OPTICAL TRANSPORT NETWORKS (OTN) AS INFORMATION TRANSMISSION A METHOD OF INCREASING RELIABILITY

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Abstract:
In the modern world, the development of the Internet and social networks has led to a sharp increase in the amount of information. As a result, it became necessary to increase the information processing capabilities of the IT network (router, switch), as well as the development of information transmission facilities. Also, in terms of increasing the transmission reliability. This article will discuss and review the standards of both OTN technologies.

Keywords:
OTN – optical transport network
SONET – Synchronous Optical Network
SDH – Synchronous Digital Hierarchy
DWDM – Dense Wavelength Division Multiplexing
ATM – Asynchronous Transfer Mode
FOADM – Fixed Optical Add/Drop Multiplexer
ROADM – Reconfigurable Optical Add-Drop Multiplexer
WSS – wavelength selective switch
CDCG – colorless, directionless, contention less, griddles
MCS – multicast switches
OSNR – Optical Signal Noise Ratio
FEC – Forward Error Correction
ASON – Automatically Switched Optical Network
NMS – Network Management System

Introduction:

In the modern world, the development of the Internet and social networks has led to a sharp increase in the amount of information. As a result, it became necessary to increase the information processing capabilities of the IT network (router, switch), as well as to develop and strengthen the means of transmitting this processed information, both in terms of increasing the amount of transmitted information and increasing the reliability of transmission. As a result, it became necessary to develop a new technology, which includes the solution of both mentioned problems. OTN technology includes WDM technology (specifically DWDM) and ASON.This article will discuss and review the standards of both OTN technologies.

What is OTN

At a relatively early stage, SONET\SDH (G.691) technology was used as an information transmission medium in trunk networks, which transmitted only one channel (Channel) in one pair of optical fibers, and the amount of transmitted information depended on the capability of this technology, while using this technology, the transmission environment was maintained (one pair of optical fiber), the transmission speed was increased. In the case of SDH, its maximum bandwidth is 40Gb/s (STM-256). The next stage was WDM (G.694.1 - DWDM) technology, by means of which, using one pair of light-conducting (optical) fibers, different types of services (SDH signals, ATM cells, IP packages) are transferred at different wave frequencies, which are called λ. Such combination was performed on the basis of FOADM optical multiplexers. The next step in the development of DWDM is ROADM, which is also a part of OTN.

DWDM has the following advantages:

Transparent environment during data transfer. DWDM does not change the frame (frame) structure or the data and control bytes of the client data.

Very large capacity. at the expense of the frequency spectrum.

Possibility of long-distance transmission. Up to 5.000 km without regeneration, up to 230 km one hop (hop).

Compatibility with existing optical cables.

High network flexibility, reliability and economy.

Easy expandability. It has modularity, which in case of expansion does not lead to disconnection of existing systems.

DWDM technology

DWDM technology is built according to the ITU-T G.694.1 standard. Which means combining different frequencies, i.e. λ, into one transmission medium, i.e. fiber.

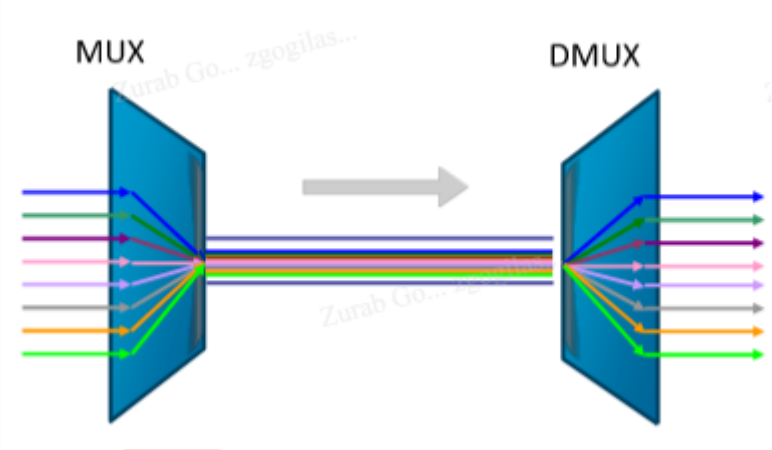

Fig. 1. Scheme of combining different waves.

It is known that in optical fiber we have three windows of transparency 850nm, 1310nm and 1550nm. When SDH or IP packets are transmitted without using a DWDM system, lasers with a wavelength of 1310 nm or 1550 nm are used to transmit them. Each service uses a separate pair of fibers, the transmission and reception must be of the same wavelength.

To use a DWDM system, it is necessary to allocate and assign a separate frequency for each service. Each such frequency channel is called OCH - Optical Channel. Optical channels are divided between 12.5GHz, 25GHz, 50GHz or 100GHz frequency. Figure 2 shows the channel allocation scheme for 25GHz frequency division.

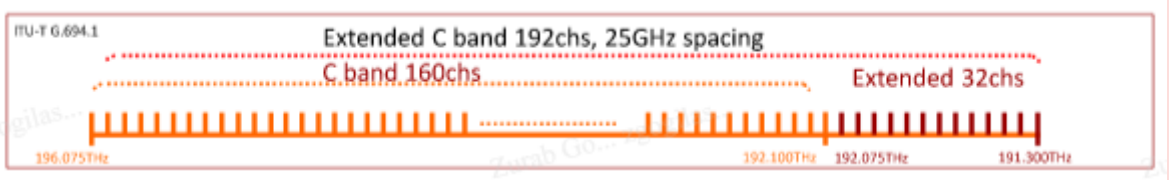

Fig. 2

Accordingly, the extended C-Band 191.300THz – 196.075THz frequency band is used for DWDM, with a total of 192 channels divided by 25GHz. Currently, the frequency division of 50GHz and 100GHz is mainly used. In addition, 50 GHz division can be carried out by secondary multiplexing of two different, even - 192.1 and odd eg: 192.15, 100 GHz frequency multiplexers.

As we mentioned, as a result of the development of DWDM, ROADM multiplexers were created, the main component of which is WSS technology. By means of WSS, the switching of waves in different directions is carried out, the signal levels can be controlled artificially by the input of the tube (Fig. 3), there are two types of WSS: MEMS-based and LCD-based.

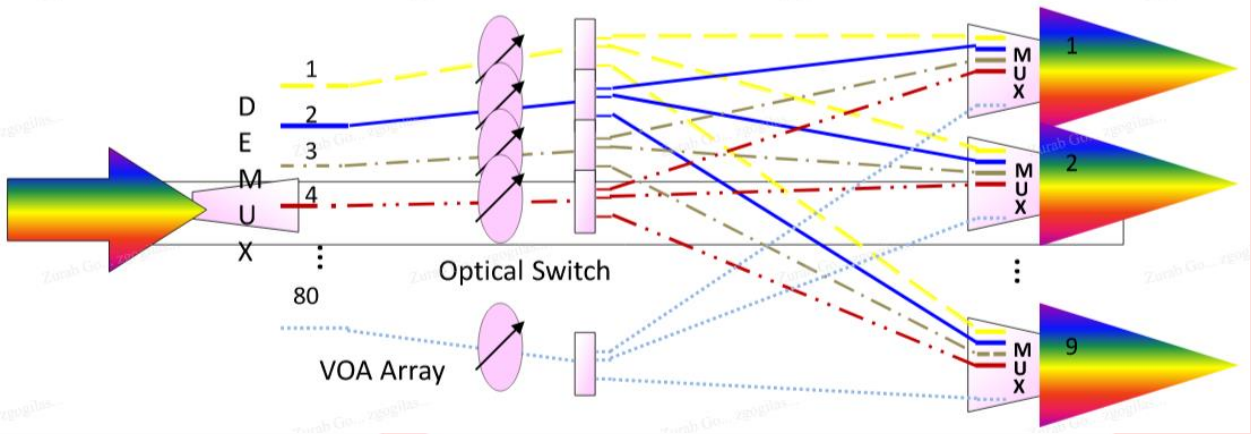

Fig. 3. Structural diagram of WSS.

The next step in the development of DWDM-ROADM is the development of CDCG technology. With the introduction of this technology, optical networks have become more flexible compared to standard ROADM, as a result of which the planning and management process of large networks (metro) has been simplified.

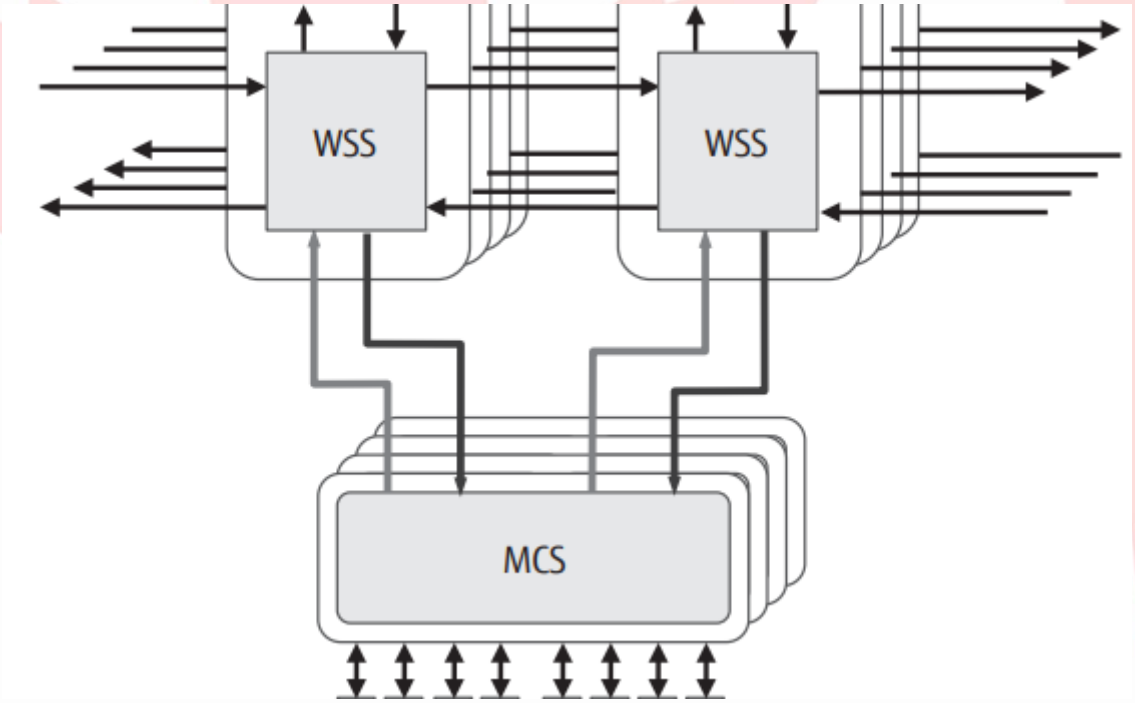

Fig. 4. CDCG- ROADM configuration

CDCG technology has the following features:

Colorless - This feature means that no restrictions are applied to multiplexed wavelengths, that is, any wavelength can be switched with any wavelength in a ROADM quantum.

Directionless - this function means that no restrictions are applied to the direction of the outgoing signal in the ROADM node (the signal can be connected to a channel that goes in any direction).

Contentionless - this feature eliminates the mutual contention of wavelengths in optical signals assigned to different directions in a single ROADM node (multiple instances of similar wavelengths may exist in a ROADM).

Gridless - without grid (divisions) - in contrast to multiplexing according to wavelengths, where signals with frequencies separated by the same magnitude are combined, this function allows combining frequencies divided by different magnitudes allowed by ITU-T. fig. 5.

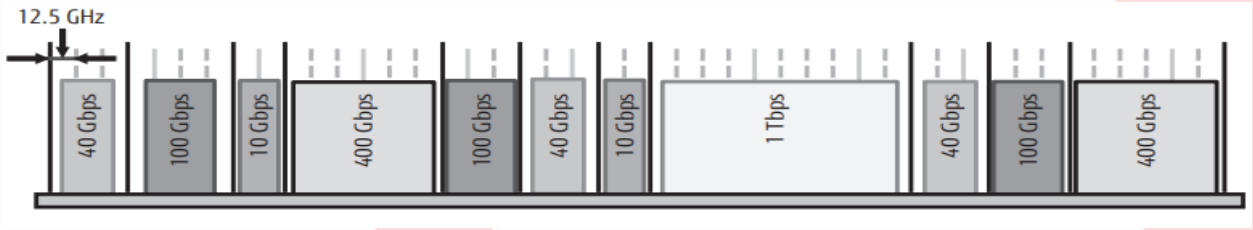

fig. 5. Without mesh (partitions).

OTN network

The OTN network is built on the basis of DWDM-ROADM and using fiber optic cables. With the OTN network, different types and speeds of services are transmitted through separate optical channels.OPUk, ODUk, OTUk, OCH, OMS and OTS channels are formed in DWDM-ROADM multiplexer of OTN. Moreover, OPUk, ODUk, and OTUk are electrical channels, and OCH, OMS, and OTS are optical channels (k denotes the level of the corresponding flow rates).

The OTS level usually also contains an OSC – Optical Supervisor Channel, an optical signal that is transmitted on a separate frequency, does not pass through an optical multiplexer, and is combined directly in the line board, bypassing the amplifiers. The corresponding scheme is shown in fig. at 6

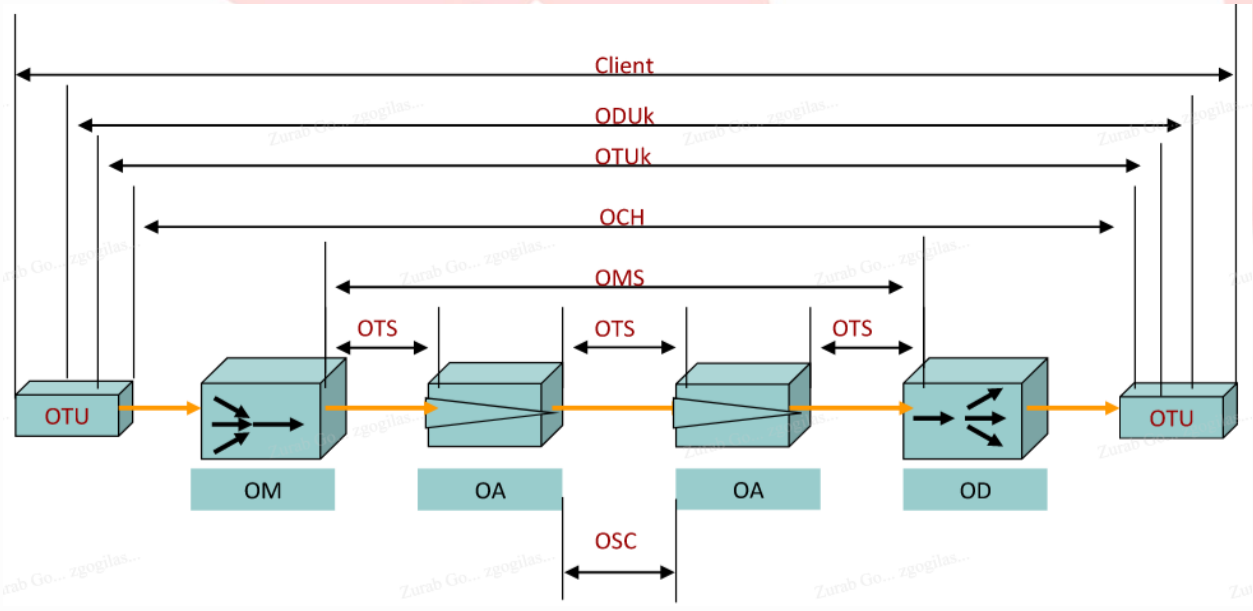

fig. 6

Through the OTN network, flows with different speeds are carried, therefore ODU/OUT transport units of different speeds are introduced, the speeds of which are given in Table 1.

Table 1. Transmission speed characteristics standardized by ITU-T.

	Transmission speed Gbps Gbps (approx.)	Note
ODU-0/OTU-0	1.25	1000 BASE-X for transporting signals such as e.g. Gigabit Ethernet
ODU-1/OTU-1	2.5 (2.67)	STS-48/STM-16 for transporting signals or two ODU-0_months ს
ODU-2/OTU-2	10 (10.71)	Eight ODU-0 or four ODU-1 for transport
ODU-2e/OTU-2e	10 (11.1)	10GB Ethernet for transport
ODU-3/OTU-3	40 (43.02)	32 for ODU0, or 16 for ODU1, or 4 for ODU2s, or for STS-768/STM-256 signals or 40GB Ethernet transport
ODU-4/OTU-4	100 (111.81)	80 for ODU0, or 40 for ODU1, 10 for ODU2, 2 for ODU3s, or 100GB for Ethernet transport

The following figure shows the insertion of the client signal into the OTN network carrier optical channel, before the optical signals are multiplexed and also after the optical signals are multiplexed.

As can be seen from Fig. 7, each level of OTN has its own header, it should be noted here that the FEC field is added to the OTUk level, which is important for long-distance optical signal transmission. With the help of the FEC function, the OSNR value is increased up to 6dB in some cases.

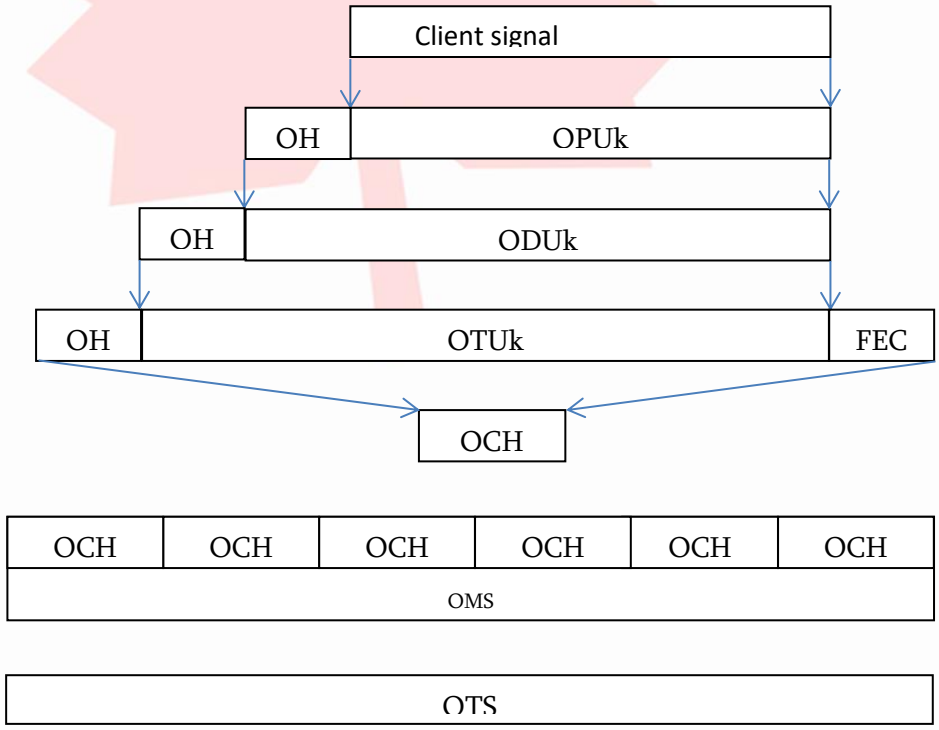

Fig.7

It is also worth noting that the OSC signal is inserted after the OMC level at the OTS level.

ASON

The ASON concept is also used to increase the reliability of information transmission. This concept allows optical transport networks to become more flexible, and by means of NMS, in case of damage in several directions of the optical cable, it is possible to quickly switch channels to the shortest working direction. As is known, there are several topologies of communication networks: ring, star, etc. The ASON concept works best in a mixed topology, since in this case, when the optical cable is damaged in several directions, it is easier to find an alternative optimal direction and the choice of directions is greater. According to ITU-T G.8080 recommendation, ASON is divided into three layers: transport layer, control layer and management layer (ASON is divided into a transport plane, a control plane, and a management plane).

Features of ASON

Previously, the optical transport network only had a transmission plane and a management plane, and there was no distributed intelligent control plane. Therefore, the ASON concept proposed to combine transmission, switching and data networks to achieve true routing and end-to-end routing. Business scheduling and network automatic recovery, it is a milestone breakthrough in the optical transport network. The transport plane includes a network element (NE) that provides a sub network connection (SNC) with various granularity of switching and grooming structures, such as fiber cross-connects, band and wavelength cross-connects; physical interfaces with various rates and multiple services. Such as SDH (STM-N), Ethernet interface, ATM interface, and other special interfaces; it has a connection control interface (CCI) that interacts with the control plane.

ASON can automatically discover the network topology. After the user or the network administrator dynamically initiates a service request, it can automatically select routes and establish, modify, and tear down service connections through signaling control.

Based on the above, OTN technology combined with ASON has created a new generation of transport network, which provides simultaneous transmission of various types of streams with high transfer rates, not only from one point to another, but also their guaranteed delivery from point A to point B (end to end).

Bibliography

1. https://www.sciencedirect.com/topics/computer-science/optical-transport-network
2. https://www.fujitsu.com/global/documents/about/resources/publications/fstj/archives/vol52-2/paper13.pdf

3. https://www.ciena.com/insights/what-is/What-is-Optical-Transport-Networking-OTN.html
4. https://www.metaswitch.com/knowledge-center/reference/what-is-optical-transport-network-otn