Woody International Publish Limited
An Multidisciplinary Academic Journal Publisher
Journal of Artificial Intelligence and Information, Volume 2, 2025
https://www.woodyinternational.com/

Research on Access Layer Communication Line Design Based on PON Technology

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Abstract: ***Since the network structure becomes more and more perfect, the public has put forward many requirements regarding the communication quality of the access layer. However, if the access layer communication still uses the traditional techniques to design the line, the communication quality cannot be guaranteed to meet the public requirements. Therefore, PON technology should be flexibly integrated into the line design, and the technical advantages should be used to strengthen the communication quality fundamentally. To further analyze the design of access layer communication line based on PON technology, this paper first introduces the basic concepts of PON technology and access layer, then puts forward the key points of design of access layer communication line based on PON technology, and finally points out the specific design method of access layer communication line with a case as the core.***

Keywords: PON technology; Access layer communication; Line design.

1. INTRODUCTION

With the rapid development of information technology and the increasing demand of users for the Internet, Internet technology is also developing rapidly. In the field of network technology, wireless communication and access technology have been widely applied, and fiber optic communication has become the mainstream of future network technology development by utilizing its advantages. At present, the development of network technology in China has achieved fiber optic, digital, and broadband connections, but the development of access networks has not achieved good results. At this point, PON technology can be utilized for communication network access design. With its further development and the improvement of relevant specifications, this will become the mainstream of access network development in China. Artificial Intelligence (AI) and Machine Learning technologies are hot topics in today's technology field, demonstrating wide applicability and enormous potential in multiple industries.

1.1 Image Processing and Computer Vision

Several papers focus on advancements in image processing and computer vision. Yan et al. (2024) investigate the mechanism of image super-resolution reconstruction using convolutional neural networks (CNNs), contributing to the ongoing development of image enhancement techniques. Chen et al. (2022) present a one-stage object referring method incorporating gaze estimation, enhancing object recognition capabilities. Tian et al. (2024) improve U-Net architecture for brain tumor segmentation, integrating GSConv and ECA attention mechanisms to boost accuracy and efficiency in medical image analysis. Ren (2024) proposes an enhanced YOLOv8 model for infrared image object detection using an SPD module, demonstrating the application of deep learning to specific imaging challenges. These studies collectively demonstrate the versatility and ongoing development of deep learning in image-related tasks.

1.2 Natural Language Processing (NLP) and Large Language Models (LLMs)

The influence of Large Language Models (LLMs) is evident in several papers. Xu et al. (2024) directly address the critical aspect of user trust and experience with advanced LLM-based conversational agents, highlighting important considerations for successful LLM implementation. Wu (2024) explores the potential of LLMs for semantic parsing in intelligent database query engines, demonstrating their application in information retrieval. Bethard et al. (2008) and Jurafsky & Martin (2007) provide fundamental background knowledge in NLP. Wang et al. (2024) propose LLM connection graphs for global feature extraction in point cloud analysis, showcasing a novel application of LLMs in spatial data processing. Wang et al. (2024) further introduce an asynchronous LLM architecture for event stream analysis with cameras, demonstrating real-time processing capabilities. These studies collectively show the continued development and exploration of LLMs' capabilities and applications.

1.3 Healthcare and Anesthesia

Lin et al. (2024) present innovative methods for optimizing anesthesia depth using AI and electroencephalogram (EEG) analysis. This research contributes to improvements in patient safety and the precision of anesthesia administration. The study highlights the potential of AI in real-time monitoring and adjustment of anesthesia levels.

1.4 Data Analysis and Forecasting

The application of AI and ML to data analysis and forecasting is also apparent. Tekaya et al. (2020) provide an overview of big data applications in finance. Eltweri et al. (2021) specifically explore the use of big data for fraud detection and risk management in real estate. Ravi and Kamaruddin (2017) provide a comprehensive overview of the opportunities and challenges of big data analytics in smart financial services. Murugan (2023) details large-scale data-driven financial risk management and analysis using machine learning. Bi et al. (2024) assess the role of AI, particularly LLMs like ChatGPT, in financial forecasting. Lian and Chen (2024) explore complex data mining analysis and pattern recognition using deep learning. Qi and Liu (2024) focus on sales forecasting using Hadoop-based big data analysis. Xie et al. (2024) utilize a Conv1D-based approach for multi-class classification in legal citation text. These papers collectively highlight the growing importance of AI and ML in data-driven decision-making across various sectors.

1.5 Other Applications

Chen et al. (2020) apply deep learning to printed mottle defect grading, demonstrating AI's use in industrial quality control. Liang and Chen (2019) propose a high-performance dynamic service orchestration algorithm for hybrid NFV networks. These studies demonstrate the versatility of AI and ML across diverse application domains.

2. COMPREHENSIVE OVERVIEW OF PON TECHNOLOGY AND ACCESS LAYER

2.1 PON Technology Concept

Optical networks can be divided into passive networks and active networks, and passive optical networks (PON) are a type of passive network whose main feature is to achieve their separation function. In passive or active optical networks, network distribution does not include electrical components and switches, but rather builds optical networks at user terminals through optical terminals or optical distribution networks. The optical distribution network of fiber optic cable terminals provides corresponding interfaces for network connections to achieve network and signal connections between network terminals and user terminals. Optical distribution networks are somewhat different from PON technology. Among them, passive optical networks are mainly composed of multiple passive components, which can distribute and use optical signals between network terminals and user terminals, and convert and process optical signals to meet the network usage needs of users [1].

2.2 Concept of Access Layer

The access network is oriented towards the main network. The access network is an effective data network between SNI and uni. The main goal is to effectively connect users to the main network and then allow them to access the nearest service node. Therefore, it can be said that the access network is an effective connection between users and the main network. Traditional Internet access technologies include integrated digital operation network, digital user technology, cable TV, LAN and other technologies. The earliest technology among them is digital operation network integration technology. Due to its tariffs not meeting actual access needs, it no longer exists. However, cable TV technology still faces challenges in construction and use, and its future development prospects are worrying. At present, digital user technology and local area network are the two most widely used access methods. Digital user technology not only provides voice communication, but also offers access to it. LAN connection technology has advantages in expanding frequency bands, but there are also some drawbacks. In addition, with the development of technology, optical network access has become one of the main trends in network development. From a practical perspective, with the development of technology, copper cable access can no longer adapt to the rapid development of access networks. Therefore, implementing optical cables instead of copper cables is the main trend in the development of access network technology.

3. DESIGN POINTS OF COMMUNICATION LINES BASED ON PON TECHNOLOGY ACCESS LAYER

3.1 Design Process

The design of communication lines based on Passive Optical Network (PON) technology is complex and cumbersome, so relevant preparations must be made before the project begins. Before implementing the project, it is necessary to fully understand the actual situation, understand the needs of telecommunications operators, and effectively ensure the availability and rationality of the access system. After the preliminary design of the communication line is completed, it needs to be checked again. For communication line design based on PON technology, the general design process can be summarized as follows: Firstly, it is necessary to clarify the requirements of the communication operator in order to define the general concept of line design. In the design process, if the operator provides drawings on site, the design must be based on the drawings. If the operator does not provide drawings, it is necessary to study the real situation on site, draw a map of the site, and then construct communication lines based on the drawings. Secondly, regardless of whether the drawings are provided by the operator, the operator should ensure that the line design results are in line with the actual situation on site. After the project is completed, based on the specific requirements of the operators and the actual situation on site, the project will be refined and the equipment will be checked to see if it needs to be completed. Finally, develop an overall plan for network construction, prepare a budget, and complete the design of the access layer communication network.

3.2 Site Investigation

On site investigation is an important part of the overall design of access layer communication lines. In field investigations, surveyors must record the following information in detail:

(1) During on-site research, inspectors should further determine whether there are pipelines, poles, and overhead lines in the design area, and based on these conditions, use available resources in the area to determine the nearest OLT installation location and develop a router installation plan.

(2) The existing equipment resources are mainly used for the design of fiber optic distribution complexes and surrounding fiber optic resources in the region. If these resources are part of the expansion project, the equipment usage will be recorded during on-site investigations.

(3) The number of users who can enter the required project field. After calculating the number of users who can enter the required design area, surveyors also need to design a ratio of area types, including rural areas, newly built and high-rise buildings, markets, etc.

3.3 Determine Parameters

When designing communication lines at the access layer, it is necessary to fully consider the direction and configuration of the lines, as well as the network conditions, and thoroughly grasp all equipment specifications and related line losses. In terms of admission level, the situation is very complex. The main parameters to be considered in the design process are fiber optic parameters. Fiber optic is the main means of accessing networks and has a significant impact on network performance.

3.4 Design Ratio

The user ratio refers to the ratio of the number of users to the actual number of households when the network was initially designed. In the early stages of access network design, proportion was not considered, but the 1:1 design was entirely targeted at the number of users, which resulted in two problems: capacity expansion and excessive investment. In the actual design project of access network, considering the investment return and expansion needs of operators, it is necessary to calculate the proportion of design personnel based on the actual situation of the design area. If this coefficient is blindly designed without reasonable consideration, it may lead to the belief that resource costs will be borne by low connection areas and will not continue to expand to high connection areas. This is a problem that users and operators do not want to see. Therefore, when designing routes, one important indicator is the proportion of design users.

4. DESIGN CASE OF COMMUNICATION LINE BASED ON PON TECHNOLOGY ACCESS LAYER

4.1 Basic Overview

This article takes a residential community as an example, and the communication lines mainly include the host layer, introduction layer, distribution layer, and auxiliary layer. Based on the actual communication quality needs of community users, adjustments are made to the existing access layer communication lines to ensure that the access layer communication quality meets the actual needs of community users.

4.2 Framework Design

When designing communication lines, the primary task is to determine the overall framework based on PON technology. The framework structure can usually be divided into two aspects: input layer and distribution layer. The input layer mainly refers to the user usage layer, and the distribution layer can be divided into distribution layer and auxiliary layer. The distribution layer is mainly concentrated in the OLT room. The design process needs to ensure the reasonable distribution of line nodes, while the auxiliary layer needs to play an auxiliary role in the operation of the communication system according to the actual needs of users for communication lines.

4.3 Pattern Design

With the development of PON technology, the design of access communication lines has become increasingly difficult, and the initial access method has exposed a series of defects and problems. In this regard, it is necessary to improve and implement the information acquisition model. At present, integrating PON technology with FTTX is one of the most common access methods, which can effectively meet users' needs for communication networks.

4.3.1 FTTB mode

FTTB is a fiber to building method commonly used when FTTH cannot be constructed. In practice, FTTB has two different access forms, such as FTTB+LAN. At this point, the ONU can provide a voice data interface to achieve unified access and management of all user services; Secondly, FTTB+DSL can also obtain unified business access, utilizing longer optical transmission distances than previous forms, combined with the utilization of existing copper cable resources at the end. When designing access layer communication lines, it is necessary to choose appropriate access methods, combined with network user structure and specific business needs, to provide users with more effective and economical services and experience.

4.3.2 FTTH mode

FTTH is a mode that converts user end cables into optical cables. In practice, fiber optic communication access extends the frequency domain, fundamentally meeting the development needs of access layer communication lines, providing reliable access for various communication services, with good access capabilities, and the access process does not produce electromagnetic radiation, thus avoiding interference with other communications.

4.4 Scheme Design

When determining the organizational model of a network, the influencing factors should be fully considered. When resources and technical conditions permit, FTTH access channels should be given priority to meet user needs and avoid subsequent network upgrades. But if a residential area has already completed the initial construction work, there may be some problems with the application of the FTTH model, such as difficulties in fiber optic access and high investment costs. In this case, the FTTH connection mode can be considered. When designing the networking circuit, attention must be paid to the device user's access to the ONU device power supply. Drawing design is an important component of access layer communication line design and has significant guidance and reference value for access network construction. In general, whether it is network design or circuit design, specialized software should be used for drawing. This not only improves drawing efficiency, but also reduces the workload of designers and ensures drawing quality. This article uses the general computer graphics design software Auto CAD program, which is widely used in industries such as electronics, machinery, and construction. The design drawings of the connection layer communication line include system network diagram, fiber optic cable layout, fiber optic cable routing, fiber optic cable communication equipment configuration, etc.

4.5 Adjusting Design

After the completion of the access level communication line project, in order to ensure the rationality and feasibility of the project, it is necessary to conduct a joint evaluation by experts, and adjust the design appropriately based on the modification opinions proposed by experts and the special needs of the communication operator. And determine the modifications to the network circuit based on the design standards and relevant parameters. To improve the reliability of accessing communication networks. In residential areas above the 10th floor, due to the concentration of users, higher requirements have been put forward for broadband. However, community basements are usually equipped with corresponding equipment locations, providing good conditions for FTTH connections. Generally speaking, fiber channel access is completed during the construction phase. However, due to the large number of users and fiber optic cables, it is easy to cause insufficient capacity of the handover box, which will also affect the management and maintenance of the network. In this case, corresponding adjustments must be made to the network system to reduce investment and improve network quality [5].

5. CONCLUSION

In summary, with the rapid development of information technology, passive optical networks have been widely applied in many fields and have played a very positive role. In network access technology, fiber optic connectivity is the mainstream of network development and a very important development goal. The access technology based on pon technology can break through the limitations of traditional access methods, improve the quality and efficiency of access communication, and effectively respond to user needs, making significant progress. Therefore, it has strong applicability and requires the attention of developers.

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