ANALYSIS OF PON TECHNOLOGY AND RESERVE PROBLEMS

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ABSTRACT

The article is devoted to one of the most popular and promising means of broadband communication - a technology called "Passive optical network" or PON for short. The article also discusses the architecture of access networks, classification, features and issues of passive optical network technology backup. A passive optical network is a fiber-optic network utilizing a point-to-multipoint topology and optical splitters to deliver data from a single transmission point to multiple user endpoints. Passive, in this context, refers to the unpowered condition of the fiber and splitting/combining components. The PON upstream distribution network, based on a fiber optic cable architecture similar to a passive optical splitting tree at nodes, is the most cost effective and can provide broadband transmission for a variety of applications. At the same time, the PON architecture has the necessary efficiency to increase both network nodes and bandwidth, depending on the current and future needs of subscribers.

Keywords: *Passive optical network, broadband, wireline communication, access technologies, optical distribution network, high sensitivity, infrastructure, receiver module, external influences.*

АННОТАЦИЯ

Статья посвящена одному из самых популярных и перспективных средств широкополосной связи - технологии под названием «Пассивная оптическая сеть» или сокращенно PON. В статье также рассмотрены архитектура сетей доступа, классификация, особенности и вопросы технологии резервирования пассивных оптических сетей. Пассивная оптическая сеть — это оптоволоконная сеть, использующая топологию «точка-многоточка» и оптические сплиттеры для доставки данных из одной точки передачи к нескольким конечным точкам пользователей. Пассивный в этом контексте

относится к состоянию волокна без питания и разделению/объединению компонентов. Восходящая распределительная сеть PON, основанная на архитектуре оптоволоконного кабеля, аналогичной пассивному оптическому разделительному дереву в узлах, является наиболее рентабельной и может обеспечивать широкополосную передачу для различных приложений. При этом архитектура PON обладает необходимой эффективностью для увеличения как сетевых узлов, так и пропускной способности в зависимости от текущих и будущих потребностей абонентов.

Ключевые слова: *Пассивная оптическая сеть, широкополосная связь, проводная связь, технологии доступа, оптическая распределительная сеть, высокая чувствительность, инфраструктура, приемный модуль, внешние воздействия.*

INTRODUCTION

In general, access networks are a complex and important component of any telecommunications infrastructure. Consumers of communication services receive services through the access network. The complexity of this component is determined by the variety of equipment as well as the variety of protocols and interfaces used. The importance of this component is determined by the significant impact on the technical efficiency and economic indicators of the communication network due to the absolute and relative abundance of technical means in the access network [1]. Currently, the dynamically developing type of access is a broadband connection, which provides the user with high-speed Internet access, a package of TV channels, the necessary video service and much more. The development of the Internet, including the emergence of new communication services, will help increase the flow of data transmitted over the network and force operators to look for ways to increase the capacity of transport networks. Consider the following when choosing a solution, variety of subscribers' needs; potential for network development; profitability.

IMPLEMENTATION OPTIONS FOR PON ACCESS NETWORKS

Analyzing the options for implementing PON access networks among access technologies, it can be divided into three groups:

- wireless networks;
- wired access networks based on copper low-frequency cables;
- wired access networks based on fiber optic cables.

Combination (hybrid) options are also available. Wireless networks are used for mobile communications and are often used in conjunction with wired connection systems (for example, to connect base stations) with DSL (Digital Subscriber Line) technology. The highest access speeds in this family of technologies are provided by ADSL2 (Asymmetric Digital Subscriber Line) and VDSL (Very high speed Digital Subscriber Line) technologies. DSL technology is of interest for use in long and low-quality subscriber lines [2]. Another feature of this technology is its low power consumption.

Analyzing the significant disadvantages of xDSL technologies, the following can be distinguished:

- relatively low transmission speed;
- relatively short distance;
- high requirements for the pairs used (pairs of category 5 are required, pair selection is required).

The main idea of the PON architecture is to use only one receiver module for transmitting and receiving data to several ONT (Optical Network Terminal) subscriber devices at the OLT (Optical Line Terminal) central node. The number of ONT subscriber nodes connected to one OLT receiver module can reach the power budget and the maximum speed of the transmit and receive equipment. For transmission of information flow from OLT to ONT - direct (downstream), usually the wavelength is 1550 nm. In contrast, the data flow from different subscriber nodes to the central node, which together form the reverse (upward) current, is transmitted at a wavelength of 1310 nm. OLT and ONT are equipped with WDM (Wavelength Division Multiplexing) multiplexers separating the incoming and outgoing currents.

Direct current is transmitted at the optical signal level. Each ONT subscriber node reads the address fields and selects from the general stream only a part of the data intended for it. All ONT subscriber nodes transmit streams on the same wavelength using the concept of TDMA (Time-Division Multiple Access). To exclude the possibility of intersection of different ONT signals, each of them has an individual data transfer table, taking into account the correction of the delay associated with the removal of this ONT from the central OLT node. This task is accomplished using the TDMA MAC (Media Access Control) protocol.

The role of PON among input technologies is shown in Figure 1. The FTTx (Fiber To The x-point) family of technologies is used to provide broadband access based on fiber optic cables. Point X is the transition point from optical fiber to another physical signaling medium. Point X can be placed at the entrance to a

building (FTTb, building), an office (FTTo, office), and so on. In general, a "non-optical" segment can be constructed from copper cables (for example, if x = 0, then cabling or structured cabling can be used).

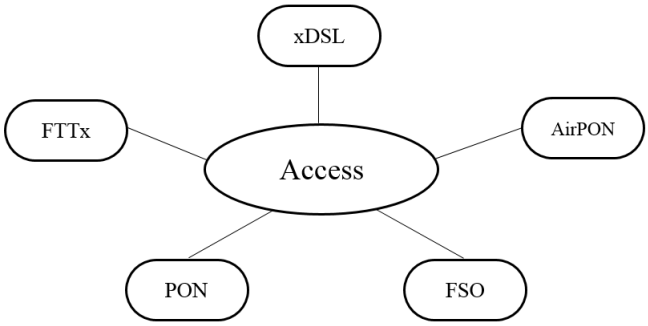

Fig. 1. Place of PON among access technologies

In general, a "non-optical" segment can be constructed from copper cables (for example, if x = 0, then cabling or structured cabling can be used) [3]. PON tree topology is often used for residential buildings. Optimizes fiber utilization by connecting as many subscribers as possible to a single cable. Depending on the final number of users and network requirements, the stream can be divided into one or several cascading levels. The smaller it is, the easier it is to maintain the system, make the necessary repairs and reduce the speed and data loss for the end user. On the other hand, the layered system allows fine tuning to meet the needs of network clients. In general, the topology is selected from a variety of options based on the actual design conditions and the principle of maximum convenience for subscribers.

ADVANTAGES AND DISADVANTAGES OF PON

PON technology occupies a special place among optical technologies. One passive network can serve many users. The general characteristics of PON technology in comparison with other access technologies can be presented as a list of advantages and disadvantages (Table 1).

Table 1. Advantages and disadvantages of PON

Advantages	Disadvantages
Very high bandwidth (XGPON technology up to tens of Gbps)	The need for new construction (creation of an optical access network infrastructure)
Lack of medium-active (power-	Relatively high cost of equipment

demanding) nodes	
Relatively long distance (up to 20 km)	

Several benefits can be added:

- high transmission speed. PON supports speeds from 155 Mbps to 2.5 Gbps, which is currently the fastest way to transfer data;

- support for different types of traffic. The system can transmit any information (data, video, audio), transmit an information stream of any origin to an apartment or office;

- great strength. The system can process streams from multiple sources simultaneously without quality loss. Several computers, TVs, IP phones, etc. can be connected to one subscriber port;

- reduce maintenance costs. PON uses passive mixers that do not require electricity or additional maintenance;

- optimal use of materials. Connecting as many subscribers as possible to a single fiber helps to use fewer wires, resulting in significant savings;

- interference immunity and voltage protection. Unlike systems using twisted pair cables (FTTH, etc.), the PON is not subject to external influences and is protected from power surges, pickups and noise;

- easy access. There is no need to place PON equipment in open cabinets, so the system can be easily accessible for inspection, replacement and repair during the cold season, and the equipment can be stored in the weather;

- easy to connect. Subscribers connect to the network quickly and without interruptions;

- the ability to close. Signal amplification allows, if necessary, to initiate an additional data stream over the existing cable - for this, light waves of different lengths are used. Thus, services such as security systems, video surveillance, security, fire safety can be added to the existing cable system;

- continuous development of PON technologies. The increase in capacity, speed and cost of components makes this data transmission technology one of the most promising technologies.

It is also worth noting the following disadvantages:

- the need to encrypt the stream. PON is a technology that is a common medium of data transmission, therefore, individual streams of information must be encrypted.

This can reduce the useful transmission rate and also does not protect the information from physical interference;

- complexity of the system. It is difficult to identify systemic problems between splitters and ONTs. Remember, network problems are minimized by choosing a professional installer who can properly install, monitor, and provide a full range of services.

PON ARCHITECTURE AND COMPONENTS

For PON and components connected to this network, the following designations are adopted:

- SN/BNN – ServiceNode/BorderNetwork Node;
- OLT – Optical Line Terminal;
- ONU – Optical Network Unit;
- SNI – Service Node Interface;
- UNI – User-Network Interface;
- ODN – Optical Distribution Network;
- S – Splitter;
- x – x point.

Central Node OLT is a device installed in the central office. This device receives data from the backbone network via the SNI (Service Node Interface) and generates a downstream stream to the subscriber nodes via the PON tree. In the ONT subscriber node, on the one hand, there are subscriber interfaces, on the other hand, an interface for connecting to the PON tree - transmission is carried out at a wavelength of 1310 nm, and reception - at a wavelength of 1550 nm. ONT receives data from OLT, modifies it and transmits it to subscribers via UNI. An optical splitter is a passive optical multipole that distributes the optical radiation flow in one direction and combines several currents in the opposite direction. Typically, a splitter can have M input and N output ports. PON networks often use 1xN splitters with one input port. Separators 2xN can be used in a redundant fiber optic system.

SN, also known as BNN, is a transport network border node through which a user obtains telecommunication services through an access network. An SN/BNN access network can have multiple SNI ports. OLT is an active PON component that enables a device to implement a specific PON protocol and control the corresponding ONUs. OLT connects to SN/BNN through SNI port. Each user-defined port of an OLT represents a common (root) point of a passive optical distribution network

(ODN), while an optical access network can contain multiple optical distribution networks connected to the same OLT.

The optical distribution network has a tree-like configuration. The common point of the ODN is called the "root" and the ends are called the "leaves." ODN allocation is created using passive device dividers. The splitter has a port in the root direction and a multi-piece port in the leaf direction. Distributed among users with ODN, ONU devices. ONU is one or more ports with an active UNI of the device, which ends the ODN "list" and is located on the user side. Different types of splitters can be used in the ODN, which allows building [4].

Advanced configuration PON distribution networks transmit an isolation signal (applied to the assembly port) towards the “leaf” and distribute the output power in a specific ratio between the component ports. In addition, the total signal power on all component ports is less than the total input signal power due to isolation losses. A type 2 splitter is distinguished by the presence of a transit port T. The principle of placing the two units is the same, but in a conventional type 2 splitter, the main output power is distributed to the transit port. Both types of splitters can have two wiring ports to implement different PON processing schemes.

BACKUP IN PASSIVE OPTICAL NETWORKS

Overcrowding in access networks is a serious problem due to the high sensitivity of implementation options to the required costs. It should be noted that the cost of firing in access networks is divided by the number of relatively few users compared to transport networks. In addition, the reliability requirements of different users connected to the same ODN may be different [5]. When organizing access networks using PON technology, the most important part of the network will be located between the OLT and the first separator. The air interruption in this section denies access to all users connected to this distribution network.

The complexity of the problem lies in the options for the backup architecture in access networks based on a large number of standardized PON technologies. The difference between backup options depends on what you are backing up:

- conventional fibers (OLT - splitting section);
- common fiber and distribution fibers (dividing part - ONU);
- OLT equipment;
- OLT and ONU equipment;
- various combinations and combinations of the above options.

CONCLUSION

The main difference between PON and other optical systems is the use of only passive equipment from the main module, which transmits and receives information flow to the end user of the whole substance. That is, there are no active switches, routers, media converters, multiplexers and other equipment that requires additional power and maintenance. All options affect availability and cost differently depending on the likelihood of fiber breakage, equipment downtime, temperature drops, etc. Optical Distribution Network (ODN) accounts for the highest costs and failures of a PON system. Thus, any architecture must minimize installation costs while still providing the required flexibility.

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