Research on Bidirectional Technical Design and Design Standardization for Broadcast Television Cable Networks: Postprint

Authors: Wu Chuanhui

Date: 2023-10-08T00:00:00+00:00

Abstract

This paper briefly explains the main principles of bidirectional technology design for broadcast television cable networks and analyzes commonly used renovation technologies, including PON access network technology, CMTS access network technology, LAN user-side access technology, and EOC user-side access technology. Meanwhile, taking a specific renovation project as a case study, it expounds upon the main content of standardization design for bidirectional technology in broadcast television cable networks.

Full Text

Research on Bidirectional Technology Design and Standardization for Broadcast Television Cable Networks

Author: Wu Chuanhui (Jingning She Autonomous County Convergence Media Center, Lishui, Zhejiang 323000)

Abstract: This paper briefly outlines the main principles of bidirectional technology design for broadcast television cable networks and analyzes commonly used transformation technologies including PON access network technology, CMTS access network technology, LAN user-end access technology, and EOC user-end access technology. Additionally, using a specific renovation project as an example, it elaborates on the key components of standardized design for bidirectional technology in broadcast television cable networks.

Keywords: television media; broadcast television cable network; bidirectional technology; PON technology; design standardization

CLC number: TN943.6
Document code: A
Article ID: 1671-0134(2021)05-117-03

DOI: 10.19483/j.cnki.11-4653/n.2021.05.037
Citation format: Wu Chuanhui. Research on Bidirectional Technology Design and Standardization for Broadcast Television Cable Networks [J]. China Media Technology, 2021(05): 117-119.

To further meet users' growing network demands and achieve the progressive development of traditional television media, implementing bidirectional technology transformation for broadcast television cable networks has become an inevitable choice. Such technological transformation can deliver better user experiences. Therefore, investigating the technologies employed in bidirectional transformation and the standardized design of such upgrades holds significant practical value.

1. Analysis of Main Principles for Bidirectional Technology Design in Broadcast Television Cable Networks

The transformation must adhere to three core principles. First, **standardization**: the selected technologies and operational system platforms must comply with both international and domestic standards, exhibit excellent openness, and support continuous technological upgrades or hybrid use with other technologies. Second, **advancement**: besides considering current user demands and technical capabilities, the transformation should address future user requirements and the feasibility and cost of subsequent network upgrades to ensure technological sophistication. Third, **reliability**: the network operation and data transmission quality and efficiency must be consistently maintained to guarantee high system reliability and avoid increased maintenance costs.

2. Application of Bidirectional Technologies in Broadcast Television Cable Networks

2.1 PON Access Network Technology

PON access network technology offers relatively low transformation costs, higher fundamental reliability, and more convenient maintenance compared to other access technologies. PON technology can be subdivided into GPON, EPON, APON, and other variants, each with distinct advantages but all based on the PON network architecture. Due to fiber' s long transmission distance, strong anti-interference capability, and large capacity, it has long been widely used in backbone networks. In recent years, as optical component costs have decreased, fiber has become the preferred transmission medium for access networks. Passive Optical Network (PON) features relatively low cost and smooth upgradeability among fiber access methods, increasingly favored by telecom operators as an ideal solution for the "last mile" problem [1]. PON access network technology employs a point-to-multipoint topology; in single-line bidirectional mode, it collects all ONU signals via combiners and passive optical splitters [2]. Beyond cost-effectiveness and reliability, high flexibility represents another key advantage of PON access network technology. Unlike other access networking forms, PON networking models face no restrictions and can flexibly establish tree or star topologies. This networking form also demonstrates high applicability in scenarios with highly dispersed user access points, enabling a single backbone fiber to satisfy access requirements for all user access points.

[Figure 1: see original paper]

2.2 CMTS Access Network Technology

Currently, CMTS access network technology is more widely adopted in Europe, America, and first-tier Chinese cities (Shanghai, Guangzhou, Shenzhen, etc.) for broadcast television cable network bidirectional transformation. In broadcast television cable networks, CMTS access network technology enables data interconnection by simulating broadcast signals, digital television signals, and network data signals, combined with load carrier frequency division multiplexing technology to accomplish RF modulation, protocol processing, and forwarding [3]. Compared with other access technologies, CMTS access network technology offers several advantages in practical bidirectional transformation. First, **low workload**: by utilizing existing coaxial cables without requiring rewiring at the user end, both transformation workload and costs are significantly reduced. Second, **operational simplicity**: CMTS-based transformations involve simpler operations and lower workload, enabling project completion in shorter timeframes. Third, **higher product maturity**. However, CMTS requires two separate networks for upstream and downstream transmission, meaning noise and interference in the upstream network degrade overall transmission quality. This necessitates introducing smaller upstream bandwidth to mitigate the issue, which consequently reduces downstream transmission speed. Stabilizing both upstream and downstream speeds at high levels requires increased communication equipment investment, raising overall transformation costs. Consequently, CMTS access network technology is more suitable for initial expansion and rapid market capture, with other access technologies needed as subscriber numbers grow.

2.3 LAN User-End Access Technology

LAN user-end access technology is commonly employed at the user access side of cable network bidirectional transformation. In practice, Ethernet switches handle data unpacking, forwarding, and transmission at rates exceeding 100 Gbit/s. Typically, LAN user-end access technology is not used alone in cable network bidirectional transformation but combined with other access technologies. Currently, this technology is more prevalent in newly built residential communities and government institutions. In practice, to rapidly capture markets while considering technical difficulty and transformation costs, EPON+LAN access methods were widely adopted during the initial phase of cable network bidirectional transformation. As subscriber numbers increase and to better accommodate user demands for high-bandwidth, low-latency, and low-jitter services, EPON+LAN access methods require technical upgrades. In practice, the common upgrade approach involves replacing equipment with gigabit uplink switches, increasing bandwidth from 100 Mbps to 1000 Mbps while continuing to leverage existing twisted-pair resources to meet higher user network requirements [4]. Moreover, as services develop and bandwidth demands increase in the future, a secondary upgrade to 10GEPON+gigabit LAN can be implemented to further enhance network capacity.

2.4 EOC User-End Access Technology

EOC user-end access technology is an access technology based on cable television coaxial cable networks using Ethernet protocols. During application, with specific media conversion technology support, data signals compliant with 802.3 series standards are transmitted through household coaxial cables. Compared with other access technologies, EOC user-end access technology maximizes utilization of existing household coaxial cable resources, effectively solving the last 100-meter access problem—a advantage shared with PON access network technology. EOC user-end access technology primarily implements 100M Ethernet standards, supporting services such as 4K ultra-high-definition IPTV. Additionally, EOC converters can effectively address bandwidth connection issues in scenarios with "coaxial cables but no network cables," using coaxial cables as the primary medium (preferably within 100 meters) with network cables as supplementary. In current cable network bidirectional transformation, EOC user-end access technology is often used in combination with other access technologies such as EPON. However, against the backdrop of vigorous development of high-definition video and broadband in the broadcast television market, user demand for network bandwidth has increased substantially, making the EPON+EOC networking approach unable to adequately satisfy user bandwidth requirements.

3. Standardized Design Case for Bidirectional Technology in Broadcast Television Cable Networks

3.1 Project Background Overview

A certain region originally employed a "dual-fiber triple-wave" approach, establishing dedicated channels for broadcast television signal and data signal transmission respectively, delivering both signals to user ends via two-core leather optical cables. This upgrade project primarily transformed the "dual-fiber triple-wave" approach into a "single-fiber triple-wave" approach. In the design, 512 households were designated as a design unit. Considering existing network resources, the network design employed a combination of thin coverage and full coverage to drive the comprehensive transition of the cable infrastructure network to fiber.

3.2 Technology Selection

This project design primarily utilized PON access network technology, with both GPON and EPON being viable options. Based on comprehensive consideration of the construction area' s actual conditions, EPON technology (channel multiplexing technology) was selected for this design. EPON systems primarily employ WDM technology, using FTTB architecture to enable single-fiber bidirectional transmission with upstream and downstream channel rates of 1.25 Gbps each. EPON' s downstream transmission uses broadcast mode, while upstream transmission uses TDMA mode. The basic unit of EPON system networking comprises OLT and ONU, where OLT, as the central office equipment, provides abundant PON ports and plays a crucial role in connecting ONU devices, while ONU, as the user-end equipment, provides corresponding data and voice interfaces for user service access.

3.3 Stepwise Implementation Strategy

First, **broadcast transmission channel**: design the broadcast transmission channel according to 100% coverage ratio. If one-step implementation is infeasible, initial network construction can begin with 80% coverage ratio, with the final 100% coverage achieved by gradually eliminating primary splitting in the equipment room as subscriber numbers increase.

Second, **data transmission channel**: during the initial construction phase, limited by low user access numbers, designing the data transmission channel with 25%-50% coverage ratio (three-level splitting structure) suffices to meet application requirements. Subsequently, as subscriber numbers gradually increase, primary splitting in the equipment room is eliminated, and the initial three-level splitting structure is adjusted to a two-level splitting network architecture, ultimately achieving 100% coverage. In practice, for scenarios such as office buildings, villa areas, and high-end apartments with clear data service requirements and higher technical demands, 100% full coverage design and construction can be introduced from the initial phase.

3.4 Application Scenarios and Design Solutions

First, new network construction: in the plan, backbone optical cables with no fewer than 10 cores must be introduced between the sub-center equipment room and basic coverage units; optical cables with no fewer than 6 cores must be introduced between basic coverage units and any splitting nodes; and distribution optical cables with no fewer than 4 cores must be introduced between any splitting nodes and corresponding household fiber distribution nodes. If special applications exist within the optical cable deployment area, including security monitoring, smart communities, or private network services, the number of cable cores can be appropriately increased according to actual requirements [5]. During actual optical cable deployment, outdoor optical cables are used in all areas except corridors, with merging implemented according to routing.

Second, low-rise buildings: primarily referring to office buildings, student dormitories, and low-rise residential communities with no more than 7 floors and no more than 21 households per unit [6]. In this project design, broadcast transmission channels and data transmission channels were designed using an approach of 80% coverage gradually increasing to 100% (three-level splitting structure smoothly upgraded to two-level splitting structure).

Third, high-rise buildings: primarily referring to buildings with no fewer than 7 floors and no fewer than 21 households per unit, including high-rise residences, office buildings, hotels, etc. In this project design, broadcast transmission channels were designed and constructed using 100% coverage (three-level splitting structure), while data transmission channels were designed using 50% coverage gradually increasing to 100% (three-level splitting structure smoothly upgraded to two-level splitting structure).

Fourth, villa areas: villa areas have clear data service requirements and higher technical demands, so 100% full coverage design and construction mode was introduced from the initial phase for both broadcast transmission channels and data transmission channels. The broadcast transmission channel employs three-level splitting structure, while the data transmission channel employs two-level splitting structure.

Fifth, bungalow buildings: primarily including self-built structures in urban villages, suburbs, and rural areas. In this project design, broadcast transmission channels were designed using 100% coverage (three-level splitting structure), while data transmission channels were designed using 50% coverage gradually increasing to 100% (three-level splitting structure smoothly upgraded to two-level splitting structure).

3.5 Renovation Network Design Solutions

First, fiber-to-the-community solution: this solution is primarily used in areas where coaxial cable distribution network renovation is relatively simple and users have relatively high requirements for broadband networks.

Second, fiber-to-the-community with coaxial cable home access: this solution is primarily used in areas where coaxial cable network transmission distance is relatively long, the home access segment transformation is relatively difficult, and network conditions are good. In practice, EPON technology is used to complete the connection between the bidirectional network sub-headend and community access points, followed by EOC technology for home access. This renovation network solution employs a "ring-star" topology that directly covers user ends. In this scenario, optical nodes can achieve coverage of 500 households.

Third, fiber-to-the-community with cable modem home access: this solution is primarily used in areas where coaxial cable distribution network renovation is relatively difficult. In practice, reverse optical receivers are deployed at the sub-headend to establish reverse RF hybrid lines [7]. Additionally, reverse modules are added to optical nodes and amplifiers, with reverse optical links (1310 nm) introduced between optical nodes and equipment rooms. High-pass filters are installed for all users within the coverage area. On this basis, CMTS (cable modem) equipment is configured in the equipment room to ensure successful system activation. This network renovation solution employs a "ring-star" topology that directly covers user ends. Under the principle of "bidirectional transmission, centralized access," the cable network is designed and constructed, with return modules introduced in both amplifiers and optical stations to guarantee network connection quality.

Conclusion

In summary, PON access network technology, CMTS access network technology, LAN user-end access technology, and EOC user-end access technology are widely applied in current broadcast television cable network bidirectional transformation. In practice, appropriate access technologies must be selected based on different conditions, combined with differentiated designs for broadcast transmission channels and data transmission channels across various application scenarios to improve the quality and feasibility of bidirectional technology transformation in broadcast cable networks.

References

[1] Si Qingya, Zhong Likai. Research on bidirectional technology design and standardization for broadcast television cable networks[J]. China New Technology and New Products, 2020(19): 36-38.

[2] Zhang Baiping. Exploration on bidirectional technology for broadcast television cable networks[J]. Satellite TV & Broadband Multimedia, 2020(13): 127-128.

[3] Zhang Zhiyuan. Research on bidirectional technology design and standardization for broadcast television cable networks[J]. China New Communications, 2019, 21(06): 41-42.

[4] Wang Qingxiao. On the introduction and application of bidirectional technology in broadcast television cable networks[J]. China New Communications, 2019, 21(06): 122.

[5] Tang Minjian, Wang Bin, Huang Huacai. Method for bidirectional network transformation based on cable-wireless convergence network technology[J]. Cable TV Technology, 2017(04): 52-54.

[6] Liang Yuejun. Bidirectional transformation of cable broadcasting television networks based on EPON+EOC technology[J]. West China Broadcasting TV, 2018(01): 247+251.

[7] He Guoquan. Application analysis of bidirectional improvement technology for cable television access networks[J]. West China Broadcasting TV, 2017(13): 242-243.

Author Biography: Wu Chuanhui (1964-), male, from Jingning She Autonomous County, Zhejiang Province. Research direction: broadcast television installation and maintenance technology.

(Editor: Zhang Xiaojing)

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