Architecture and Application of the Hard Disk Playout System at Hainan Broadcasting and Television Station (Postprint)

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Abstract

This paper systematically presents the architecture and equipment selection of the hard-disk playout system for Hainan Radio and Television Station, as well as the operational modes of equipment modules and the system workflow.

Full Text

Preamble

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Abstract: This paper systematically introduces the architecture and equipment selection of the hard disk broadcast system at Hainan Radio and Television Station, as well as the operational modes of equipment modules and system workflow.

Keywords: hard disk broadcast; Omneon; Isilon

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1. Overview

With the continuous development of broadcast television technology and the widespread application of network technology in program broadcasting, broad-

cast equipment has become increasingly networked, digitalized, and automated. Over time, the original hard disk broadcast control system began to show its age and could no longer meet current broadcasting requirements. In early 2017, our station launched a comprehensive new system hard disk replacement project. Starting in mid-2017, we gradually upgraded our hard disk broadcast control system. The project took nearly six months and was completed before the end of 2017. This paper systematically introduces the architecture and equipment selection of the hard disk broadcast system at Hainan Radio and Television Station, as well as the operational modes of equipment modules and system workflow.

2. Composition and Operation of the New Hard Disk Broadcast Control System

The Dayang all-hard-disk digital broadcast control system consists of: 14 broadcast control workstations, 8 local workstations, 7 scheduling workstations, 8 server upload workstations, 8 video servers, 1 nearline storage unit, and 2 database servers.

The HD channel broadcast stream for this system is 50 Mbit/s. The maximum effective storage capacity of the broadcast video server is 6 TB, which can store approximately 240 hours of HD television programs. The nearline storage has a maximum capacity of 90 TB, capable of storing over 3,600 hours of HD television and radio programs.

The hard disk broadcast control system architecture includes: broadcast system control, program scheduling, upload and review, nearline storage, SQL Server database servers, and peripheral application servers.

[Figure 1: see original paper] Working Principle

As shown in Figure 1, after program scheduling is completed, the schedule is saved and simultaneously notifies the upload unit. Upload personnel select the entries to be uploaded based on the program schedule. After uploading and passing review, entries are migrated to nearline storage. According to the established migration strategy, programs scheduled for the next few days are proactively migrated to the broadcast server. The migration period is set to 3 days, meaning entries to be broadcast are migrated into the broadcast server 3 days in advance, while content from the previous day is deleted.

The nearline storage system is composed of EMC Isilon S210 and S200 units. Isilon' s single distributed file system integrates three traditional architecture layers (file system, volume system, and RAID) through a single software layer. OneFS enables every storage node to know the entire system' s file distribution, striping, and index information. Accessing a single storage node is equivalent to accessing a global namespace server. This global information assurance gives the system no capacity limits and no single point of failure, while achieving optimal performance in bandwidth, scalability, and manageability.

The fundamental algorithm for Isilon' s high scalability and redundancy uses Reed-Solomon erasure coding, a data protection technology that splits data into multiple equally-sized blocks that cannot be directly read. Metadata information is attached to each block, enabling complete data recovery from a subset of all blocks. The number of blocks required for recovery is determined by the amount of metadata information attached to each block. More attached metadata means fewer blocks are needed for recovery. In other words, as long as some blocks remain, data will not be lost, and these blocks can be distributed across different disk locations.

In the Isilon file system cluster, each file is divided into multiple 128 KB data blocks, which are evenly distributed across cluster nodes. When a file is accessed, multiple nodes in the cluster can provide data to users or applications, thereby achieving high cluster performance.

2.1 Broadcast Control System

From a safety perspective, the broadcast control system is designed with completely independent broadcast and upload units—that is, broadcast and upload are physically separated at the hardware level, with server equipment completely isolated to ensure that failures from uploading do not affect broadcasting.

Two Omneon MediaDeck 7000 video servers are configured in master-backup mode. The servers use pure hardware encoding/decoding and hardware RAID storage, equipped with 3 TB SATA hard drives (4 disks) for storing broadcast content.

The Omneon MediaDeck 700 is an integrated version of the Spectrum video server, combining storage, system management, Gigabit Ethernet transmission, and video input/output modules in a 1 RU chassis. It is 100% compatible with Spectrum servers and shares the same design structure and features. The modular server structure is shown in Figure 2 [Figure 2: see original paper].

The operating system uses an embedded Linux system optimized by Omneon for server performance and storage.

The Omneon MediaDeck 7000 employs modular design, with each component having separate fans and power supplies. All connections feature dual links to avoid single points of failure. The storage system uses RAID6 dual parity verification. The system prioritizes real-time data requirements. System startup time is less than 180 seconds. Modules can be replaced or added without restarting, ensuring uninterrupted broadcasting under any circumstances.

It supports hot-swappable, field-replaceable I/O modules with 2 freely configurable channels. The slot chassis can mix two different MediaPort modules in a single enclosure, with modules operating independently and allowing replacement without affecting other modules' normal operation. It features effective front panel information display and dual redundant hot-swappable power supplies.

2.1.2 Broadcast Service Workstations Each channel' s broadcast workstation primarily functions as equipment control, configured with dual hot backup. The two stations serve as each other' s master and backup, monitoring each other' s working status via network heartbeat detection. When the backup machine detects interruption of the host' s heartbeat, it immediately takes over broadcasting. Master and backup workstations output through an ECO-422 switcher for dual selection. Each broadcast control machine is equipped with a MOXA multi-serial port expansion card, enabling one broadcast control machine to control multiple peripheral devices through the 422 switcher. A 7250 card is installed in the backup broadcast control machine to trigger control of the 422 switcher. Workstations can save the day' s program schedule locally, enabling local schedule broadcasting when the system network is paralyzed or cannot connect to the database server.

2.2 Upload Entries and Review

Upload and review have two modes: local upload and server upload. Local upload uses 8 MIG-4C-1250HD capture workstations with local storage capacity of 1.5 TB, one encoding and one decoding port for upload and review. After uploading, content is saved directly on the local machine and, after review, sent to nearline storage for broadcasting. Server upload includes Omneon video servers and upload workstations. Workstations control the Omneon video server' s encoding channels via 422 protocol, storing content directly in the Omneon video server. Review is performed through the Omneon video server' s decoding channels, and after passing, content is sent to nearline storage for broadcasting. The workstations themselves have no storage space.

Seven scheduling workstations constitute the program schedule production system, with all 7 stations capable of independently editing program and advertisement schedules. Scheduling can be done before or after uploading. Program and advertisement schedules can be edited separately and then merged for broadcast.

2.4 Database Server

Two DELL PowerEdge 720 III servers are configured, using SQL Server 2008 database management system. EMC AUTOSTAR software controls information sharing to achieve master-backup switching and data synchronization between servers.

The Dell PowerEdge R720 is a dual-socket 2U rack server with flexible features, highly scalable memory I/O capacity, and flexible network options that can easily run complex workloads.

It is a versatile platform with highly scalable memory (up to 768 GB) and strong I/O capabilities, capable of easily running various applications and virtualization environments. With Intel E5 processor support and dual RAID controllers, the R720 can robustly handle extremely demanding workloads as a high-performance computing (HPC) data node.

The R720' s flexible and powerful I/O and storage capabilities include 16 built-in hard drives and integrated expansion slots supporting 3rd generation PCIe, greatly increasing capacity. Optional hot-plug, front-access PCIe SSDs (up to 4) enable performance enhancement and in-chassis storage tiering.

The two servers use network heartbeat to maintain synchronization. When the host fails, the backup can automatically take over within a very short time. Under normal conditions, SQL Server runs on the host while the backup remains on Standby, with the heartbeat network monitoring server status. When the primary server fails, the backup server immediately starts SQL Server to ensure normal service. The PowerEdge 720 III servers use a single virtual IP address externally. Users access the same IP before and after master-backup switchover.

2.6 Peripheral Software Configuration

Peripheral software mainly includes synchronous migration and reference clock.

2.6.1 Synchronous Migration Synchronous migration has two main functions: first, migrating programs from nearline storage or upload storage to Omneon video servers for broadcasting; second, migrating programs from online storage or upload storage to nearline storage.

Synchronous migration is controlled by client programs on the migration server.

2.6.2 Reference Clock The reference clock provides a unified time reference for the entire broadcast control system through the internal network. A clock daemon program in the master database reads GPS clock signals and distributes them to various servers and workstations via the clock server as time calibration references, ensuring complete clock synchronization throughout the system.

The all-hard-disk digital broadcast control system introduced in this paper, from design concept to equipment configuration, is entirely based on our station' s actual situation and relevant regulatory requirements. The configuration is reasonable, with safe, stable, reliable, and efficient performance. Although some occasional fault points have appeared during use, after troubleshooting to find the root causes and solving them one by one, overall performance has been good. At the same time, upgrade space has been reserved, laying a good foundation for the upcoming all-HD era.

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