Analysis of Cable Television Network Transmission Technologies for 4K Ultra-High-Definition Television Postprint

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Abstract

The rapid development of modern Internet technology has driven the integration of networks into all facets of daily life, encompassing clothing, food, housing, and transportation. Its core function is to accomplish information transmission. Application to cable television signals can enhance television program quality and ensure stable playback. This paper briefly analyzes the concept of 4K ultra-high-definition cable television network transmission, examines various transmission technologies for 4K ultra-high-definition television via cable networks, explores future development trends, and discusses practical application strategies, with the aim of providing valuable reference for relevant technical personnel.

Full Text

Analysis of Cable Television Network Transmission Technology for 4K Ultra-High-Definition Television

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Abstract: The rapid development of modern Internet technology has driven network integration into every aspect of daily life, including clothing, food, housing, and transportation, with its core function being information transmission. When applied to cable television signals, this technology can significantly improve television program quality and ensure stable playback. This paper briefly analyzes the concept of 4K ultra-high-definition cable television network transmission, explores its future development trends through an examination of various transmission technologies for 4K ultra-high-definition television, and discusses practical application strategies, aiming to provide useful references for relevant technical personnel.

Keywords: Internet technology; 4K ultra-high-definition television; cable television network; transmission technology; high-order modulation technology

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1. Concept of 4K Ultra-High-Definition Cable Television Network Transmission

The emergence of 4K ultra-high-definition television has enabled modern audiences to enjoy significantly enhanced viewing experiences. 4K ultra-high-definition television refers to a physical resolution of 3840$\times$2160$pixelsonthetelevisionscreen, whichtheoretical$ This increases the pixel count from approximately 2 million to over 8 million, approaching the ten-million-pixel standard of mainstream digital cameras on the market today, and substantially improves image fineness. In simple terms, 4K ultra-high-definition television seamlessly combines four high-definition screens to display images at four times the resolution of full high-definition. While current 4K televisions cannot fully support 3D technology, they possess clear technical advantages over full high-definition television in other areas due to their ultra-high resolution. Most cable television networks utilize coaxial cable as their transmission medium, which can be divided into broadband cable and baseband cable categories. Composed primarily of copper wire, these cables support high-capacity information transmission, enabling smoother cable television playback with superior transmission quality that meets modern viewing demands.

2. Overview of Cable Television Network Transmission Technologies for 4K Ultra-High-Definition Television

2.1 4K Display Technology 4K display technology encompasses two main components: the innovative technology for converting 2K to 4K resolution, and display panel technology. In current domestic and international television panel configurations, LED technology, LCD technology, and OLED technology are commonly employed. LED technology offers superior luminous efficacy compared to LCD technology and provides certain advantages in panel thickness. OLED technology demonstrates stronger color presentation effects than both LED and LCD technologies, though it has limitations in screen size and luminous duration. Market data indicates that 4K ultra-high-definition televisions have captured the largest television market share in recent years, showing promising market prospects. To gain greater market share, some television manufacturers

have transitioned from traditional 2K display technology to 4K display technology, enriching television content and improving picture quality to better fulfill entertainment functions for 4K ultra-high-definition television users.

2.2 HEVC Technology The primary difference between 4K ultra-high-definition television and full high-definition television lies in resolution—4K ultra-high-definition television offers four times the clarity of full high-definition television. However, this represents more than a simple resolution upgrade; corresponding improvements in data throughput and frame rates are also necessary. During this process, information sources must be compressed, requiring new encoding standards to meet the technical demands of 4K ultra-high-definition television. Traditional high-definition television production technology employed the MPEG-2 encoding mode, which could satisfy basic data processing requirements but was incapable of efficient source compression. The application of HEVC (High Efficiency Video Coding) technology effectively enhances signal compression efficiency using the H.265 compression standard, which can substantially increase the video bit rate for 4K ultra-high-definition television.

2.3 Big Data Technology Human activities constantly generate information transmission, producing massive volumes of data. Big data technology has been applied across numerous fields, including military communications, signal transmission, and architectural design. In the context of 4K ultra-high-definition television cable network transmission, big data technology not only strengthens television signal processing but also analyzes underlying hidden information through various data analytics, thereby improving the efficiency of television network data processing. The value concepts and practical applications of big data represent a major breakthrough in human development history, enabling the understanding of developmental patterns through data information to promote human progress. Virtual information constitutes the core content of big data technology, focusing on optimizing information resources for cable television network transmission by constructing virtual task analyses to meet user application demands and accomplish optimization tasks for 4K ultra-high-definition television.

2.4 High-Order Modulation Technology The application of QAM (Quadrature Amplitude Modulation) technology in digital cable television has significantly improved anti-interference capability and stability. The core principle lies in QAM technology' s adaptability to different modulation levels, such as 8QAM, 128QAM, and 512QAM. As modulation levels decrease, spectrum utilization exhibits a proportional relationship, while anti-interference capability substantially improves. Conversely, higher modulation levels result in significantly increased frequency utilization but decreased anti-interference capability, imposing rapidly escalating requirements on network systems. Therefore, the standard modulation level for conventional 4K ultra-high-

definition television is 64QAM, a standard that ensures optimal balance between transmission quality and spectrum utilization in cable television networks.

3. Development Trends of Cable Television Network Transmission Technology for 4K Ultra-High-Definition Television

3.1 Programming Trend The continuous development of information technology in the new era has effectively promoted the popularization of cable television network transmission technology, with simpler operational methods that have essentially achieved "operation possible for anyone who can read." Some 4K ultra-high-definition television functions can even be automatically controlled through voice commands, substantially improving television practicality. When developing cable television network transmission systems using automation technology, system programming design must be completed in advance. This development approach offers rapid development speeds and diverse target functions, adapting to the new era' s diversified design requirements for cable television network transmission systems and delivering excellent user experiences. The development model for cable television network transmission technology features high degrees of freedom, allowing technical personnel to complete original programming tasks through system code design, making it suitable for personalized user requirements with clearly defined target customer groups.

3.2 Diversification Trend The development of cable television network transmission technology for 4K ultra-high-definition television should emphasize market-oriented development, designing corresponding television software systems based on actual market demands. During product design phases, market research should be conducted to enhance user experience while meeting basic customer needs and optimizing 4K ultra-high-definition television configuration. However, the technology itself has relatively high limitations and somewhat singular functionality. The application of cable television network transmission technology can enhance the diversified functions of 4K ultra-high-definition television. For example, with television network support, users can customize playback lists in advance and utilize replay modes after broadcast. This represents the design advantage of diversified cable television network transmission technology, enabling software reform according to different market demands, reducing project development costs while improving user experience.

3.3 Personalization Trend China' s current cable television industry is developing rapidly, with related enterprises introducing television network systems to expand the consumer market for 4K ultra-high-definition television. When users access cable television networks, designers incorporate big data analysis into video recommendations, judging user interests based on recent search records to push more preferred television programs and thereby improve cable television network service quality. Similar to how Haidilao hotpot restaurants

distinguish themselves through refined service compared to ordinary hotpot establishments, this personalized, customized service characteristic represents a high-quality service standard. Cable television network transmission technical personnel have recognized this trend, moving toward personalized development to promote efficient operation of data processing tasks within cable television networks and fully leverage the high-quality and convenient advantages of 4K ultra-high-definition television.

3.4 Compatibility Trend The open information sharing model of cable television networks can effectively improve data processing efficiency for television transmission, though it also introduces certain data processing risks. With the continuous growth in the number of 4K ultra-high-definition televisions and the widespread application of new scientific and technological methods, the frequency and volume of information interaction in cable television services continue to increase, making security domain division more difficult and expanding the scope of data processing for television network transmission technology. Consequently, stability issues have gradually become prominent. During daily operations, cable television networks experience varying information transmission demands across different time periods, with some interaction links experiencing surges that cause network fluctuations, leading to 4K ultra-high-definition television malfunctions that prevent automated control effects and, in severe cases, result in data leakage. Modern cable television network transmission operates on a large scale, with increasing quantities of equipment and management difficulty in television systems. Ensuring overall equipment control security has become a focus of cable television network operation management. The application of emerging technologies such as microelectronics has effectively improved the compatibility of cable television networks, alleviating management pressure and workload for technical staff to some extent while enhancing network dependency, enabling data transmission even in environments with excessive data throughput.

4. Application Analysis of Cable Television Network Transmission Technology for 4K Ultra-High-Definition Television

4.1 Leveraging User Base Advantages Survey data on cable television set-top boxes indicates that domestic network television 开机率 (startup rate) is approximately 65%. However, this only demonstrates that television remains one of the mainstream methods for video information acquisition, though its dominant position is no longer secure. Taking a second-tier city as an example, its television coverage audience reaches 7.653 million people, but this number has been declining in recent years. Online video users number 3.626 million, with a usage rate exceeding 60%, while mobile video users total 2.565 million, with a usage rate of approximately 40% and an annual increase of over 700,000 users, representing a growth rate exceeding 80%. Analysis of viewing duration and demographics reveals that mobile video users' viewing time has surpassed that of television users, and the influence of mainstream television users is con-

tinuously diminishing due to an aging audience. Consequently, cable television network transmission technology development currently possesses a strong user foundation and should leverage modern video media industry models, capitalizing on its own strengths to make data content the primary competitive means for achieving market dominance. This approach emphasizes improving the professionalism and richness of cable television networks, highlighting the application of various new devices and the high-tech performance of 4K ultra-high-definition television.

4.2 Economic Cost Investment Considerations During the construction of cable television networks for 4K ultra-high-definition television, multiple factors must be comprehensively evaluated. Whether using optical cable networks or cable construction, substantial upfront capital investment is required, resulting in extremely high construction costs. In terms of economic efficiency, microwave multipoint distribution system (MMDS) transmission technology delivers information wirelessly with relatively small capital investment, thereby reducing economic costs. Regarding applicability, MMDS transmission technology is particularly suitable for rural areas with fewer obstacles and reduced signal interference. Widespread promotion of MMDS transmission technology in rural cable television network construction can not only reduce television viewing costs for users but also lower infrastructure construction costs for information transmission. In medium and large cities, Hybrid Fiber-Coaxial (HFC) cable television network transmission technology is more appropriate, as its high-quality television information transmission can satisfy urban residents' demands. Moreover, the high population concentration in cities enables effective cost recovery for fiber-optic trunk line construction, providing television audiences with more diverse options.

4.3 Transforming the Television Competitive Market The current television market landscape shows that traditional television data transmission models lag behind, particularly under conditions of 4G network popularization and large-scale 5G network application, where all industries must integrate Internet elements. Cable television network transmission technology for 4K ultra-high-definition television has transformed the traditional television competitive market, achieving significant reforms in television media industry models. Regarding television network construction, the threshold for construction rights should be raised, as current cable television network transmission management thresholds are too low and should resist unqualified social institutions applying for management licenses. Concerning television network transmission platforms, current smart television media operators broadcast television programs through OTT (Over-The-Top), though the App itself is an integrated system that relies on PC Internet and mobile clients for signal transmission. Marketization of media platforms has promoted diversified development of television program formats to meet the television media needs of different audiences. In terms of core market modules, Internet technology should be applied to construct ca-

ble television network industry models that adapt to modern market economic environments. Taking The New York Times as an example, its NYT Picks module collects and presents comments from core users, transforming them for secondary dissemination. This reform and innovation, supported by big data and artificial intelligence technologies, enables rapid collection of 4K ultra-high-definition television user characteristics, reforms content presentation formats, and emphasizes a new creative field of "content plus technology" for cable television network transmission.

4.4 Innovating Television Application Models The emergence of Internet media has profoundly influenced traditional media communication patterns, accelerating the loss of fixed audiences for traditional media. In the Internet era, people' s program viewing methods are no longer limited to television sets but include cable networks, satellite networks, and other platforms, with program selection largely determined by user preferences. With the arrival of the Web 4.0 era, various new media platforms continue to emerge, with live streaming, video, and other novel media communication methods presenting public information. Content production models have shifted from Professional Generated Content (PGC) to User Generated Content (UGC). Throughout this process, television media has upgraded to cable television networks, serving as a bridge connecting media and users. By integrating comprehensive video content, network-based television services are realized. As an open exchange platform for user information sharing, cable television networks determine user attention directions based on published content, becoming an important competitive factor in the reform and innovation of 4K ultra-high-definition television. This effectively leverages the competitiveness of cable television network transmission technology. Cable television networks must seize Internet opportunities to form new communication methods characterized by "converged edge industries," using 4K ultra-high-definition television as the primary foundation to build a carrier for smart television services. By leveraging the diffusion effect of new communication models, the television industry can achieve geometric growth effects and promote extensive expansion of cable television network transmission technology. Under these circumstances, cable television network development must center on communication, with terminal content migrating according to user preferences to provide intelligent application requirements such as on-demand and catch-up viewing, technically forming the "6A" phenomenon for 4K ultra-high-definition television.

4.5 Communication Network Considerations Different cable television network communication models each possess distinct advantages in practical application, though they also exhibit certain limitations that require remediation through various transmission technologies to ensure efficient television signal transmission. First, when applying cable transmission technology, television signal strength decreases with increasing cable length, and environmental temperature factors also affect transmission quality. Therefore, cable trans-

mission technology applications should incorporate signal amplifiers at cable nodes. Second, based on current cable television network transmission technology levels, optical fiber represents an ideal information transmission material, though its persistently high manufacturing costs create certain barriers to cable television network development. Third, MMDS transmission technology features lower construction costs but is significantly affected by signal transmission environments, imposing certain requirements on the natural topography of television network transmission areas and exhibiting inherent noise vulnerabilities that impact user experience. In MMDS transmission technology applications, bidirectional communication for 4K ultra-high-definition television signals can be achieved by adding cable modems and employing synchronous code division multiple access technology. Thus, regardless of the cable television network transmission technology employed, post-construction maintenance management is extremely important. For established cable television network systems, daily maintenance must be perfected to ensure normal operation of all equipment, promptly address component aging issues, and guarantee application effectiveness of cable television network transmission technology for 4K ultra-high-definition television.

Conclusion

With the increasing number of 4K ultra-high-definition television users in China and continuously improving market share, the transformation of cable television network transmission technology for 4K ultra-high-definition television represents a key direction in China' s television media construction under the background of the information age. Through systematic consideration of cable television network architecture and network transformation, emphasizing the dominant position of 4K ultra-high-definition television and leveraging its advantages in efficiency and security to enable simultaneous multi-interface operations, relevant technical personnel must continuously strengthen the quality of cable television network transmission technology renovation projects, promptly seize development opportunities, and provide high-quality television signals to deliver high-caliber services to audiences.

References:

[1] Li Yang, An Yuanwei, Kang Jianhua, et al. Analysis of Cable Television Network Transmission Technology for 4K Ultra-High-Definition Television[J]. Radio & Television Information, 2020, 27(11): 45-47.

[2] Hu Jianhua. Research on Transmission Characteristics of 4K Ultra-High-Definition Television Cable Networks[J]. China High-Tech, 2020(20): 96-97.

[3] Cao Mei. Analysis of Cable Television Network Transmission Based on 4K Ultra-High-Definition Television Broadcasting[J]. Wireless Internet Technology, 2020, 17(10): 82-83.

[4] Liang Yan. Research on Cable Television Networks as Information Transmis-

sion Methods for Smart Communities[J]. Intelligent City, 2019, 5(23): 45-46.

[5] Nan Jianqiang. Preliminary Research and Implementation of 4K Ultra-High-Definition Cable Television Network Transmission Technology[J]. Digital Communication World, 2019(05): 107-108.

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