

УДК 004.7.

doi:10.20998/2413-4295.2017.07.21

ТОПОЛОГИЯ ОПТИЧЕСКИХ СЕТЕЙ FTTH (FIBER-TO-THE-HOME)

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АННОТАЦИЯ В настоящее время архитектуры на базе PON получили большое распространение. Основными факторами большинства конфигураций Ethernet FTTH является гибкость бизнес-модели и способность поддерживать будущие сервисы. В этой статье описываются различные архитектуры сетей доступа, рассматриваются протоколы доступа, а также анализируются характеристики оптических сетей FTTH (Fiber to the Home). Успешность их деятельности является стимулом к динамичному развитию этой отрасли.

Ключевые слова: топология; PON; Ethernet FTTH; оптические сети; архитектура сети

TOPOLOGY OF OPTICAL NETWORKS FTTH (FIBER-TO-THE-HOME)

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ABSTRACT This article describes different architecture of access networks, access protocols; also, we analyzed the characteristics of optical networks FTTH (Fiber to the Home). The optical fiber with today is the main transport medium in the backbone and metro network. Using of fiber optic cable instead of copper cable has allowed to significantly increasing the quality of service. The greatest potential for broadband networks today have a fiber-optic technology under the general term FTTX (Fiber To The X - fiber to the X point), in which from the node connection to a specified location (point X) comes optics, and then to the subscriber - copper cable (and possible option, in which optics routed directly to a subscriber unit).

Fiber optic access networks currently based on different architectures and technologies. Standards for these technologies and available of equipment make development of service-provider networks without risks. The success of their work stimulate to the dynamic development of the industry. Nowadays the PON architecture became very popular. The main factors of the most configurations of Ethernet FTTH it is the flexibility of the business model and the ability to support future services.

Keywords: Topology; PON; Ethernet FTTH; optical networks; network architecture

Introduction

Goal. This article describes different architecture of access networks, access protocols; also, we analyzed the characteristics of optical networks FTTH (Fiber to the Home).

The optical fiber with today is the main transport medium in the backbone and metro network. Using of fiber optic cable instead of copper cable has allowed to significantly increasing the quality of service.

At present, many corporate customers have access to the services of the type "point to point" fiber-optic networks. At the same time, residential customers and small business sector often use digital subscriber line (xDSL) and hybrid fiber-coaxial lines, the main drawback is that limited bandwidth.

Although fiber-optic lines have throughput limitations, there is one obstacle complicating their active implementation in the residential sector and small businesses - is the high cost of connecting each caller. After a great number of connections type "point to point" would require large amounts of active components, fiber optic cables. The cost of construction and operation would become unreasonably large.

The greatest potential for broadband networks today have a fiber-optic technology under the general

term FTTX (Fiber To The X - fiber to the X point), in which from the node connection to a specified location (point X) comes optics, and then to the subscriber - copper cable (and possible option, in which optics routed directly to a subscriber unit).

There are variations of FTTX network architectures, the main ones are:

FTTN - Fiber to the Node, Fiber to the node 1km from the subscriber;

FTTC - Fiber to the Curb, fiber to the cabinet 500m from the subscriber;

FTTB - Fiber to the Building, fiber to the building, only 100m from the subscriber;

FTTH - Fiber to the Home, fiber to the apartment / office phone.

Services and bandwidth requirements

Speed Internet access is growing rapidly. It related to the respective application requirements and the possibilities of service providers and the industry as a whole. Most of the bandwidth of most modern broadband networks consumes peer applications and content with increased insistence to network resources (eg, videos). The race between the demands of applications and technical capabilities similar to the one that took place in

the PC manufacturing industry, where at each step of increasing processor speed and memory applications appear instantly, fully absorb new resources, such as application processing system or video editing.

Still, the deployment of new broadband networks stimulated mainly the requirements of today's applications, rather than future needs. The most capacious in terms of bandwidth usage are apps for streaming video. It would seem that for streaming high-definition television (HDTV) and browsing the Internet bandwidth of 20-25 Mbit / s is enough for a long time. However, historical data and the forecast for the near future (see. Figure 1) shows that the growth of bandwidth requirements is exponential. Currently, in some European countries, some service providers already offer for private customer's access at speeds of 1 Gbit / s, and it has built an extensive network with 100 Mbit / s. Such connection speed subscribers are only possible based on FTTH technology.

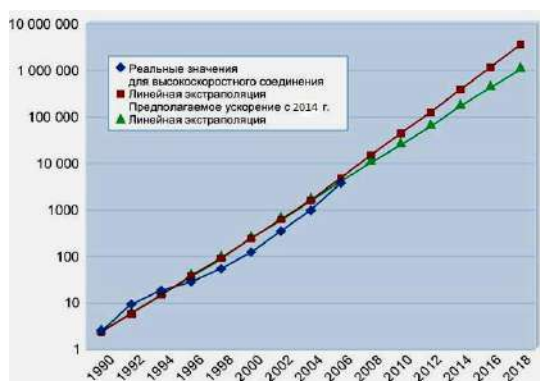


Fig. 1 – Bbandwidth growth (according to Heavy Reading «FTTH Worldwide Market & Technology Forecast»).

Some applications require a stable broadband access:

1. Download large movie files for editing and post-processing.
2. Collaborative editing or other forms of cooperation in which very large files transmitted.
3. Telepresence systems (Telepresence), including parallel transmission of video, voice and data applications.

Traffic most applications has been uneven and high-speed data transmission is required only for a short period. Because they can share aggregation and backbone network, where you can lay the significant oversubscription. In contrast, streaming applications such as video broadcasting, video on demand and IP-telephony (VoIP), on the other hand, require a bandwidth reservation for the entire period of application. It is also necessary to bear in mind the growing traffic symmetry. File sharing in peer networks, remote collaboration, IP-telephony and other applications create initially symmetric traffic flows as opposed to client-server

applications with asymmetric traffic, such as streaming video or web browsing [1].

Web aggregation and backbone networks are relatively easy to modernizing and increasing the capacity is possible with relatively little additional cost. Investments in the infrastructure of access, however, viewed as long-term. In this regard, network designers have to determine whether the use does not involve limitations, selected access technology in the future required bandwidth.

Architecture FTTH networks

Experience suggests that the main costs when deploying FTTH networks accounted for construction works and the cost of the fiber optic cable is a relatively small part. Moreover, although the cycle life FTTH network and its electronics is several years, fiber optic cable and the distribution network have a longer life span (at least 30 years). Such durability and high cost of construction involve high demands on the proper design of fiber optic lines.

Architecture deployed FTTH networks divided into three main categories:

- "Ring» Ethernet-switch.
- «Star» Ethernet-switch.
- "Tree" using PON passive optical network technology.

Architecture based on Ethernet

The need for fast time to market and reduce costs for customers led to a network architecture based on Ethernet-switching. Data transfer via Ethernet and Ethernet-switching began to generate income on corporate networks market, led to a decline in prices, the appearance of the finished products, and accelerate the development of new products.

At the heart of the first European Ethernet FTTH network projects lay architecture, in which the switches are located on the ground floors of apartment houses were united in technology for Gigabit Ethernet ring.

Then the widespread Ethernet architecture of the "star" (see. Figure 2). This architecture requires a dedicated fiber-optic lines (typically single-mode, single-fiber lines with Ethernet data transmission over 100BX or 1000BX technology) from each terminal to the point of presence (point of presence, POP), where there is their connection to the switch. Terminals may be in the individual residential houses, apartments or apartment buildings, in the basement of which are located switches that put their lines for all the apartments with the appropriate transfer of technology [2].

Architecture-based PON

If you are using architecture based on passive optical network PON networks to deploy FTTH fiber optic distributed via passive optical splitters with a branching factor of up to 1:64 or even 1: 128.

Architecture based on the PON FTTH usually supports the Ethernet protocol. In some cases, an additional length of the downstream wavelength (downstream), allowing you to provide traditional analog and digital TV services to users without the use of set-top boxes with IP support.

Figure 3 shows a typical passive optical network PON, which uses a variety of optical network terminators (optical network termination, ONT) and optical network unit (optical network unit, ONU). ONT designed for individual use by the end user. ONU devices are usually located on the ground floors or in the basement and shared by a group of users. Voice services, and data services and video brought from the ONU or ONT to the subscriber via cables laid in the customer premises. [3].

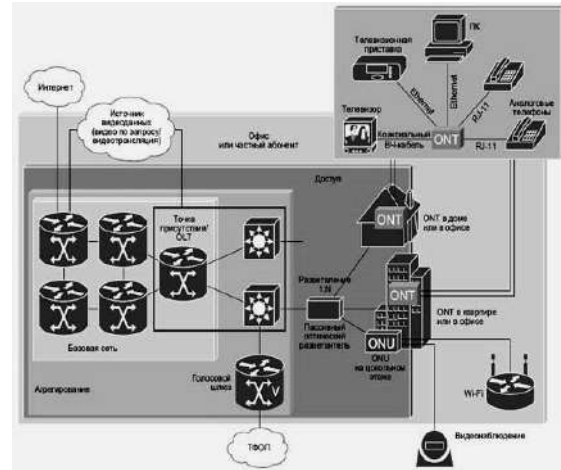


Fig. 3 – The architecture of a passive optical network (PON)

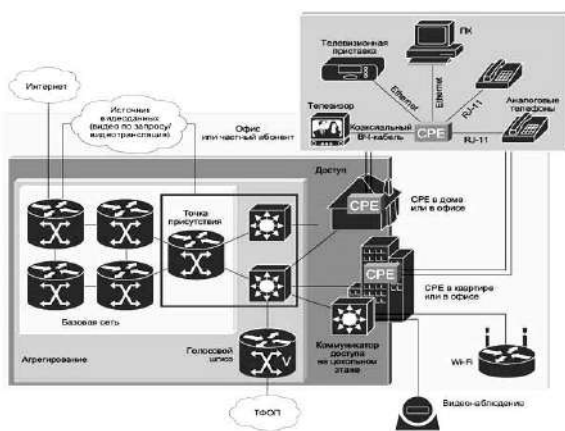


Fig. 2 – Ethernet FTTH architecture topology "Star"

The most significant aspect of FTTH deployments based on the PON is saving fiber optic lines in the area of optical splitters to a central office or point of presence.

Firstly, in the topology "point to point" a dedicated optical interface for each subscriber, which increases the cost of this architecture greatly compared with that where the ports shared by a large number of subscribers. However, experience in implementation of a large number of projects has shown that the use of the Ethernet-allocated ports can compete on price with the use of PON ports of the high cost of the latter. Ethernet ports cost is very low due to the sheer number of shipments of such ports for corporate networks and service provider networks, while GPON ports used only for this technology and manufactured in much smaller quantities.

Second, assuming the presence of a 100 percent subscription service FTTH, then the network point of presence is required on basis of half the PON equipment than for Ethernet FTTH network. At the same time, if we take into account the actual percentage of the subscription to the services (as described below), the difference erased. This is the fact that the need to port the optical line termination (OLT) to the first network subscriber based on PON, so the amount cannot be reduced OLT ports due to the low percentage of subscription services.

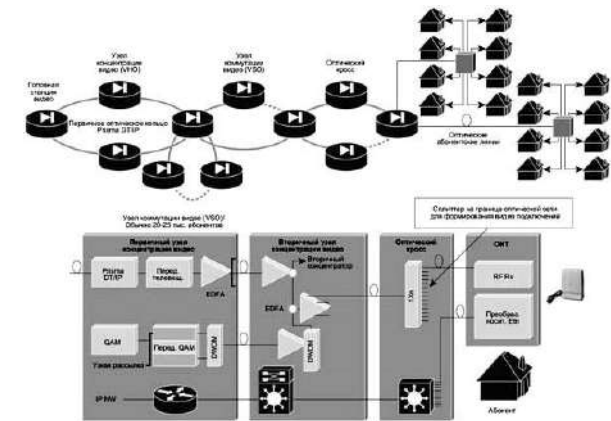


Fig. 4 – Architecture overlapping television signal.

However, the widespread addition of a second fiber-optic lines to the topology of P2P FTTH «point-to-point» (see. Figure 4). Currently, service providers are deploying hybrid architecture, topology using "point-point" for all interactive services, including IP-TV, and the topology of overlay additional passive optical network for the dissemination of video broadcasting. This structure optimized for a larger number of subscribers as compared with PON network for interactive services [4,5].

PON-architecture issues

- The total bandwidth. Bandwidth tree in the PON fiber-optic lines used as a large number of subscribers, which allows making a profit at the expense of reducing the cost of each subscriber. Although GPON technology provides total bandwidth downstream of 2.5 Gbit / s, it cannot reflect the growth of services and future customer's requirements in the long term, because the bandwidth needs grow exponentially.

-Encryption. Because the PON - a technology with a common transmission medium, it is necessary to encrypt all data streams.

The GPON technology is carried downstream encryption only, and the use of secure Advanced Encryption Standard (Advance Encryption Standard, AES) with 256-bit keys allows you to increase the security of personal data of end users and provides service providers the ability to prevent theft of services. However, the reliability of the standard AES leads to reduced productivity. To encrypt a substantial amount necessary to transfer the service information together with each packet, which may lead to a noticeable reduction in the useful data rate PON (depending on the combination of different traffic types) [6].

- High operating transmission speed. In connection with the use in passive optical networks PON common transmission medium, each terminal (ONT or OLT) is forced to operate at the aggregate data rate. Even if the customer has paid only for 25 Mbit / s, each endpoint optical network (ONT) PON in this tree must operate at a speed of 2.5 Gb / s (GPON). Operation of electronic and optical devices at a rate 100 times greater than the required data rate increases the price of components.

- Need for greater power of the optical signal. Each branching ratio of 1: 2 link budget decreases by 3.4 dB. When the branching ratio of 1:64 in the energy potential of the communication line is reduced by 20.4 dB (equivalent to a power ratio of 110). Thus, in this model all the optical transmitters in the PON architecture should provide 110 times more optical power in comparison with the architecture FTTH «point to point» transmission on the same distance.

- Access to the local loop. LLU (Local Loop Unbundling (LLU) - this is the method used currently abroad on a mandatory basis in the networks of telephony to provide access to alternative operators to subscriber copper communication lines This approach allowed us to significantly increase the penetration of the DSL service market and reduce prices for broadband access services to subscribers by competing providers [7].

PON networks are not satisfy the requirements LLU because there is only one fiber optic line to connect the caller group, which therefore can't be separated on the physical level, but only at the logical level (see. Figure 5). Most of the new FTTH networks in Europe offer some form of LLU, which opens up new business opportunities.

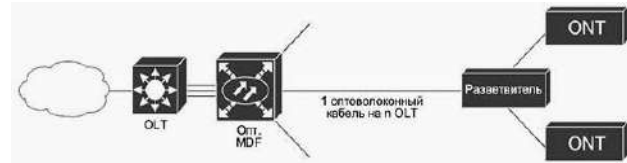


Fig. 5 – LLU implementation limits for architecture based on the PON splitter

It is theoretically possible to increase the flexibility of switching of clients between the optical splitters PON by combining the splitter with an optical distribution frame in the switch cabinet area (see. Figure 6). This feature is useful when it is difficult to predict the percentage of subscribers to the subscription services, such as too large building, and fulfill the requirements LLU if necessary [8,9].

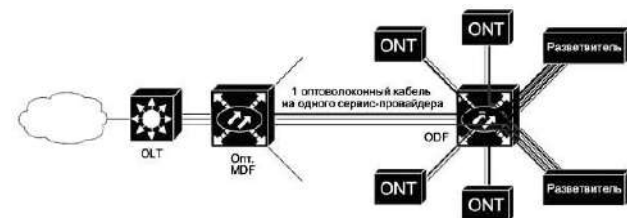


Fig. 6 – A fiber optic line with an optical distribution node for the implementation of LLU requirements

Subscriber Access. Typically, when deploying FTTH network is performed simultaneous connection of fiber-optic lines to all potential customers in the region. In the case of a passive optical network all, the fiber optic connected to the hub and shrink feeder optical cable to the central office or point of presence. Subscribers can subscribe to FTTH services only after the deployment of fiber-optic lines.

Ethernet FTTH solution has many advantages over the architecture based on the PON.

1. Virtually unlimited selectable bandwidth.

Direct fiber optic line can provide virtually unlimited bandwidth, which allows for maximum flexibility in deploying services in the future, as bandwidth needs increase.

2. Ethernet FTTH architecture enables service providers to ensure that each subscriber and bandwidth required creating network profiles bandwidth for each client individually. Each individual or business user can get a symmetrical bandwidth of any desired width to it.

3. Long range.

In typical configuration, it has cheap monofilament line, or using the 100BX 1000BX technology, with predetermined maximum steps of 10 km radius in typical configurations of Ethernet FTTH access networks.

4. Flexible growth.

Use ports on Ethernet FTTH access switch may only those subscribers who have subscribed the service provider.

5. Technological independence.

Although Ethernet FTTH current configuration may employ Gigabit Ethernet technology, it can become irrelevant for the next 30-40 years. However, single-mode fiber optic is a medium capable of supporting any new transmission technology. Moreover, in some cases, to connect corporate subscribers using fiber-optic technology, such as SONET / SDH and Fibre Channel.

6. Migration of bandwidth.

Since single-mode fiber optic are not dependent on the technology used and the data rate can be easily increased speed for a subscriber, without affecting the other. This means, for example that the subscriber is currently used Fast Ethernet technology, in the next year can choose Gigabit Ethernet by its simply switching the fiber-optic subscriber lines to another port on the switch and replace the Ethernet device at the customers home. This change will not affect the work of other subscribers Ethernet FTTH access networks.

7. LLU.

LLU - a property that has Ethernet FTTH architecture. The implementation of the principle of separation of subscriber lines was the main criterion for choice of FTTH in Europe, as they sought to build a network, where the access to the infrastructure of fiber optic access network could have multiple service providers.

8. Safety.

Today fiber line is the most protected area (in the physical layer), especially in comparison with the common transmissions. In addition, Ethernet switches used in service provider areas and they used to ensure the separation of the physical layer ports and logical level of subscribers and have a lot of security features that are able to prevent practically all intrusion attempts.

9. Equipment at the customer home.

10. High optical signal power (per 20.4 dB higher than Ethernet optical interfaces)

11. High speeded

optic infrastructure of FTTH architecture based on the PON, in future we can use less expensive fiber infrastructure. In general, we don't talk about using of FTTH networks, we talk about how quickly it can developing.

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Conclusion

Fiber optic access networks currently based on different architectures and technologies. Standards for these technologies and available of equipment make development of service-provider networks without risks. The success of their work stimulate to the dynamic development of the industry.

Nowadays the PON architecture became very popular. The main factors of the most configurations of Ethernet FTTH it is the flexibility of the business model and the ability to support future services.

The development of fiber-optic communication lines in living areas - a big investment and will bring incomes in the next 30-40 years. Different circuit of FTTH network has advantages, but if we will use a fiber

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Please cite this article as:

Kravchenko, Y., Tolyupa, S., Varabash, O., Trush, A., Leshchenko, O. Topology of optical networks FTTH (FIBER-TO-THE-HOME). *Bulletin of NTU "KhPI". Series: New solutions in modern technologies*. – Kharkiv: NTU "KhPI", 2017, **7** (1229), 150–155, doi:10.20998/2413-4295.2017.07.21.

Пожалуйста, ссылайтесь на эту статью следующим образом:

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Кравченко, Ю. В. Топологія оптичних мереж FTTH (FIBER-TO-THE-HOME) / **Ю. В. Кравченко, С. В. Толуца, О. В. Барабаш, О. В. Труш, О. О. Лещенко** // *Вісник НТУ «ХПІ»*, Серія: Нові рішення в сучасних технологіях. – Харків: НТУ «ХПІ». – 2017. – № 7 (1229). – С. 150-155. – doi:10.20998/2413-4295.2017.07.21.

АННОТАЦИЯ В данной статье архитектуры на базе PON набули великого поширення. Основними факторами більшості конфігурацій Ethernet FTTH є гнучкість бізнес-моделі і здатність підтримувати майбутні сервіси. У цій статті описуються різні архітектури мереж доступу, розглядаються протоколи доступу, а також аналізуються характеристики оптичних мереж FTTH (Fiber to the Home). Успішність їх діяльності є стимулом до динамічного розвитку цієї галузі.

Ключові слова: топологія; PON; Ethernet FTTH; оптичні мережі; архітектура мережі

Поступила (received) 08.05.2016