Design and Application of HD/SD Production and Broadcasting System for Hengshan County Television Station (Postprint)

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Abstract

A high-definition/standard-definition (HD/SD) simulcast system refers to a system in which television programs are edited in high definition, and the content of the same television channel is broadcast simultaneously in both high-definition and standard-definition modes. The HD/SD simulcast system for county-level stations is constructed based on the need for an efficient, stable, and secure broadcasting system, and plays a positive role in promoting the high-definition development of television program production and broadcasting. Accordingly, this study investigates the design of the HD/SD simulcast system for Hengshan County Television Station by integrating the existing facility conditions of Hengshan County, aiming to propose a design solution that aligns with the actual circumstances of Hengshan County and satisfies the construction requirements of HD/SD simulcast systems. The discussion encompasses aspects including design background, design requirements, design principles, and design solutions. The conclusion provides a necessary summary of the construction and operational status of the entire HD/SD simulcast system, with the aspiration of offering theoretical references for related research.

Full Text

Preamble

Abstract: An HD/SD simulcast system refers to a television broadcast system where programs are edited in high definition and simultaneously transmitted in both HD and SD formats on the same channel. The construction of an HD/SD simulcast system at the county level addresses the need for an efficient, stable, and secure production and broadcast infrastructure, actively promoting the development of HD television programming. This paper examines the design of the HD/SD simulcast system for Hengshan County Television Station based

on its existing facilities, aiming to present a design solution tailored to Hengshan' s actual conditions that meets the requirements for HD/SD simulcast system construction. The discussion covers design background, requirements, principles, and the proposed solution. The conclusion provides a necessary summary of the system' s construction and operational status, offering theoretical reference for related research.

Keywords: County-level television station; HD/SD simulcast system; design solution; system construction

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Broadcast television technology has now entered the era of digitalization, networking, and integration. Meanwhile, high-definition digital television represents the inevitable trend in broadcast technology development, serving as a driving force for advancing culture and meeting the diverse spiritual and cultural needs of the people.

Hengshan County Television Station' s analog SD production and broadcast equipment has been in service for over a decade. Due to funding constraints, there was no unified planning during initial deployment, and the existing equipment has become outdated and obsolete, with failure rates gradually increasing during program production and broadcasting, making it unsuitable for continued use. Addressing this issue requires the urgent establishment of a new, high-definition production and broadcast system—a top priority for current county-level television stations. The current facility upgrade primarily comprises two systems: a high-definition non-linear editing network system and an HD/SD simulcast system, together forming a relatively complete HD/SD production and broadcast system.

In accordance with national HD television construction standards and combining its actual circumstances, Hengshan County Television Station has built an integrated, fully digital HD network covering the entire station, unifying functions such as ingest, production, broadcasting, engineering packaging, background rendering, program scheduling, and HD/SD simulcast. This comprehensive broadcast system can handle over 95% of the station' s business operations, providing an advanced platform that meets future converged media development needs at the county level.

1. Design Principles

In system design, it is essential to maintain a forward-looking perspective while considering practicality and compatibility for future operations, ensuring the system meets the station' s program production, broadcast management, and

storage requirements. Simultaneously, the system' s compatibility must guarantee seamless integration with the station' s existing program resources, enabling the new system to connect with various standard programs and achieve resource sharing across the television station.

1.1 Forward-Looking Principle

Broadcast television professional technology products must not only satisfy current production and broadcasting requirements but also maintain system advancement for a considerable period into the future, thereby extending the system' s service life. Considerations should include future developments such as new media business applications and OB van projects, anticipating the station' s career development and new business domains.

1.2 Advanced Principle

Building upon considerations of network environment reliability, usability, and efficiency, every effort should be made to utilize advanced technologies. In Hengshan County Television Station' s overall project planning and equipment selection, all components must meet China' s broadcast television standards while aligning with international television technology development requirements. The system design should prepare for future upgrades and expansion to better accommodate upcoming program upgrades and developments.

1.3 Security and Reliability Principle

A reliable, secure, and stable network structure is obviously crucial for a television station' s equipment planning. For system security, a backup system is indispensable and must be completely isolated from the main system. This ensures that even if the main system fails, the backup system remains unaffected and can quickly take over. Naturally, the system requires comprehensive, rigorous monitoring and management during operation so that even when faults occur, they will not impact the station' s related operations.

1.4 Scalability Principle

Project planning must consider excellent upgradeability and extensibility, ensuring the television station has ample room to prepare for future new project launches and developments, such as smooth transition to full HD formats in the future. The solution must account for future technology upgrades and new business requirements.

1.5 Practical Efficiency Principle

The production and broadcast solution for Hengshan Television Station employs systems and various software/hardware equipment that can effectively meet the production and broadcast requirements of different programs and various

program retrieval needs. The system can also achieve secure, high-definition storage of various program formats. Moreover, the system enables rapid retrieval through both precise and fuzzy search capabilities, efficiently facilitating internal resource utilization within the television station.

1.6 Standardization and Openness Principle

By employing standardized platforms and utilizing standardized specifications, standardized development can be achieved. Through the application of these standards, a standardized production and broadcast system can be well developed. In the development of Hengshan Television Station' s production and broadcast system, great emphasis was placed on standardization principles and requirements.

2. Design Scheme for HD/SD Simulcast System

The HD/SD simulcast system used by Hengshan Television Station fully complies with national broadcast television requirements. The complete system is actually composed of two subsystems: a high-definition non-linear editing network system and an HD/SD simulcast system.

2.1 High-Definition Non-Linear Editing Network System

The non-linear editing network system in the broadcast television industry has special requirements, necessitating connections with numerous AV devices and access to massive video/audio files. The storage system of the HD non-linear editing network is the core issue in the overall system design, as this design is critically important for the entire system' s performance, security, and scalability. Based on the station' s actual situation and comprehensive considerations, an Ethernet+NAS network structure was adopted, utilizing advanced 10Gb NAS storage as the foundation, core switches for transmission, and HD/SD non-linear editing workstations for data exchange. The overall architecture is relatively simple, highly reliable, and easy to maintain with low maintenance costs. This ensures the system can fully meet the station' s development needs for a considerable period, fully demonstrating the system' s value and effectively extending its service life.

[Figure 1: see original paper] System Topology Diagram of Hengshan County Television Station Production and Broadcast Network

[Figure 2: see original paper] System Topology Diagram of Hengshan County Radio and Television Station Non-Linear Editing Production Network

2.1.1 Main Components of the System Platform Central Storage: One 16-bay 10Gb storage node is employed, providing two 10Gb Ethernet interface channels to meet HD program production requirements. It is configured

with 17 4TB SATA hard drives, with 16 drives using RAID6+S fault tolerance and one drive serving as a cold spare, providing an effective capacity of 52TB.

Program Production Workstations: The system includes one high-end packaging workstation, two HD editing workstations with cards, and eight HD editing workstations without cards. All workstations enable interaction of materials, subtitles, special effects, and program project files, achieving collaborative work and improving program production efficiency. Additionally, six more HD editing workstations without cards were later added to meet rough editing requirements, demonstrating strong extensibility.

2.1.2 Storage Capacity Planning Based on the 52TB storage space configuration, existing HD video/audio materials generally do not exceed 50Mbps, fully meeting program production storage requirements for the next five years.

2.1.3 Non-Linear Editing System Workstations High-definition television basically has a resolution of 1920*1080. These non-linear editing workstations fully consider the audience' s visual experience, featuring a 16:9 widescreen design and equipped with 5.1 surround sound, enabling audiences to experience the most advanced "visual feast."Of course, to perfectly achieve this audio-visual effect, it is necessary to ensure shooting picture quality during production while continuously improving picture quality in post-production.

The non-linear editing system environment adopts the mainstream Windows 7 environment, improving response speed for various complex and lengthy programs. The system uses first-tier domestic brand mainstream equipment, employing a second-generation GP2U+Acc. rendering engine based on DirectX11 architecture. It utilizes broadcast-grade video/audio boards supporting SD/HD SDI and analog component, composite, and other video interfaces for full-process HD/SD production and monitoring. It can easily achieve audio production from stereo mixing to surround sound and more complex formats, meeting all professional post-production audio needs.

2.1.4 Video and Audio Ingestion For video and audio ingestion, signals are received and converted through capture cards, then saved to hard drives, and finally edited using editing tools to become part of the television station' s resource database for convenient user selection and utilization.

The system supports ingestion from XDCAM and P2 cards for HD video materials shot by HD cameras, and supports importing materials, images, and other multimedia files.

2.1.5 Editing and Production Functions The non-linear editing system workstation supports in-track transitions, Trim tools, and curve speed variation tools, providing richer, more practical, and more efficient storyboard editing operations with more track-specific manipulation methods.

2.1.6 Subtitle System Functions The subtitle system embeds subtitle functions in plug-in form. The subtitle plug-in features a unique timecode track design with convenient dialogue and scrolling screen production tools, enabling smoother preview of HD subtitles while adding magnetic attraction settings on the timeline. It is a true 3D subtitle production system compatible with both HD and SD formats.

2.1.7 Non-Linear Editing Resource Management The non-linear editing system can effectively manage HD/SD materials, templates, and other resources for the television station and can be applied to large-scale program post-production work. As program production requirements become increasingly higher and program formats more diversified, collaborative work can significantly improve production efficiency. Moreover, various special effects and templates in program materials can be arbitrarily split or combined to facilitate the deployment and utilization of various materials. Meanwhile, the system provides relevant prompts for resource types, such as offline or online materials, to facilitate user use. It features a new tool similar to the Google toolbar for rapid resource location based on full-text retrieval. A large number of pre-made sound effect materials are available to add appropriate audio effects to programs at any time. It supports modifying special effects templates and subtitle template tree structures for more convenient template invocation. All these functions are designed to efficiently and high-quality complete HD television program production.

2.2 HD/SD Simulcast System

2.2.1 Architecture Design Hengshan County Television Station designed its broadcast system to accommodate two channels, both implementing HD/SD synchronous broadcasting. The entire broadcast system requires unified design, aesthetic presentation, scientific configuration, and rational layout. The system also includes dedicated video playback servers, related databases, upload systems, secondary storage systems, and HD conversion systems.

Among these, the broadcast server is the brain of the entire system, determining the performance and security of the broadcast system. The broadcast control system is responsible for broadcasting various programs, advertisements, and information, with relatively high safety requirements in practice. The system adopts primary and backup broadcast video servers with broadcast control equipment remotely controlled by software, which is convenient, fast, and secure, achieving the original design intent.

2.2.3 Video Broadcast Server Broadcast-grade video server products are employed, featuring standard 2RU universal rack-mount servers based on the latest mainstream server and media I/O technology. They can simultaneously support multi-channel HD or SD broadcasting with open software/hardware platforms and standard interface protocols. The system can interconnect with

current non-linear programs and editing networks, thereby forming a stable, secure, and reliable system platform.

All major hardware components of the broadcast server support hot-swapping, and the system' s redundant power supply, disk arrays, and fans can all be hot-swapped according to requirements. Through these designs, maximum reliability and convenience of hardware equipment are ensured. Through excellent system management and hardware quality performance, zero-frame precise playback can be achieved, and 24-hour high-quality broadcasting can be maintained.

2.2.4 Database System The database is crucial for the entire HD/SD system, effectively managing various materials in the television station' s HD/SD system and precisely managing program schedules and other data. Therefore, in database design, both primary and backup databases are implemented. This ensures that if the primary database fails, the backup database can immediately switch over, guaranteeing normal system operation.

The database system is highly functional, capable of managing television station information, users, channels, equipment, and advertising resources, with various query functions and user operation process detection. Additionally, the database includes program material information management, system configuration management, operation logs, and broadcast logs, effectively ensuring the security and high efficiency of the entire system.

[Figure 3: see original paper] System Architecture Diagram of Primary and Backup Broadcast Video Servers and Broadcast Control Design

[Figure 4: see original paper] Server Operation Monitoring Interface

2.2.5 Broadcast Control System The broadcast control system represents a core application in the design process, employing hot backup technology and a hardware system design with no single point of failure. Through these technologies, the television station can properly handle emergencies and effectively guarantee high system security.

The broadcast control system essentially implements various configuration operations on associated workstations and server software/hardware. Hengshan Television Station's HD/SD broadcast control workstations adopt a primary-backup cross-backup method to control video broadcast servers, broadcast switching matrices, and other equipment pools, using coordinated scheduling to ensure safe broadcasting. If any broadcast control workstation fails, other workstations take over and execute broadcast control for that channel. For example, if the primary server fails, it automatically switches to the backup server; if both primary and backup servers fail, it automatically switches to emergency signal broadcasting; if primary broadcast control fails, backup broadcast control automatically takes over control of all equipment.

Equipment Configuration: - Video Server (1 unit): Implements primary

broadcasting for 2 channels and HD signals for 2 channels - Broadcast Control Workstation (1 unit): Implements control for 2 channels - Ingest and Scheduling Workstation: Used by the chief editor' s office for program schedule ingest, review, and editing - Broadcast Peripherals: Meets peripheral equipment needs for HD/SD simulcast of 2 channels, including broadcast switchers, multi-view monitoring, HD digital frame synchronization, HD audio loudness control, HD/SD keying, HD/SD station logos, HD down-conversion, etc., supporting the relay of 2 HDMI signal programs

2.2.6 Secondary Storage System To ensure system security, a secondary storage system was specially designed. Considering Hengshan Television Station' s actual situation, a DAS architecture-based secondary storage system was implemented using hard drive storage. This system offers high security and can guarantee the safety of television station program data.

The secondary storage system is based on DAS architecture, enabling data exchange in the storage array through migration servers while allowing external data to utilize the storage array. Additionally, stable bandwidth can be maintained during migration, preventing high-load bandwidth requirements from affecting other television station operations. The secondary storage system features powerful redundancy mechanisms and has no single point of failure. Moreover, the network environment based on secondary storage architecture can effectively increase storage capacity and migration speed. Migration is more convenient, simply requiring the addition of migration servers to the secondary storage network.

Program upload workstations deliver uploaded programs to the secondary storage system. Migration is automatically managed in the background by servers. Through intelligent migration, the current migration status and data occupancy ratio can be monitored, effectively tracking load conditions during data migration.

2.2.7 Ingest System Design Considering convenience, practicality, and security, the ingest system includes the following functions: distributed remote upload mode combined with centralized ingest. The broadcast system is configured with three material upload workstations for uploading special programs, TV dramas, etc., applicable to two HD/SD channels.

Upload Review and Download Functions: Upload workstations can upload and review materials in the system and adjust upload methods according to needs. For example, materials can be uploaded to the server first or to the secondary storage array, then migrated to the server. Data uploaded to the server can also be used directly. This method is suitable for programs with strict requirements, such as news and column programs. For TV dramas, movies, and advertisements, the method of uploading to the secondary storage array first and then migrating to the broadcast server for playback is used.

The upload server includes editing, review, and other functions, enabling editing, review, and management of various materials. It can also view program duration and content, and determine whether video signals have been encoded during program upload.

2.2.8 Emergency Switching System Each channel uses an 8x2 broadcast switcher for broadcast switching. The main signal sources for each channel include: primary and backup server signals for each channel (2 channels), with CCTV and live signals each occupying one channel. If the primary server fails, the broadcast control station automatically switches to the backup broadcast server signal, effectively compensating for broadcast failures.

2.2.9 HD Down-Conversion System HD/SD simulcast systems are mainly implemented in two ways: one through independent HD and SD broadcast channels, and the other through synchronous playback of SD channels based on HD signals. This system uses the conversion method for HD/SD playback. The system includes two conversion methods: squeezed transformation for directly broadcast HD programs and processing HD signals to convert them into SD programs for broadcasting. Both down-conversion methods can be implemented in integrated switching equipment.

Conclusion

Since its design and construction, the Hengshan County Television Station HD/SD simulcast system has demonstrated excellent technology and overall good operational status, with no major failures occurring, meeting and exceeding the expected design goals. The completion of the entire system has enabled Hengshan County Television Station to fully achieve an HD network-based workflow for production, broadcasting, storage, and transmission in its HD channel construction. The system meets the requirement of 100% HD program production and broadcasting for Hengshan County Television Station' s HD channel, with smooth main operation of HD/SD simulcast and storage processes, achieving complete file-based interconnection. This ensures both the efficiency and quality of HD program production while maximizing the security of the HD/SD broadcast system.

The long-term efficient operation of the HD/SD simulcast system depends not only on rational layout design and excellent construction quality but also on daily maintenance and management, as well as solving various problems discovered during actual operation to improve overall system performance. A truly efficient, stable, and safely operating HD/SD simulcast system for Hengshan County Television Station can provide a reference model for other county-level stations in China and lay a solid foundation for achieving county-level converged media strategic goals.

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