2400; 16GB RDIMM, 3200MT/s memory; 2\$×\$600GB 10K SAS 2.5" hot-swap hard drives in RAID1; RAID controller; 4 Gigabit Ethernet ports; redundant 550W power supply; 2U rack-mount fixed rails.

Playlist Editing/Compilation Workstations -2 Units
Hardware configuration same as above. Software: HD program compilation/compilation system software, playlist editing software module, program encoding/upload module, program management software module.

Review Workstations -2 Units
4U professional industrial chassis or brand computer: Intel i5-12400 processor; 8GB DDR4; system drive: 250G M.2; 2TB SATA drive; 32-inch monitor; USB optical mouse/keyboard; wooden speakers. Software: program review software module responsible for program and playlist review, variable-speed playback, and batch review support.

4.2 Broadcast Control Peripherals

HD Switchers -4 Units (Primary-Backup)
Support HD/SD-SDI and HDMI video input modes; 8×HD/SD-SDI inputs, 2×HDMI inputs, 2×PGM HD/SD-SDI distributed outputs, 3×PST HD/SD-SDI distributed outputs; support 1×standard external sync signal input (REF); support PGM channel 1 input-to-output bypass on power loss; standard dual power supply.

HD Switcher Remote Control Panels, HD Embedded Audio Proces-

sors -2 Units each
Sync Signal Generator -1 Unit
HD Character Generator/Logo Inserter with Keyer Mixer (with remote control panel) -1 Unit
HD Distributor -4 Units
Beidou Time Server (network time service, 1U rack-mount) -1 Unit

HD Video/Audio Encoders -2 Units
2-channel HD-SDI/HDMI encoding output with 2 primary-backup ASI and 2$\times$1000$MIPoutputs$; $H.264andMPEG-2adjustable$; $hot-swapdualpowersupply$; $support2\times ASIinput$, 1×$I input; enable HD/SD simultaneous broadcasting.

4.3 Monitoring System

SDI HD Encoding Cards -12 Units
1×SDI input, 1×SDI loop-out; support SRT/RTMP/RTMPS/HLS/TS over UDP/RTP/RTSP/Onvif, etc.; customizable SIP/GB-T28181 protocol support.

HDMI HD Encoding Cards -4 Units
1×HDMI input, 1×HDMI loop-out; support SRT/RTMP/RTMPS/HLS/TS over UDP/RTP/RTSP/Onvif, etc.; customizable SIP/GB-T28181 protocol support.

Multi-Channel Video Integrated Monitoring System -1 Set
Multi-View Dividers -2 Sets
Control Console -1 Unit
Video Wall

4.4 Network and Security Equipment

Core Switch -1 Unit
Capacity (full-duplex): 336Gbps/3.36Tbps; packet forwarding rate: 51Mpps; dimensions (W×D×H): 440$\times$160×$43.6mm; weight $ $2.5kg$; $1Consoleport$; $24\times 10/100/1000BASE-Tports$, 4×$1000BASE-X SFP ports; input voltage: 100V-240V AC, 50/60Hz; power consumption: 9W-24W AC; operating temperature: 0℃-45℃; relative humidity: 5%-95% [14].

Security Gateways -2 Units
1U chassis, single power supply, "2+1" architecture; 4$\times$$10/100/1000Base-T ports each for internal and external networks; 32GB SSD each; 2 Console ports and 4 USB ports total; performance: throughput $ $500Mbps; maximum concurrent connections $ $100,000; MTBF $ $50,000 hours; latency <1ms; maximum database synchronization rate $ $2,000 records/second; virus scanning capability with automatic or manual virus database updates.

USB Isolators -2 Units
Firewalls -2 Units

5. Advantages of Yanggu County Media Convergence Center' s High-Definition Broadcasting Solution

(1) **Enhanced Radio and Television Program Quality.** High-definition broadcasting technology provides clearer pictures and greater image detail than standard definition, making programs more visually appealing [15]. For Yanggu Media Convergence Center, this improves the quality of news, cultural programs, and other content, enhancing viewer experience.

(2) **Multi-Platform Content Distribution Capability.** With internet proliferation, Yanggu Media Convergence Center can publish content across multiple platforms. High-definition broadcasting technology enables distribution through traditional television, online video platforms, social media, and other channels, expanding audience reach and media coverage [16].

(3) **Decreasing Equipment Costs.** As high-definition technology becomes more widespread, equipment costs continue to decline, allowing county-level media convergence centers to build high-definition broadcasting systems at relatively low investment. Maturing technology also simplifies operation, lowering technical barriers for local media.

(4) **Enhanced Local Media Influence.** High-definition broadcasting enables Yanggu Media Convergence Center to compete with larger media organizations in content presentation, improving program quality and thereby strengthening its influence and credibility, which is crucial for attracting audiences and enhancing Yanggu County' s image.

(5) **Data Flow and Real-Time Interaction Support.** High-definition broadcasting solutions typically include better data transmission and real-time interaction capabilities, enabling Yanggu Media Convergence Center to interact with audiences more conveniently through social media, SMS platforms, voting, and commenting functions, thereby increasing audience engagement.

(6) **Improved Program Storage and Management.** High-definition video formats facilitate more efficient program storage and management systems, while archived high-definition content retains its value for extended periods. This benefits the center' s long-term development, historical content preservation, and future editing utilization.

(7) **Future-Proof Technology.** As higher resolution standards such as 4K and 8K gradually become mainstream, adopting high-definition broadcasting technology lays the foundation for future upgrades and transitions, preventing technical obsolescence.

(8) **Enhanced Content Diversity.** High-definition broadcasting not only improves image quality but also supports diverse content formats, enabling multi-camera setups, virtual sets, and other rich content forms

that expand creative possibilities for Yanggu Media Convergence Center programs [17].

In summary, high-definition broadcasting technology is a core component of media convergence center construction. Since its implementation, it has effectively enhanced Yanggu County Media Convergence Center' s program quality and dissemination capabilities, increased flexibility and efficiency in multi-platform content distribution, and strengthened interactive features. Through scientifically sound technical solutions, precise equipment selection, and intelligent system integration, Yanggu Media Convergence Center can ensure system stability while adapting to future technological development needs, driving media convergence and content innovation, and enhancing overall competitiveness and influence [18].

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