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***N. Smailov[1], G. Yussupova[2], S. Marxuly[3], D. Kuanysh[4], Y. Yendybaiuly[5]**

[1,3]Kazakh National Research Technical University named after K. Satpayev, Republic of Kazakhstan, Almaty

[1,2,4,5]Almaty Academy of the Ministry of Internal Affairs named after M. Esbulatov, Republic of Kazakhstan, Almaty;

DESIGN OF A PERMITTED NETWORK USING FIBER-OPTIC-BASED SOLUTIONS MATHEMATICAL MODELING

The main goal of the research is to increase the speed of exchange in broadband subscriber access networks, primarily using PON technology, since the needs of subscribers are constantly growing and modern structures can no longer provide them.

This article discusses the PON technology, types of WDM technology, equipment designed for communication networks using WDM, designs and parameters of WDM multiplexers. The possibility of implementing WDM-TDM hybrid multiplexing in existing PON systems is considered. Conclusions are drawn about the relevance of the use of this technology in order to modernize existing access networks.

The rapid development of technologies for the production of electronic optical devices and optical fibers made it possible in the mid-80s to use fiber to connect individual users and organizations.

The launch of the first distribution networks was carried out using point-to-point topologies, but a few years later the technology of passive optical networks (PON) was created, which allows organizing point-to-point topologies.

Keywords: WDM technology, hybrid multiplexing WDM-TDM, PON systems, AWG multiplexer, mathematical models.

Introduction

The emergence of fiber networks was an important event that gave a powerful impetus to the process of informatization of society.

The first systems found application in military applications with telephone networks and used multimode gradient fiber for data transmission.

The next step is to switch to a single-mode fiber, which allowed to increase the speed and increase the maximum distance over which data can be transmitted. Traditional microwave and satellite data transmission systems began to replace optical trunks.

PON allows you to create a broadband multiservice network through which, in addition to standard types of traffic and simple types of services, many other data can be transmitted.

The main part

With the development of the Internet, the number of communication services provided is constantly growing, which leads to an increase in the flow of data that needs to be distributed. This forces mobile operators to look for new opportunities that increase the capacity of transport networks [1-2]. When making a decision, it is necessary to take into account the efficiency of the network, the needs of subscribers, and the potential for further development of the network:

A hybrid service model is used to provide access to NGN services through the PON. The implementation of the logical model of access to NGN services via the PON is shown in Figure 1.

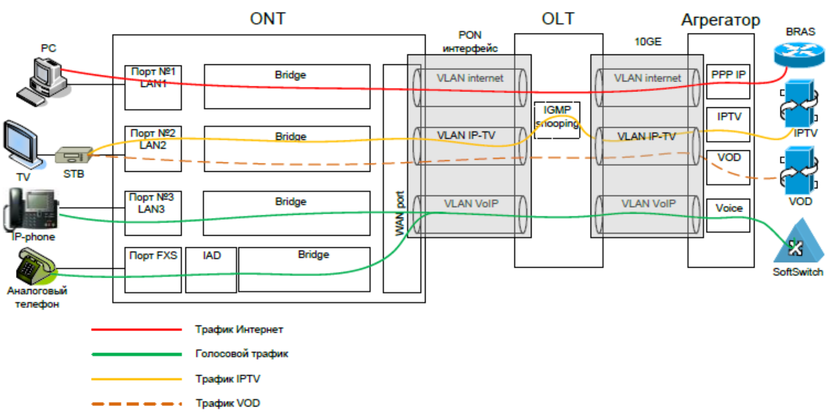

Figure 1 – Implementation of the logical model

When organizing access to Triple Plane services in the sections between subscriber equipment (optical network terminal – ONT), three VLAN services are organized on the latter equipment (the VLAN service model is being implemented), including one VLAN for the distribution of Internet traffic, VoIP and IPTV traffic.

The ONT hardware compares the physical port identifier for connecting subscriber equipment and the corresponding VLAN service identifier[4–6].

Under the influence of temperature and humidity, the total losses and the back reflection coefficient may increase, which leads to an increase in the number of errors in the transmission of information. A great contribution to the study of the influence of temperature and humidity on the reliability of electrical and optical elements was made by N. Sinnadurai, whose empirical equation reflects the relationship between the time of failure, temperature and humidity of the environment in which the system under study is located.

$$t_1 / t_2 = (RH_1 \ / \ RH_2)^X \cdot e^{(E_A / k \times T_1 - E_A / k \times T_2)} \quad (1.1)$$

where t1 and t2 are the time of occurrence of failures at temperature T_1,T_2 (Kelvin) and relative humidity $RH_{1,2}$, respectively;

k is the Boltzmann constant, eV/K;

E_A-activation energy;

X is the coefficient of influence of humidity.

To calculate the activation energy, it is necessary to conduct tests under various temperature conditions and constant humidity ($RH_1 = RH_2$). In this case , the expression has the form [6]

$$t_1 / t_2 = e^{(E_A / k \times T_1 - E_A / k \times T_2)}, \quad (1.2)$$

EA when expressed:

$$E_A = \frac{k \times T_1 \times T_2 \times \ln(t_1 / t_2)}{T_2 - T_1}, \quad (1.3)$$

To calculate the coefficient of temperature exposure, it is necessary to conduct tests at a constant temperature and different humidity ($T_1 = T_2$). In this case, the expression has the form

$$t_1 / t_2 = (RH_1 \ / \ RH_2)^X, \quad (1.4)$$

We get *X*:

$$X = \log_{RH_1 / RH_2} t_1 / t_2, \quad (1.5)$$

Substituting the values of the activation energy and the coefficient of moisture exposure into the expression, we can calculate the operating time of the element to failure at the specified values of temperature and humidity.

One of the main elements of passive optical lines is a fiber-optic cable. An important aspect of the reliability of optical cables is the value that characterizes the voltage in the optical fiber. As a rule, the concept of relative elongation (%) of an optical fiber under the action of a tensile load is used to estimate the voltage in an optical fiber. Knowing the relative elongation of the fiber, we can calculate the time to failure using the following expression

$$T_0 = 2 \cdot 10^{-7} \cdot x^{-18,5}, \tag{1.6}$$

where T_0 is the failure time, x is the elongation of the optical fiber (%).

When working on a cable, an increase in its fiber occurs due to factors such as temperature drop, third-party interference in the performance of work, vandalism, etc. Control of fibrous tension allows you to identify the problem area in time and take the necessary measures to restore it.

Network architecture. The network architecture modeled by Optisystem is shown in Fig. 1.

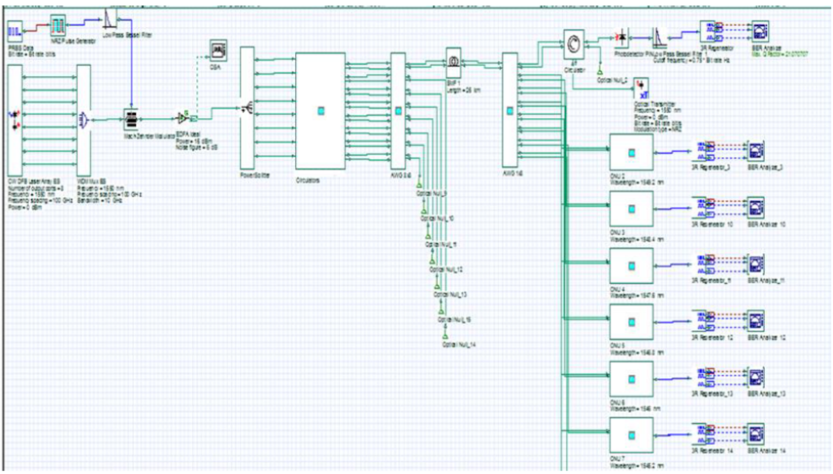

Figure 2 – Network architecture

It is based on the use of two-level AWG multiplexers. The first level is the NxN AWG multiplexer (Fig. 2), which connects the optical transmitting equipment with N remote nodes [8–9].

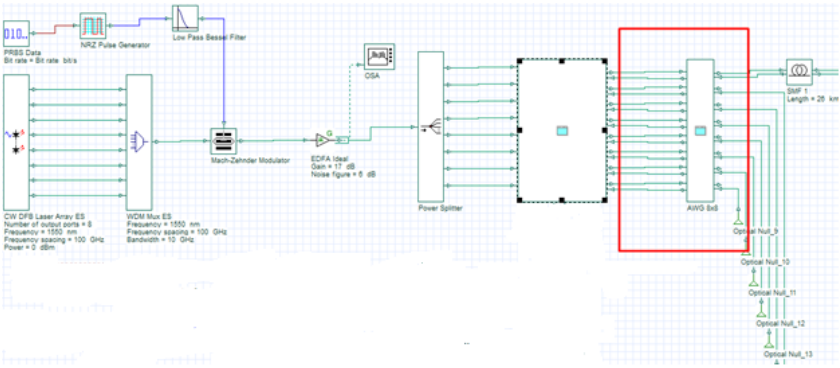

Figure 3 – Multiplexer of the first level of the AWG

These remote nodes use the initial bandwidth and adjacent AWG FSR of 2 for each of the output ports ... N will have a wavelength of 1khn. The ONU has two receivers. The Multicast receiver is a simple photodetector. A single receiver can also modulate streaming data. Any device capable of remotely modulating the carrier sent from the OLT is suitable for use as a reflecting semiconductor amplifier (RSOA). Since ONU has no light generation, they are independent of wavelength. However, the raw optical media must be sent from OLT. The second level with the AWG multiplexer is shown in Figure 3 [9–11].

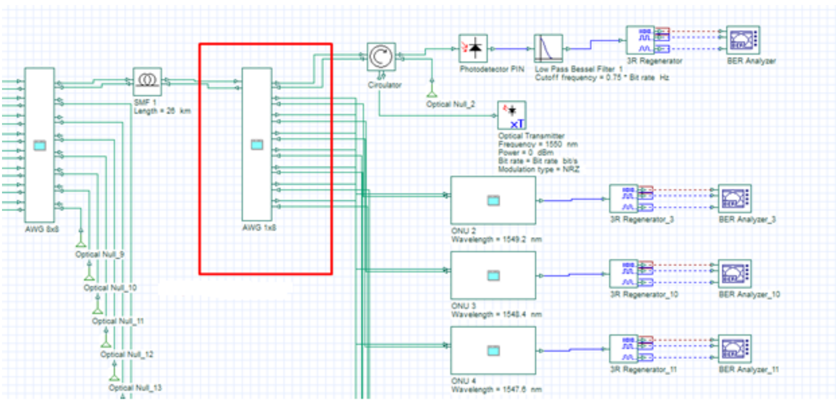

Figure 4 – Second-level AWG multiplexer

Simulation results – to check the quality of the transmitted signal and the correctness of modeling the network topology on the end-user side, a diagram of the signal source is shown (Fig. 4).

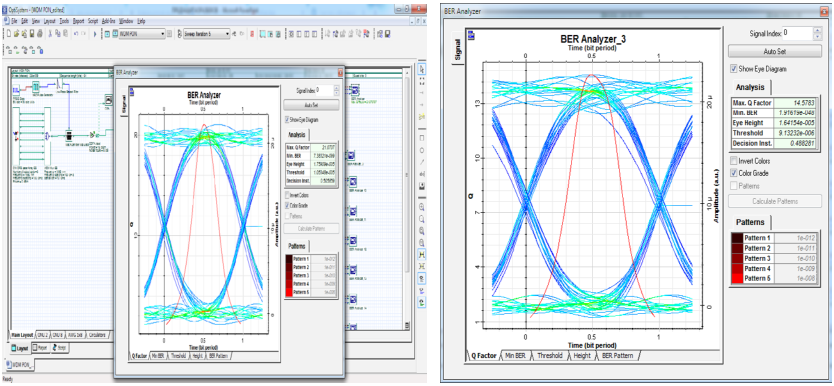

Figure 5 – Diagram of the source on the end user side of the signal

Conclusion

This article examines the requirements for services provided to subscribers in broadband access networks, network topology, PON network structure, and assesses the reliability of a passive optical network. The study showed that networks built using PON technology are the most promising and convenient for scaling and improvement.

During the writing of the article, all the tasks were completed and the results of the model were obtained. The WDM optical multiplexing technologies are considered, which make it possible to increase the efficiency of using a single-wire structure and the parameters of optical multiplexers and demultiplexers, as well as the parameters of optical fibers. A mathematical model of a hybrid network based on the new TDM and WDM PON is proposed.

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**Н. Смайлов[1], Г. Юсупова[2], С. Марксұлы[3], Д. Қуаныш[4], Е. Ендібайұлы[5]*
[1,3]Қ. Сәтпаев атындағы Қазақ ұлттық техникалық зерттеу университеті, Қазақстан Республикасы, Алматы;
[1,2,4,5]М. Есболатов атындағы Алматы Ішкі істер министрлігінің академиясы, Қазақстан Республикасы, Алматы қ.
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ТАЛШЫҚТЫ-ОПТИКАЛЫҚ НЕГІЗІНДЕ ШЕШІМДЕРДІ ҚОЛДАНА ОТЫРЫП, РҰҚСАТ ЕТІЛГЕН ЖЕЛІНІ ЖОБАЛАУ МАТЕМАТИКАЛЫҚ МОДЕЛЬДЕУ

Жүргізілген зерттеулердің негізгі мақсаты кең жолақты абоненттік қол жеткізу желілерінде, ең алдымен PON технологиясы бойынша алмасу жылдамдыгын арттыру болып табылады, өйткені абоненттердің қажеттіліктері үнемі өсіп келеді және қазіргі замангы құрылымдар оларды қамтамасыз ете алмайды.

Бұл мақалада PON технологиясы, WDM технологиясының түрлері, WDM көмегімен байланыс желілеріне арналган жабдық, WDM мультиплексорларының дизайны мен параметрлері *қарастырылған. Қолданыстағы pon жүйелерінде WDM-TDM гибридті мультиплексингін жүзеге асыру мүмкіндігі қарастырылады. Қолданыстағы қол жеткізу желілерін жаңғырту мақсатында осы технологияны қолданудың өзектілігі туралы қорытындылар жасалды.*

Электрондық оптикалық құрылғылар мен оптикалық талшықтарды өндіру технологиясының қарқынды дамуы 80-жылдардың ортасында жеке пайдаланушылар мен ұйымдарды қосу үшін талшықты пайдалануға мүмкіндік берді.

Алғашқы тарату желілерін іске қосу нүкте-нүкте топологияларын қолдану арқылы жүзеге асырылды, бірақ бірнеше жылдан кейін нүкте-нүкте топологияларын ұйымдастыруға мүмкіндік беретін пассивті оптикалық желілер (PON) технологиясы жасалды.

Кілтті сөздер: WDM технологиясы, гибридті мультиплекстеу WDM-TDM, PON жүйелері, AWG мультиплексоры, математикалық модельдер.

**Н. Смайлов*[1], *Г. Юсупова*[2], *С. Марксұлы*[3], *Д. Қуаныш*[4], *Е. Ендібайұлы*[5]
[1,3]Алматинская академия Министерства
внутренних дел имени М. Есбулатова,
Республика Казахстан, г. Алматы;
[1,2,4,5]Казахский национальный исследовательский технический университет
имени К. Сатпаева,
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ПРОЕКТИРОВАНИЕ РАЗРЕШЕННОЙ СЕТИ С ИСПОЛЬЗОВАНИЕМ МАТЕМАТИЧЕСКОГО МОДЕЛИРОВАНИЯ РЕШЕНИЙ НА ВОЛОКОННО-ОПТИЧЕСКОЙ ОСНОВЕ

Основной целью проводимых исследований является повышение скорости обмена в сетях широкополосного абонентского доступа, прежде всего по технологии PON, т.к. потребности абонентов постоянно растут и современные структуры уже не могут их обеспечить.

Данная статья рассмотрена технология PON, виды технологии WDM, оборудование, предназначенное для сетей связи с применением WDM, конструкции и параметры мультиплексоров WDM. Рассмотрена возможность реализации гибридного *мультиплексирования WDM-TDM в существующих системах PON. Сделаны выводы об актуальности применения этой технологии с целью модернизации существующих сетей доступа. Стремительное развитие технологий производства электронно-оптических устройств и оптических волокон позволило в середине 80-х годов использовать оптоволокно для подключения отдельных пользователей и организаций.*

Запуск первых распределительных сетей осуществлялся с использованием топологий «точка-точка», но несколько лет спустя была создана технология пассивных оптических сетей (PON), позволяющая организовывать топологии «точка-точка».

Ключевые слова: Технология WDM, гибридное мультиплексирование WDM-TDM, системы PON, мультиплексор AWG, математические модели.

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«Торайғыров университеті» КЕ АҚ
140008, Павлодар қ., Ломов к., 64, 137 каб.

«Toraighyrov University» баспасы
«Торайғыров университеті» КЕ АҚ
140008, Павлодар қ., Ломов к., 64, 137 каб.
67-36-69
e-mail: kereku@tou.edu.kz
www.vestnik.tou.edu.kz