# The investigation of types of optic fiber in information transfer with developed network

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# Abstract

Today, wherever there are modern telecommunication system, cable TV (television) systems, computer networks and Internet, there will be heard something about optic fiber too. Also, customers need services like recording voice and video, and different devices are used such as notebooks, cellular phones, video camera, etc. Therefore, a wide range of mobile and fixed devices well emerge. From the customer's viewpoint, the network heterogeneity is incomprehensible. In past, there were different networks to respond to these various need by service providers which were optimized for a special need. For example PSTN was designed for voice services, IP network for Internet services (web) and data network based on switching for services like ATM and frame relay, and also special network for a special application such as video conference. This report presents on estimate of IP Generation networks, NGN advantages, and also important role of optic fiber transfer technology which is developed recently. DWDM technology makes the access to NGN possible. NGN services based on develop switching will be integrated with a control level. Three architectures of different networks will be introduced in this part including shared IP only network, compound network, fiber network, and dark fibers, which will be described.

**Keywords:** Optic fiber, Switching, PST, DWDM, WDM, NGN.

# 1. INTRODUCTION

A summary of optic fiber and its run procedure will be explained here. The optic fiber is a modern technology but its presence has been very long. The primary efforts occurred to develop cabling optic fiber in 1930 decade, but it lasted some decades until this technology reached the reality and its application. In the late 1960, the process curting obtained and reformed fiber optic nucleus from glass. Today, devices like optical fiber converters make it possible that information will be exchanged between optic and copper systems. Anyway, each technology has its own advantages and disadvantages. Some of optic signals may weaken in core length because of lack of purity of the glass, which depends on glass purity degree, transfer light wavelength and total light reflection. There is an integrated optic network with a bandwidth about Tera Hertz (Hz Tr) in Iran, it is formed of highways to send and receive information. The possibility of presenting multi-media services is not possible without this sensitive and accurate technology. Different devices like notebooks, cellular phones, video cameras, etc. are used. Therefore, a side range of fixed and mobile devices will emerge. A summary of optic fiber and its run procedure will be explained here.

# 2. NEXT GENERATION NETWORKS (NGN)

There is not an acceptable definition of NGN, and currently it is ambiguous. The provided definitions of NGN are relatively widespread. The organizations like ETSI and ITU-T have introduced the main features of NGN. For example ITU-T; NGN is defined as a network based on a package, which provides services including communication services, the ability of using multiple bandwidths, and the quality of service which is provided for transfer technologies. Generally, NGN is described as all IP or integrated networks based on package. NGNs do not cover the network features solely, but its service features provide new opportunities for network operators, service providers, communication producers, and the users. Most of experts, usually, know NGN as a multi-service network based on IP technology. NGN provides an open architecture for applicable programs and separate networks, and it lets them present separately. Applicable programs may develop independently. The standardization is of a great importance (increasingly) with an open architecture, but it lets the users choose the best current products. A new applicable program may be implemented in an amount of time shorter than Public Switched Telephone Network (PSTN). The companies which produce and sell computer equipment and devices, may develop applicable programs and services for final users. The service providers may pack several applicable programs inside a service, or applicable programs may be used by the users on a peer to peer base.

## 2-1- MAIN COMPONENTS OF NGN

NGN architecture, in addition to old data and voice equipment, includes different types of convergent network equipment such as call controllers time period of connection between two computers, media communication bridges, signaling communication bridges, the feature service providers, program service providers, media service providers, management service providers, mediators of bill issued, presenting telecommunication services to users which includes transfer devices and cabling. The nucleus technologies include package transfer technology, traffic engineering protocol, a technology which guarantees the service quality such as MpLs, the communication technology (multi-part) like immediate multi-destination message broad cast technology of session control, etc. [6]

Soft switch: A call controller is called time period of connection between two computes too, and it is one of the components of NGN nucleus. Because it controls different types of applications like voice and other services which are added to increase the transfer value. Soft switch is a control device based on software which facilitates the call control among NGN protocols such as MGCP, SIP, H. 232, and old technology protocols like Integrated Services Digital Network (ISDN) and SS7. Also, it is in relation with program service providers, applicable programs which are not on soft switch directly. One of the soft switch roles is PSTN mediator which is done by signaling systems.

Gateway: It is a connection bridge which acts as an entry gateway in other network. There are three types of connection bridges for connection to other networks: Trunking gateway, Access gateway, Signaling gateway which are set in service provider network.

Application server: The application server is set6 in service provider network, and it provides executive and reasonable service for services and application programs which are not on soft switch directly. Significantly, soft switch routes the program server calls when an application program is requested. Totally, service provider is service distribution, and the control between application program servers and soft switch. [9]

# 3. INTEGRATED OR CONVERGED NETWORKS

The separate networks use separate required devices for video, data, and voice services. NGN deformed different types of programs in the packages, and it delivered simultaneously. The connection between NGN and current networks such as PSTN, ISDN, GSM may be provided by communication (connection) bridges. [5]

NGN lets the users access to a variety of applications with the same quality in each geographical area. It makes this possible that the shipping links and watchtower support transfer currency, business, and leisure needs in a situation which the user chooses. [7]

If PSTN is based on smart network and inaudible terminals (ends), but NGN enjoys a smart network and smart terminals. In this network, the service providers provide different types of services easily and with no need to heavy equipment of network. [8]

# 4. SWITCHING EQUIPMENT

Some of new bandwidth networks are interconnections, and sometimes, the switches are appointed. The main duty of interconnections is flexible bonding and connection management for network providers. The interconnections are categorized into three categories:

1. Electrical/ Digital interconnections

The devices which act to receive, process and send data in Electrical filed, which are old inter connections (SDH/ SONET) with copper mediators.

2. Optic cross- connect (OXC)

The equipped digital cross- connections are equipped with optic mediators, they usually are used as O-E-O switches (optical- Electrical- Optical). These connections are available for most of the customers widely.

3. Pacific Xtreme Combat (PXC)

The equipment which are used to receive, process, and send data in optic zone, and they are used as O-O-O switches (Optical- Optical- Optical). Few sellers produce these connections.

## 1-4- OPTICAL CROSS- CONNECTS

Most OXCs are complex devices which have the ability of working like SONET/ SOH cross connects, in addition to ATM and Ethernet switches, Ethernet. Giga bit with VLANs, Cos and other special protocols. Because the bandwidth mediators are optical, these cross connections are called optical. This means that connection to other devices is through optic fiber but the main process is done in electrical zone. OXCs may have several electrical (copper) mediators, for development, including fast Ethernet, Giga bit Ethernet on copper. Optic cross connections use high- speed switching up to 640 Giga bit on second and undeveloped ASICs to process the received signals with high bit rate. [9]

## 2-4- PACIFIC XTREME COMBATS

PXCs are totally different from OXCs. The most important difference between on OXC and a PXC is in data processing in electrical zone and converting it to optical zone in mediator output when signal is in optical zone ix PXCs. The multiple converters for PXCs: Most devices are not integrated with transfer equipment, therefore they need a Dense Wavelength Division Multiplexing (DWDM) system at the end of the fiber, which causes return different wavelengths (by transponder/ receiver) to electrical zone. In other PXCs, each certain port is connected to a fiber couple on switch. These cross connections have separated wavelengths in a fiber optically, and switched them to a desirable output port. [5] then they are package again and are sent on output fiber related to the port. Therefore, there are not DWDM terminals and electrical terminals in route. As a result, the signal remain in optical zone.



**Fig 1:** Wavelength Division compact System (DWDM) [4]

There are some problems is using PXCs in multi-lambda optical network. In this report, multi- lambda means a network which is made with DWSM equipment, and there are multiple parallel optical channels on each connection. In some points of network, PXCs must be used for routing the wavelength in order to prepare flexibility. Because of high usage and high application of DWDM technology on optic fiber, some constraints were appeared in transfer of this technology through DSF fiber in order to increase telecommunication networks capacity. These constraints were less in SM fiber than in DSF fiber. Therefore, there was the former constraint in SM fiber which is high dispersion of it in this window. Four wave mixing phenomenon (FWM) will have the most impact in zero dispersion. This phenomenon causes unwanted optical components which their harassment will be more, if the wavelengths are more and their distance is low, because filtering the desirable wavelengths is done so hard and sometimes, these unwanted wavelengths are exactly set on the main wavelengths, which are not filterable. So, DSF fiber has a high constraint to utilize in DWDM systems. [5]

# 5. FIBERS AND TRANSFER EQUIPMENT

## 5-1- DIFFERENT TYPES OF FIBERS AND THEIR CAPACITY

In an optic transfer system, the information is transferred on fiber as the following method. Electrical signals are converted to optical signals, and they move along the fiber until they reach an optical signal detector which convert optical signal to electrical signal. The light resource diffuses the optical pulses in special wavelengths. A wavelength refers to a lambda or a channel. Lambda, wavelength, and channel expressions are used equivalent. Although the wavelengths are not visible with eyes, but they are often shown as colors. The fiber capacity is so high. Data rate transfer equipment supports from 10 Giga bite on second in one lambda and 128 lambda which is equivalent to 1.28 Tera bite on second that is the fiber capacity. Each fiber route can have eight channels that each one has optic cable including 192 pair of fiber. So, this capacity can carry more than one pet bite on second, but the lower capacity is used. Some cables are seen with 6 fibers which are used to transfer single color with rate of 10 mega bite on second. [10]

The common method in carrier systems for optic transfer in long distances provides a higher bit rate in each lambda. It increases the number of supported lambdas in an optic fiber. The capacity of 10.2 Tera bit on second is proved on a fiber in a laboratory. Therefore, when a system operate in such a range, lots of non- linear problems will happen, which future generation fibers are required with high quality. The features of the first generation of single- mode fibers is determined by ITU, G. 652 suggestion, that is recognized as single- mode fiber standard. Today, most of single- mode fibers are used according to G. 652 recommendation is Europe. It is true about optical cables of submarine. Modern fiber routes are usually with G. 652 fibers of one standard for NDSF. G. 652 optic fiber is designed by DWDM multi-channel systems. ITU, G. 692 recommendation was designed (50Hz, 100 Hz, 200 Hz) which explains DWDM is fibers. The high capacity and long distances of connections needs optimization of several parameters including the number of wavelengths, frequency distance, modulation figure, the distance between optical amplifiers, power level of fiber input, non- linear effects like (SPM, XPM) and (FWM), choosing the type of fibers, the compensation of fibers dispersion, and their arrangement. The color dispersion effect is recognized by bit rate scaling and it should compensate in high speed systems (in 10 Giga bit on second and higher) exactly. [12]

The completed technique is using a fiber which its dispersion is unlike fiber dispersion which is used in transfer system. Discounted Cash Flow (DCFs) are normally used as separate modules, and they have been pasted in amplifier stations. Therefore, in order to improve the installed systems, they go toward higher bit rate. The main components of an optic fiber transfer system are transponder and receiver. Transponders receive the coded electrical signals and convert them to optic signals (modulation), and then they send on fiber.

Laser Diads (LD) may be used to produce light (semiconductor) and they are suitable for transfer in long distances. The optic resource diffuses the optic pulses in special wavelengths. Then LDs can transfer them in range of 1550nm and they have the ability of modulation about 10 Giga Hertz. The optic output modulation is used in bit rates of 10 Giga bit on second and higher bit rates. The prices LDs are necessary for transfer in short distances. The receivers have been pasted in other end of the fiber and they use an optic detector in order to convert and input optic signal to an electrical signal. The wavelength of receiver side should match with transponder side. [11] The important features are including different types of saturation, sensitivity, bit error rate for digital level, signal to noise ratio for analogue level. Bit error rate is the number of errors which occurs between transponders and receivers. The maximum saturation is the received power which may be accepted. If more power is received, the signal distortion will be more, and it leads inefficiency. The sensitivity is the minimum power which must be received from and input signal.

A weak signal may cause reading bits or low SNR incorrect. WDM is a method to increase the capacity of an optic fiber which is done through sending more than an optic beam in fiber simultaneously. OADM is equipment which releases traffic (the number of channels) from an optic circuit with no need to converting electrical signals. When the traffic increases in a network node, OADM may be used for optic of passing traffic. The advance OADM equipment requires complex engineering which removes it through release it for every optic channels. OADM equipment may convert to optical switches to support multiple fiber routes, and they can substitute optic channels without converting O-E-O. [8] The optic amplification was introduced in 1980 decade which was described with developing the distance between expensive O-E-O amplifiers for optical network economic. An O-E-O network must use the optical amplifiers depending on the type of equipment of 100-4km and O-E-O amplifiers in each 400-500km. The O-E-O amplifier requires a separate converter and amplification for each channel.

Raman and Erbium (EDFA) amplifiers are used without converting O-E-O for far optic transfer (for example 2000km) and very far transfer (for example 4000km). the aim of O-E-O converter is to return, rebuilding and re-set of optic signal. This place is not available with optic devices in today market. Although, research activities are progressing, and we expect pure optic amplifiers in future. [3]

## 5-2- RANGE

The fiber, together wires, connectors, and other equipment between transponder and receiver have physical features such as attenuation, dispersion, etc. which removes it the optic signal from the normal/ natural form. Over dispersion means failure in transfer (unsuccessful transfer). Some devices are used for optic amplification, compensation of dispersion, and reproduction of long distances. [4]

In urban network of mediator cards or routers or O-E-O switches (with transponders and receivers) may be used with G.652 dark fibers for maximum distance of 125km in send rate of 2.5 Giga bit on second in each wavelength (the maximum range of former equipment was 80km) and maximum 80km in 10Gigabit on second in each wavelength. The transfer capacity is used for Coarse Wavelength Division Multiplexing (CWDM) systems which are cheaper with less density and bandwidth for more amplification (with spread distance). The transponders and receivers are usable for transfer in two directions on a fiber with a range about 125km and the transfer rate to 1 Giga bit on second. The transponders and receivers are available for transfer rate of 40 Giga bit on second or higher speeds (technically), but they are not commercially widespread yet.

There are not mediator devices between transponder and receiver in these transfer systems.

It is obtained by G. 652 fiber and the higher bandwidth in transfer rate of 10 Giga bit on second (and higher) in each wavelength. For example the transponder/ receiver send or receive Ethernet data on the fiber to 120km. [6]

# 6. CHOOSING NETWORK ARCHITECTURE

We explain three different network architectures in this part. We investigate a network architecture which is almost similar to previous research network regardless of used router technology and capacity. This network is called shared IP-only. We explain the networks which are able to present switched point-to-point connections in addition to an IP service or hybrid networks. We explain NREN which has a direct role to prepare the base connection.[7]

## 6-1- SHARED IP-ONLY NETWORK

The shared IP-only network is referred to a network which all connections are through the utilization of IP routers in it in this report. [3]

## 6-2- COMPOUND NETWORK (IP + SWITCHED)

A network is called compound network which is mode from an all- IP component and it is completed by connections based on switch. The general users can use a shared IP substructure. This shared IP substructure may be used to support the users with needs for service quality. [10]

A different method may be used to support the users of private network. The switching equipment which provide the services of Ethernet Giga bit and traffic integration or division for better efficiency of SDH were available previously (and are developing now). This means that a STM-64 circuit may be divided into several Ethernet Giga bit and STM-16 circuits (or less), and they may be presented on a special mediator for the users. This cheap solution (because of low price of mediators on these equipment) is the ration of all- IP solution which is presented previously. [13]

In fact, switching equipment and IP routers are similar to switching equipment and transfer, but finally, the do not require ASICs and needed software for advanced IP services. This architecture has its own agreements and disagreements based on network management and resource.

For resource support, most of sellers of switching equipment are active in process of supporting G-MPLS, because the implementations are not always according to standards. Therefore, the sellers are not able to work together. [9] this means that distributed connection resources between switching equipment and IP routers need continuous management. There are two available options for operational management such as network architecture:

- National Research and Education Network (NRENs) management, switching equipment and IP

- NRENs managements, IP equipment and providing a switching service which is managed.

There is a clear sign between connection providers and switching/ routing elements in each one of these cases, like shared- IP- only network which is connection provider that presents multiple wavelength.

Because alone wavelengths may be presented separately to project users. From the perspective of NREN, it is accounted as a dear point. This is about cases that are the optic elements. Therefore, the network architecture may be described as a network with multiple wavelength. [5]

## 6-3- THE FIBER NETWORK

In this architecture, a NREN controls a substructure of fiber network.

NREN may provide lots of wavelengths (with constraints of used technology) as it is needed. Totally, NREN may make shared IP-only network or hybrid network from fiber network and present services to its users. [6]

This network architecture is so similar to architecture of hybrid network. But there is a key difference that NREN controls the fiber too. A fundamental point to make is that: how does the network work? There are two options:

1- The fiber network works by a traditional carrier from NREN. This is a new model of cooperation between NRENs and carriers. In line and line- Termination equipment are chosen and run by the owner. In this case, the third person will implement based on fiber from NREN.

2- The fiber network is absolutely run by NREN. The expertized progresses in transfer equipment, even on an international scale, make this option possible. [8]

# 7. DARK FIBER

Dark fiber is special optic fiber of a customer (or a group of customers), where the customer is responsible for connecting transfer equipment to it. The optic network implementation based on Dark fiber is categorized according to geographical range of installations meaning the ground of college, metro, regional, continental, or intercontinental.

The main difference of above examples is described as the following: The distance which signals must be transferred.

Density means the number of wavelengths (signals, colors) in a dark fiber. Each one of these parameters has a different meaning for transfer equipment. In future, the required density of connections is by NRENs (1-64), and some of dark fibers are by the carriers (32-256).

In both cases, the needed density in edge of networks is less than core. The requests for transfer distance is the same for both cases, but shopping of lambda services from carriers may be cheaper than using dark fibers for longer distances (2000km and higher). The professional companies which are expertized to dark fiber systems secure the fiber installation, and keeping it from the customer. In most cases, there is not the additional compound management, or economical and human resources to support dark fiber customer. This case is more reliable rather than old telecommunication services. The additional compound management, is detected in long distance fiber lines (longer than 250km), when the optic signal needs amplification or reproduction in communication (connection) lines. In such cases, the customer is responsible for managing equipment between two communication (connection) lines, and the fiber company presents some help (local help). [10]

#  8. CONCLUSION

The fiber technology has a good procedure now, and its producing techniques is improving. The fibers support accessibility to communication (connection) bandwidth. With fiber technology and amplifiers (EDFA), the transfer systems may cover for speeds of 2.5 Giga bit on second and 10 Giga bit on second with no need to reproduce, ranges of 1000-1500 km (long distances) and 3000-4000km (very long distances). With research activities, we expect pure optic amplifiers in future. We can cover long distances by using pure optic fiber network relatively cheaper than old networks.

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