An Overview of Data Fault Tolerance Technology in Television Broadcast Control Systems (Post-print)

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Abstract

In the new media era, as people' s material living standards improve, demands for television program quality are becoming increasingly stringent. As the final gateway for television programs, the performance of television broadcast control systems must be continuously enhanced to meet audience requirements. The application of data fault tolerance technology can strengthen the security, stability, and reliability of television broadcast control system operations, prevent major broadcast accidents, and provide high-quality broadcast services. Strengthening the introduction and optimization of data fault tolerance technology makes it more suitable for the operational requirements of current television broadcast control systems and enhances program broadcasting security. This paper will analyze the development status of television broadcast control systems and investigate the design and implementation of data fault tolerance technology within these systems.

Full Text

Data Fault Tolerance Technology in Television Broadcast Control Systems

Abstract: In the new media era, rising material living standards have led to increasingly stringent demands for television program quality. As the final gateway for television programs, broadcast control systems must continuously enhance their performance to meet audience expectations. Data fault tolerance technology strengthens the security, stability, and reliability of broadcast control system operations, prevents major broadcast accidents, and delivers high-quality broadcast services. This paper analyzes the current development status of television broadcast control systems and investigates the design and implementation of data fault tolerance technology within these systems.

Keywords: broadcast control system; security; reliability; data fault tolerance; data

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The rapid development of internet and digital technologies has introduced new technologies, optimizations, and opportunities to radio and television broadcast control systems, while simultaneously imposing higher demands on technical capabilities and security reliability—where downtime is measured in seconds. Consequently, multiple technical approaches must be employed to improve broadcast control systems and ensure secure, high-quality transmission of broadcast information. The fundamental concept of fault tolerance was first proposed by von Neumann, with widespread commercial adoption occurring in the 1980s. The technology was subsequently promoted in energy, transportation, manufacturing, and logistics industries, and has now been implemented in television broadcasting. Data fault tolerance technology enhances data service continuity and improves broadcast quality and stability. It addresses numerous drawbacks of traditional primary-backup approaches, meets the development needs of modern digital broadcast control systems, reduces staff workload, and its compatible management model has gained widespread acceptance among operators. The extensive application of data fault tolerance technology in current television broadcast control systems effectively improves operational security and stability, prevents unexpected broadcast accidents, and ensures real-time program broadcasting. During digital transformation, strict adherence to principles of channel standard compliance, scalable upgrades, local adaptation, and smooth transition is essential. Systematic optimization is achieved through audio/video file multi-path distribution design, file server data fault tolerance design, and database fault tolerance design.

1. The Necessity of Data Fault Tolerance Technology in Broadcast Control Systems

During the prosperous development of the television industry, networkization, informatization, and digitization have driven continuous upgrades to broadcast control systems. In configuring system hardware and software, strict quality control and technological advancement must be maintained to prevent stability issues caused by equipment quality or performance deficiencies. Obsolete technologies should be eliminated to ensure technical sophistication. During system installation and operation, environmental conditions and operational requirements must be analyzed to eliminate single points of failure in both links and nodes that could cause broadcast interruptions. Implementing mutual backup for critical nodes and equipment reduces failure probability and gradually improves system performance. Current television broadcast control systems are rapidly evolving, and upgrades must accommodate sufficient expansion capacity

to meet industry development needs, enhance upgrade flexibility, and adapt to high-quality broadcast requirements.

With the development of digital broadcasting and network technologies, increasing user demands and growing program volumes have expanded data loads in broadcast systems, making data services a critical technology. Equipment quality control and backup design alone cannot guarantee secure broadcasting. Broadcast control systems represent a sophisticated and extensive operational architecture where television programs have become file-based, networked, and data-centric. Consequently, processing massive data and files is subject to multiple influencing factors, and system failures can cause severe broadcast accidents involving data interruption, corruption, or loss. Integrating advanced digital transmission equipment with data fault tolerance technology minimizes the impact of data failures on broadcast control systems. Data fault tolerance technology in broadcast control systems detects data and files in real-time to identify faults and reduce fault latency, eliminates transient faults without causing physical damage and masks faults that do not affect broadcasting, limits fault propagation to prevent impact on other areas, and effectively restores corrupted or lost data to its original state. Widespread application of this technology prevents unexpected accidents, ensures uninterrupted and error-free system operation, and facilitates system upgrades.

2. Design and Implementation of Data Fault Tolerance Systems

Data fault tolerance technology plays a vital role in fault detection, diagnosis, and resolution within broadcast control systems. In modern television industry development, where broadcast quality requirements are increasingly stringent, uninterrupted data services must be ensured with immediate recovery when faults occur. Data fault tolerance technology effectively controls service interruption and enables data recovery functionality. Database interface reliability has significantly improved, with backup servers being particularly critical for enhancing system reliability.

2.1 Multi-Path Distribution Design for Audio/Video Files While hardware failures can be repaired or replaced, data loss is often irreversible and highly impactful. Multi-path distribution and storage of program materials in broadcast control systems are crucial for fault switching and recovery. The audio/video file multi-path distribution function of data fault tolerance technology reduces server load while ensuring system security and maintaining real-time broadcasting during failures. Broadcast materials are stored in real-time across primary and backup file servers and broadcast workstations, with automatic distribution of television program materials from primary servers to different backup file servers (i.e., backup paths). This constitutes the primary work of multi-path distribution, effectively preventing data corruption and loss. Furthermore, when system failures occur, real-time broadcasting is ensured and system reliability is enhanced.

In multi-path distribution, coordination among upload workstations, file servers, and public servers must be strengthened. All these devices operate in primary-backup mode to meet multi-path distribution requirements and improve data transmission and storage backup speeds. During program material upload and storage, a combination of file server upload and secondary storage is employed—specifically, primary-backup file servers and primary-backup secondary storage (disk towers). When material issues occur on one distribution path, identical material from other paths can be redistributed to that path, ensuring real-time material access across the entire broadcast control system.

Multi-path distribution utilizes SQL Triggers to effectively capture information requiring updates for real-time material file refreshment, representing a critical link in the process. Copy execution programs must be constructed for audio/video file multi-path distribution, with database command calls and copy program communication implemented through Socket interfaces. In television broadcast control systems, terminals in audio/video file multi-path distribution primarily refer to broadcast workstations, which access database systems through database data modules. Database tables and stored procedures are invoked, with program update, addition, and deletion operations primarily implemented through stored procedures in data modules. Database construction should include backup path tables, audio program tables, extended storage, and triggers. Socket primitives provide connection establishment, address binding, data reception, data transmission, and connection closure for control command implementation. Copy execution programs are realized through data source name acquisition, config.ini file retrieval, SQL connection release, and communication thread SocktServerThread processes.

2.2 File Server Data Fault Tolerance Design File server fault tolerance is primarily achieved through error detection and file inspection recovery. The Active-Standby dual-machine master-slave hot backup mode is applied for file server error detection. Backup machines send ping commands to primary machines at approximately 0.1-second intervals to check network status. When the default primary server fails to respond, the backup server takes over, triggers an alarm, and enables manual repair of the primary file server and data.

File inspection and recovery primarily comprise three functions: CheckUselessFileThread (inspecting useless files), HandleCoherenceThread (checking file consistency), and DeleteUselessFileThread (eliminating useless files). Dual-machine fault tolerance systems are employed in file server data fault tolerance design. File consistency checks involve searching broadcast file records in the database and accessing all paths storing the file to compare modification timestamps, enabling effective recovery of repaired primary file servers. These operations maintain data type consistency between primary and backup servers for timely file data recovery. Useless file elimination involves opening SQL databases, retrieving file paths, checking file existence in paths, and verifying file records in JM tables to enable useless file removal.

2.3 Database Fault Tolerance Design As the data storage center, the database serves as the management and information hub of broadcast control systems. Integrating data replication technology with database fault tolerance technology is a key method for improving television broadcast control system performance and ensuring operational security and reliability. In backup databases on LAN servers with identical configurations, data from another database is replicated, enabling the backup database to update synchronously when the original database completes data updates. Backup servers are primarily applied when database failures occur, with backup machine operation scripts controlling primary machine startup and operation deletion scripts.

Database fault tolerance design should employ data hard copy technology, database network management technology, and data replication technology, based on the master-backup server fault tolerance switching principle in digital audio systems to complete database distribution. Role switching between primary and backup servers through data creation/deletion, transactional replication, and data distribution significantly enhances system fault tolerance capability.

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