

The Comparative Success of Disruptive Innovations in the Fiberoptic Industry

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ABSTRACT

This paper examines the recent experience of the fiberoptic industry where disruptive innovations have been common but the results in terms of individual company market share and profitability have varied considerably.

The fiberoptic industry has gone from a period of extraordinary growth and profitability in the nineties to the present stage of excess capacity and worldwide glut in a matter of five years. An industry that was once characterized by exceptional new technology development and product innovation both at the large company level as well as smaller independent unit level is now considered as the largest failure in the U.S. economy since the Second World War.

This paper is narrowly focused on the disruptive innovations as opposed to sustaining innovations in the industry and relies on the experience of large transnational corporations such as Corning, Lucent, and Alcatel as well as the experience of smaller "niche" players in New England. With the drop in venture funding for smaller players, the Hill & Jones Model and, the Christensen Model do not adequately explain the performance of many companies specializing in disruptive innovations. The paper explores alternative approaches to business growth and market share expansion in the present environment where lack of liquidity has curtailed risk-taking by both small entrepreneurs and large industrial manufacturers.

The author has conducted extensive interviews with the members of the New England Fiberoptic Council regarding their experiences with the new technology development, commercialization, and recent product innovations. While utilizing the insights gained from these interviews, the paper compares their experiences with the conventional examples cited by Christensen, Johnson, Gilbert, Chesbrough, and others from automotive, electronics, and computer industries. This comparative analysis validates traditional assumptions of the Disruptive Innovation Theory but it also illustrates the dangers in any simplistic generalization regarding a volatile industry such as Fiberoptics. Using the company database maintained by NEFC, the paper summarizes the key innovations introduced in the industry over the last twenty years by selected firms. It isolates the "disruptive" innovations and makes projections regarding their impact today and their potential for the future.

Historical Background

My first exposure to fiberoptic technology dates back to 1978 when I assumed optical product management responsibilities at American Optical Corporation, then one of the largest optical companies of the world. Working with Dr. Walt Siegmund, who had supervised early work of Dr. Will Hicks, a true pioneer of fiberoptic technology, I found American Optical to be more focused on medical and healthcare applications as opposed to telecom uses that have become so dominant in recent years. We were purchasing high purity glass from Corning Glass Works where Dr. Peter Schultz had perfected low loss fibers for telecommunications applications. But the center of innovation for fiberoptics was at Bell Labs, then part of AT&T. With the merger of Ted Valpey's firm Valtech with CommScope, the disruptive innovation of fiber cabling as an alternative to copper cabling had already begun. Later, during my association with SpecTran Corporation in the early eighties, Peter Schultz developed several fiber-preform manufacturing innovations, and he alongwith Drs. Aslami & Jaegar, created several brands of multimode fibers for the telecom industry. That process saw the emergence of multiple sustaining innovations when Lucent purchased Spectran and introduced additional high performance fibers for the telecom industry employing newer approaches to preform manufacturing at its Sturbridge plant.

By the time I left American Optical in 1982, when it was sold by Warner Lambert and broken up into many parts, medical uses of fiber had become an insignificant part of the total fiber market that was now dominated by telecom applications. The emphasis was shifting clearly in favor of single-mode fibers where

Corning had become the dominant producer in the world. By 1983, AT&T was laying submarine cables across the Atlantic containing two pairs of single mode fibers each carrying 280 million bits per second.

With the onset of a key disruptive innovation of this period, fiber amplifiers, the long distance communications, whether underwater or on-land, were about to change forever. These were first thought out again at American Optical by Dr. Eli Snitzer when he had actually moved away from optical fiber research to concentrate on lasers. Erbium-doped fibers turned out to be perfect amplifiers and submarine cables just like the above ground cables started using these amplifiers instead of repeaters for global communications. Using Raman amplification techniques and carrying soliton light pulses, the Bell Labs engineers were able to transmit one trillion bits per second through a single optical fiber. This set the stage for the current phase of all optical networks where optical fiber has become the basis of multiple innovations in the business and personal communications industry.

MARKET SHARE AND PROFITABILITY DETERMINANTS

Exhibit A, prepared with the help of IGI, provides in a matrix format, the product line breakdown for major players in the fiberoptic industry covering such innovations as the DWDM systems, optical switches, terabit routers, and access systems for enterprise and residential markets. The disruptive innovations have come about more from the telecom company demands and less from the traditional producer base of fiber manufacturers. Historically, the industry has been affected by the regulatory

environment and the market expectations regarding the bandwidth demand. Goldenberg & Levav et.al.(2003) have outlined five innovative patterns that by manipulating existing components of a product line and its immediate environment can lead to a market share enhancement for the company. One of the technologies they have highlighted for the optical industry is the innovation of photochromics - a technology developed originally by Corning for glass lenses and later extended to plastic lenses in a disruptive fashion by American Optical during my association with the company. Levav et al. suggest photochromics as an example of a dependent relationship between a product and its environment. Corning Glass Works was the market leader in the seventies and it was focused on ophthalmic sunglasses that changed from clear to dark lenses in the sunlight because of their photochromic properties. We at American Optical felt that the consumer preferences were shifting to lightweight plastic lenses for their comfort and convenience. Our R&D scientists Rotenberg and Carmelite were the first to develop a photochromic coating for the plastic(CR39) lenses. We gained market share by launching the product in Europe first and licensing the "Photolite" technology in 1980 to Nikon of Japan for Asian markets. In a comparable situation today for the fiberoptic industry, the photosensitive fibers based on co-doping of germanium and boron offer a similar opportunity for new fiber bragg gratings needed by the sensor industry (Shu, Zhang, and Bennion 2002). Wallace (2002) has analyzed the growing use of fiberoptic sensors in petroleum exploration and processing fields. Using a two-Bragg grating sensing system, BP has successfully deployed a fiber based monitoring system in the Gulf of Mexico, and the North Slope of Alaska. Similarly, Norsk Hydro is utilizing multi-fiber P/T gauges and distributed

temperature sensing systems in the North Sea. These developments suggest the potential for non-telecom applications for fiberoptics. U.S. Military and Homeland Security Departments are now using fiber sensors in a variety of non-telecom applications that are radically different from the original product characteristics for intended markets. NEFC members have confirmed in their interviews the diversification strategies that are bound to enhance their market shares even in an uncertain environment for new capital infusion for the industry. A number of new products have the potential of disrupting the traditional market position of Alcatel, Fujikura, Furukawa, Sumitomo, Corning, and other large producers in the industry. Alternative product lines based on EDWAs (erbium-doped waveguide arrays) for cross-connects and reconfigurable multiplexers are gaining popularity in the marketplace.

THE REGULATORY ENVIRONMENT FOR THE TELECOM MARKET

There have been significant discontinuities within the U.S. local telecoms markets over the last twenty years. Many companies have lost business and market shares in this market in a pattern different from the European and other global markets. They assumed that entry would be relatively cheap, that the market would be capable of sustaining multiple local access networks immediately, that existing companies would not seek to deter entry of new companies in hopes of entering long-distance business agreements, and that regulators would reduce (not raise) entry costs to new firms. Entry into local markets are extremely expensive and requires companies to sink huge costs and achieve economies of scale quickly if they are going to survive future

competition. Bell operating companies are perceived as monopolists and because they have the power to raise prices and restrict output and additional entry into the market; Congress decided that government regulation and remediation was required and necessary. Regional Bell operating companies still have the incentive and ability to engage in strategic, anticompetitive vertical conduct, particularly in the markets for terminal equipment and long-distance callings. Recent FCC decisions have created more uncertainty for the relative market position of ILECs and long distance companies that made huge investments in long-haul fiber backbones during the nineties.

The Advent of Advanced Photonics

Optical networking is critically dependent on advanced photonic components including robust functional components and WDM networking. Such components include fibers, amplifiers, WDM sources, WDM routers, tunable lasers, λ - monitors, ultra-wideband amplifiers, dynamic gain equalizers, integrated add/drop, WDM XC-Fabrics, and λ - Converters. WDM Networking includes point-to-point systems, WDM Add/Drops, WDM Rings, WDM cross-connects, and WDM Mesh Networks. WDM applications evolve from long distance (400G, Xtreme, Lambda Router) to high-speed switch / router (Rubicon), metro/business access (Metro/EON), and optical/wireless architectures.. From metro/business access to LAN (Interconnect, Routing) and Cable TV and from LAN to residential access (WDM PON), the applications have been challenging for competitive market strategists. The rapid evolution and deployment of optical networking systems has been driven by innovation in fiber, optical

components, and transmission systems techniques. Scalable optical networks employing optical switching and routing require highly functional and dense optical components and circuits that must be cost-effective. The development and marketing of such components requires continuous infusion of new equity capital which has slowed in recent years.

RECENT INDUSTRY SETBACKS

Following years of double-digit growth, the market for optical networking equipment retrenched in 2001 and has continued to erode during 2002 and 2003. However, new DWDM producers such as Atoga, Altamar, Movaz, PacketLight, PhotonEx, Lumentis, Seneca, Innovance, All Optical Networks, Ceyba, Xtera, Zaffire, Astral Point, ONI, and Sycamore, are showing resilience in the market. Established customers dependent on bandwidth have experienced that on average 20% of deployments need to be upgraded each year, potentially representing \$2.5 billion in revenues for the vendors. In the DWDM & OCX market, the sources for demand come from two areas:

established customers by adding transmit-receive cards to already installed systems and deploying new systems as capacity fills and first time deployment for DWDM in smaller market rises.

Examples of functional blocks include transponders, gain blocks, optical switch fabrics, mux-demux blocks, and monitors. Migration to transponders can increase supplier revenues even if unit sales are stagnant. Customer empowered optical networks are built on the paradigm that the customer owns and controls the

wavelengths (Virtual Dark Fiber). The customer controls the setup, tear down, and routing of the wavelength between itself and other customers. Wavelength resource management is done on a peer to peer basis rather than by a central administrative organization. Customers treat networks today as assets, rather than services. In the future, customers will purchase networks just like computers, machinery, or other big equipment and will be able to trade, swap, and sell wavelengths and optical cross connects in the commodity transaction markets.

Fiber to the Home Prospects

Currently deployment of DSL and cable modems is hampered by high cost of deploying fiber into the neighborhoods. Cable companies need fiber to every 250 homes for next generation cable modem service, but currently only have fiber on average to every 5000 homes. Telephone companies need to get fiber to every 250 homes to support VDSL or FSAN technologies. Wireless companies need to get fiber to every 250 homes for new high bandwidth wireless services and for the cost effective provision of mobile internet. The cost of "last mile fiber" has to come down considerably if these applications are going to be embraced by the consumer. An innovative fiber deployment system will provide opportunities for small service providers to offer service to public institutions as well as homes. For e-commerce and web hosting companies it will generate new business in out sourcing and web hosting. Bargas & Power(2003) have shown that newer DWDM systems have reduced the cost of turning up new wavelength services by eliminating the need for typical upgrades inherent with legacy networks. Additional innovation in the DWDM infrastructure will

be the key to lower operating costs associated with commissioning of future wavelengths while optimizing transmission performance of ever changing transport networks. Advanced fiber devices have enabled the transmission of high speed internet-centric services creating a broadband digital infrastructure that has changed the profile of both public sector and private sector enterprises. These new service requirements have the potential of reversing the telecom fiber glut that exists in the U.S. Market. The Matrix of Companies in Exhibit A shows how a number of fiberoptic manufacturers have diversified into related products and services. They have joined major nonfiberoptic producers such as Intel, Sony, Cisco, Sun, and U.S. Surgical Corp that have made a name in the field of disruptive innovations.

The Role of Asset Based Telecom Services

A new business model that may return the fiberoptic industry to its old level of profitability is the asset based telecom provisions. In asset based telecom approach, the customer owns the infrastructure (dark fiber, switches, and wavelengths) while the carrier provides the service and network management. It relieves the carrier of huge capital cost of infrastructure and gives customer greater flexibility in the choice of service provider and control of the network. Asset based telecom puts customer in control and ownership of the network is in its hands.

Metro asset based telecom include condominium fiber networks. Several next generation carriers and fiber brokers are now arranging condominium fiber builds, including IMS, QuebecTel, Videotron, Ceogeco, Dixon Cable, and GT Telecom.

Organizations such as schools, hospitals, businesses, municipalities, and universities

become anchor tenants in the fiber build. Each institution gets its own set of fibers on a point to point architecture, at cost, on a 20 year IRU (Indefeasible Right of Use). Fiber is installed and maintained by 3rd party professional fiber contractors, usually the same contractors used by the carriers for their fiber build in the system.

In the condominium fiber market for business there has been significant reductions in price for local loop costs. Also, there has been no increase in local loop costs as bandwidth demands have increased. The ability to outsource LAN and web servers to distant locations increases as LAN speeds and performance can be maintained over dark fiber.

The growing trend for Fortune 500 and large institutional customers is to acquire and manage their own fiber in the metro area. In the long haul, the purchase of point to point wavelengths as IRUs rather than as service is increasing. Carriers will increasingly provide services and management rather than own and operate infrastructure.

The Technology Overview

The whole industry shift from copper to fiber has led to several disruptions for users as well as the service providers. Today's telecom network owes its existence to a transition that has created many failures in the process.

Network drivers have experienced several trends, including: migration from repeaters to amplifiers, increased speed on existing fiber (from 2.5 Gb/s to 10 Gb/s; and from 10 Gb/s to 40 Gb/s), more channels on a single fiber, and quicker provisioning of spans.

Enabling technologies have allowed new cabling architectures optimized for fiber, short wavelength fiber LAN electronics, and small-form-factor (SFF) fiber connectors. Centralized fiber architecture offers real savings today, with single point administration, reduced ports costs and life-cycle savings, and is accepted in standards worldwide. Fiber LAN electronic costs are decreasing, with 850 nm short wavelength generally less expensive, and 100BASE-SX offering lower costs, and smooth migration. In conclusion, fiber to the desktop can be cost effective today. Because of the explosive growth of the internet, there is increasing need for more bandwidth in metro and access, and new high speed data and broadband services. The current wave of price reductions of optical components and equipment will create new applications. Cheap fiber deployment in conjunction with mandatory water and sewer rehabilitation projects by municipalities along with increasing importance of dark-fiber networks may stimulate fiber deployment in metro and access networks. There is increasing need for capacity and high speed services by network and service providers (internet, data, & multimedia), public and private institutions, and businesses. Metro optical network requirements include: having multi-protocol and multi-service platforms, being scalable with DWDM ("Pay-as-you-grow"), having point and click provisioning (in seconds, not months), having different QoS and SLAs, with different billing options, switching and routing of wavelengths, including "Wavelength Services", and having a longer-term, so that all-optical transport with opto-electronic conversion is only at the edge of the networks. Optoelectronic components for metro networks include tunable lasers and filters, transceivers and transponders, OADMs (Fixed and Re-configurable), opaque and

transparent OXCs, compact optical amplifiers, DWDM components, uncooled lasers for CWDM, components for optical monitoring and control, and protocol transparent devices.

Thus, it makes no sense to lay “just enough” fiber because the biggest issue at present is the lack of last-mile capacity. There is no way for carriers to be able to make money laying a data network on top of one that is optimized for voice. A new network, built using fiber optics at the core and at the edge will have to be in place for effective utilization of fiberoptic systems. No network has unlimited capacity to reach every customer, carrier, or ASP. Thus, carriers will be unable to compete effectively unless they start working with their neighbors, and fellow competitors, in the long haul, metro, and access markets. The carriers that will be the most successful will be those that work together at the lowest cost and in the lowest unit of time in order to be the most efficient.

By incorporating an intelligent optical network environment, carriers will be able to manage down capital expenditures and improve network-operating efficiencies.

Several components of next-generation subsystems that enable intelligent optical networking include tunable lasers, optical amplifiers, and transponders, OCMS, and dispersion compensators. By entering into an intelligent optical network environment, carriers will increase revenue and improve service velocity, reduce the cost to deploy, provision, and maintain communication networks, and enable the migration of their voice-centric infrastructure to serve an ever-increasing IP-oriented demand.

The Metro Deployments

A new flexible approach for fiber deployment can be considered as an innovation that has disrupted the traditional outlook on fiber. Cities and towns are beginning to develop their own approaches towards fiber deployment for metro applications. Municipalities are beginning to deploy their own fiber optic infrastructure to gain complete control over their own private and secure network and to eliminate leasing expenditures to telecom companies. This way they have the option to make a city-owned asset pay for itself and produce revenue. Several characteristics of this flexible approach are that it deploys fiber in both man-accessible and non-man accessible existing sewer and drainage systems, it incorporates state-of-the-art materials and equipment developed to streamline the entire installation and upgrade process, and it is cost effective and delivers true fiber-to-the-desk connectivity. The individual fiber tube (IFT) is the low-cost fiber optic deployment alternative in that there is no stranding of unused fiber, there is true fiber-to-the-desk connection through Individual Fiber Management (IFM), and that for the first time, there is access to simple connectivity and easy upgrades. Such a Metro system is becoming a growing trend due to several important aspects such as: revenue sharing opportunities (individual fiber tubes allow a city or telecom for the first time to share, lease, or rent to make revenues); construction (no large crew and/or equipment is needed, permits, restoration, and moratoriums become non-issues); speed to market (customer connection to network is accomplished in days rather than months); instant network (backbone is lit by leasing individual fiber tubes and then blowing and

splicing fiber); and secure network (it eliminates "hot cuts" or unintentional access to lit fiber).

The New Network Service Tools

The service providers remain focused on aggressively reducing costs and pursuing key innovations in optical switching even though there has been rapid change in the business environment. Optical switching cannot be discounted because use of optical switching can dramatically reduce OpEx and CapEx, and with optical switches, new services can be introduced non-disruptively over existing SONET/SDH infrastructure.

Many component manufacturers are using tunable laser technologies to address the challenges faced by network service providers today. The emerging trends in the system architectures have been higher channel counts, higher data rates, longer reach, tunable components, and better network design and management softwares. Tunable lasers are the differentiating tool for new systems architects because of the advantages they offer to the systems vendors and network operators. Tunable lasers allow system vendors to design flexible networking equipment; improve system maintenance and trouble-shooting; and reduce systems maintenance costs for carriers. They also allow network operators to deliver flexible bandwidth services, reduce network operating costs (inventory, provisioning) and increase new revenue generation. One factor that might stimulate fiber deployment in metro and access networks is the cheap fiber deployment in conjunction with mandatory water and sewer rehabilitation projects by municipalities and the increasing importance of dark-

fiber networks. Metro fiber networks will become important as there is increasing need for capacity and high-speed services by networks and service providers, public and private institutions and businesses. There are several requirements for metro optical networks including: multi-protocol and multi-service platforms; that are scalable with DWDM; point-and-click provisioning with different billing options; and switching and routing of wavelengths services.

Summary and Conclusions

Disruptive, discontinuous, or radical innovation as a competitive strategy is not new to the fiberoptic industry. It has followed the typical pattern of most high technology industries especially the electronic and computer industries. Tushman & Anderson (1986), Wheelwright & Clark(1992), Christensen(1997), Todd(1997), Johnson & Scholes(1997), Hill & Jones(1998), Trott(1998), Veryzer(1998), Hamel(2000), Ahuja & Lampert(2001), and Rice et.al.(2001) all have provided relevant examples from several industries where disruptive innovations carried out by niche players have led to the erosion of market presence by industry leaders. Smaller players who paid more attention to newer applications that met new customer needs as opposed to satisfying old customer needs better have been rewarded for their ingenuity. McDermott & O'Connor(2002) have shown in a multidisciplinary study that project teams engaged in radical innovation projects encounter a more challenging environment than those engaged in incremental or sustaining innovations. A comparison of Fortune 500 Companies from 1972 to those still on the list in 2002 demonstrates how companies

that did not anticipate or capitalize on disruptive innovations hurt themselves compared to the responsive firms. The degree of responsiveness to changes in the market and business trends will determine the success of any competitive strategy and fiberoptic industry is no exception in this regard. The innovative process that accompanies technological change has been more important for telecom companies and other service organizations in this industry. The enabling nature of fiberoptics is such that by enhancing capacity and bandwidth availability, it has ushered new services that in turn have been disruptive for other industries. A good example is the emergence of web services industry. Web technologies such as "http" and "html" represented the first wave that resulted in significant advances in electronic commerce. While some industries such as newspapers, other print media, travel agencies, and point of purchase stores suffered because of it, a whole new market of internet advertising took shape because of it. New UDDI directories using "web service description language" are now in the forefront of the web-based marketing initiatives. They remind us of companies such as Charles Schwab and Bloomberg Financial that entered their industries as disruptive technologies but helped expand the total market within a short period of time. Several NEFC members such as CyOptics, DRAKA, Gould, JDS Uniphase, Newport, Nufern, Panduit, Schott, Verrillon, and Xanoptics are credited with significant innovations in recent years. Because of the macroeconomic downturn and the ensuing liquidity problems, the disruptive aspect of these innovations has not yet materialized and several branded or proprietary products have become part of the mainstream market without much fanfare. The market leaders such as Alcatel, Lucent, and Nortel have lost market share to newer

players such as Sycamore and Ciena that figure prominently in Exhibit A Database. Timing of product acceptance by the telecom companies has been more of a deciding factor than the disruptive nature of the innovation.

According to KMI estimates, over fifty million miles of fiberoptic cable has already been buried underground which is enough to circle the whole planet approximately sixteen hundred times. There were competitive and regulatory pressures that were responsible for this massive "over-build" of capacity at a cost of over one hundred billion dollars. The net result is that capital infusion into this industry has dropped disproportionate to other industries. That has affected the process of innovation and risk taking in the industry. Only a small fraction of the buried dark fiber capacity has been put to use. The industry needs both sustaining and radical type of innovations in the applied and service sectors if the past investments have to yield desirable returns. Recent FCC Rulings have opened up the wireless arena to telecom companies. Techman International, an early manufacturer of wireless modems, was one of the first to receive an FCC license in 1984 for telecom networking devices. But the regulatory policy that was too restrictive and cumbersome slowed the growth of this industry. With the recent technological advances and the popularity of the cellular networks, we have the opportunity to integrate high bandwidth fiber backbones with fixed wireless and mobile solutions. Exhibit A Database companies such as Corvis, Ericsson, and Nortel that are beginning to link fiberoptic networks to wireless systems are going to define the new marketplace. The fiber manufacturers such as Corning should not look at wireless option as a competitive threat. Just as WDM proved itself to be a complementary technology and led to the expansion of fiberoptic market size,

the wireless innovations should also help create additional opportunities for fiber producers.

The Internet Freedom and Broadband Deployment Act of 2001 has opened up new avenues for expansion of fiberoptic services especially to the emerging “fiber to the home” sector. The popular Gigabit Ethernet has reduced the cost of high bit rate transmission to the desk and has enabled network upgrades without redesign and replacement of existing components. Simultaneously, VCSELS have extended the capacity and life cycle of existing multimode cable products. The emerging multiwave optical layer that is based on innovative DWDM systems has removed many bottlenecks from ever expanding telecom networks. The demand for high bandwidth internet services is leading to new product innovations. Applications such as WebTV, palm-pilot video, streaming video on demand, tv quality(full motion) cellular pictures, and high-end consumer preferences are setting a new standard for the integration of bandwidth-rich fiberoptic solutions with the ease of wireless systems.

EXHIBIT A

The Fiberoptic Company Database for the Study on Disruptive Innovations

MD = Wave Division Multiplexing Systems	TR = Terabit Routers
AC = Access Systems	AG = Aggregation Devices
VD = Video	EA = Enterprise Access
OS = Wavelength Routers / Optical Switches	RA = Residential Access

Company	<u>MD</u>	<u>AC</u>	<u>VD</u>	<u>OS</u>	<u>TR</u>	<u>AG</u>	<u>EA</u>	<u>RA</u>
Acclaim Technologies					X			
Accordian Networks		X						
ACD Telecomm.		X	X			X		
ADVA	X						X	
Advanced Fiber								X
Agilent Tech.				X				
Alcatel	X							X
Alidian	X					X		
Altitud AB				X				
ANDA Nets.								
Antec			X					
Appian Comm.							X	
Argon Nets.					X			
Artel			X					
Astral Point Comm	X							
Atmosphere Networks	X							
Avici					X			
Bandwidth 9				X				
Bay Networks					X			
Blaze Net. Pro.							X	
Brightlink Nets.				X				
Broadband Tech								X
Broadcom			X					
C Speed Corp.				X				
Centerpoint	X							
Cerent					X			
Charlotte's Web					X			
Chiaro Networks				X				
Chorum Technologies				XX				
Chromatis	X							

<u>Company</u>	<u>MD</u>	<u>AC</u>	<u>VD</u>	<u>OS</u>	<u>TR</u>	<u>AG</u>	<u>EA</u>	<u>RA</u>
Ciena	X	X		X				
Cisco Systems				X	X			
CoreTek				X				
Corning				X				
Controlware Australia Pty. Ltd.	X							
Corvis	X			X				
Cronos				X				
Cyras						X		
DiCon Fiberoptics				X				
Dynarc					X			
Ericsson	X							X
Extreme Nets.					X			
Finisar Corp.							X	
First Fiber							X	
Foundary Nets.					X			
Fujitsu	X	X						
General Inst.			X					
Geyser Networks, Inc.						X		
Harmonic Lightware			X					
Hitachi	X							
Ignitus Comm. LLC		X				X		
Intellect Comm.		X						
IntelliSense Corp.				X				
Ipicom						X		
IronBridge					X			
Juniper	X			X	X			
Kestrel	X							
LIGHTech Fiberoptics				X				
LightWave Microsystems				X				
Lucent	X	X	X	X	X		X	X
Luminous Net.		X						
Luxn							X	
Marconi	X							X
Mayan						X		
Metro-Optix		X						
Monterrey Nets				X				
Nbase-Xyplex		X		X			X	

<u>Company</u>	<u>MD</u>	<u>AC</u>	<u>VD</u>	<u>OS</u>	<u>TR</u>	<u>AG</u>	<u>EA</u>	<u>RA</u>
Nanovation Technologies, Inc.				X				
NEC	X							
NEC elumnant		X						
New Access / Zaffire	X							
NetCore					X			
Network Photonics	X							
Net Insight		X						
Nexabit					X			
Nortel	X	X		X				X
Novalux				X				
Optical Micro Machines				X				
Optical Network	X							
Optical Solutions								X
Optical Switch Corp.				X				
OptiMight	X							
Osicom	X							
Packet Engines								
PairGain							X	
Pirelli	X							
Quantum Brdg.							X	
Redback nets.						X		
Scientific Atla.			X					
Siara Systems						X		
Siemens	X			X				
SilkRoads	X							
Sirocco Systems		X						
Sycamore	X			X		X		
Synchronous Comm.			X					
Tellabs	X							
Tellium	X			X				
Templex				X				
Terawave							X	
Texas Instruments				X				
Torrent					X			
Unisphere Solutions						X		
Xros, Inc.				X				
Zaffire	X							

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Glossary of Fiberoptic Terms related to Disruptive Innovations

Access network

A term used to refer to that part of the network that connects the exchanges with the customers. Some carriers use the expression "CAN" for customer access network. In the U.S., the access network concept is commonly referred to as the "local loop" or the "subscriber loop". Depending on the distance to the exchange, the customer density, and other factors, the access network or subscriber loop in some cases is further segmented into two types of plant: feeder and distribution. Many recent innovations relate to access network.

Acousto-Optic

Refers to the interaction of acoustic and optical waves.

Add/drop

Multiplexers used at a network node or point-of-presence to separate out a lower-speed signal from a higher-speed multiplexed signal, or to combine a lower-speed local signal into a higher-speed transport signal.

ADSL

Asymmetric digital subscriber lines. Refers to a technology that uses copper-pair telephone wiring for a high-bit-rate transmission path in the downstream direction and a narrow-band path in the upstream direction. The technology has been proposed and evaluated for a number of applications, including switched digital video services, where the application requires enough bandwidth for video in only the downstream direction. The bit rates used in trials for the downstream path are typically 1.544 (T-1) or 2.048 Mbps (E-1), although an extended ADSL technology with 8 Mbps (downstream only) has been developed.

AMPS

Advance Mobile Phone Service

AM-VSB

Amplitude modulated vestigial sideband. Refers to the RF (analog) modulation scheme used with lasers in CATV applications.

ANSI

American National Standards Institute. Refers to a standards-writing organization that organizes committees and oversees the development and publication of standards, including standards for network interfaces, communication protocols, and other communication technologies.

APD

Avalanche photodiode. Refers to a type of semiconductor detector that has an internal gain capability-to multiply the photocurrent resulting from detected photons.

ASE

Amplified spontaneous emission. Refers to a phenomena in the operation of erbium-doped fiber amplifiers that results in higher noise and reduced efficiency.

Asynchronous

A transmission and switching technology that relies on the use of bits or strings of bits at the beginning and the end of the data payload. These are called "framing bits." This technology differs from synchronous transmission, where the data payload is referenced to a clock.

ATM

Asynchronous transfer mode. Standard for cell switching to route packets of digital information, designed to accommodate burst data transmission. An ATM cell has a fixed length of 53 bytes: 5-byte header plus 48-byte payload. The standard is a CCITT/ITU and ANSI specification that includes operation at bit rates from 1.544 Mbps up to 2 Gbps. The standard defines both the multiplexing and cell relay protocols.

Bandwidth

In data communications, this refers to the rate of data transmission in terms of the volume of bits per second. The greater the bandwidth of a network transmission protocol, the more data transfer opportunity available in the network.

Baud

A unit for characterizing the signaling rate of a digital link or transmission device. It refers to the number of digital signal transitions in one second. With some data encoding formats, the baud rate is equal to the bits per second. This would be the case with non-return-to-zero formats. In others, such as Manchester, two transitions per bit are required.

BRG

Bragg Reflection Grating

BLSR

Bi-directional line-switched ring. Refers to the use of SONET/SDH multiplexing equipment in ring-configured networks to reroute traffic in the event of a failure with a maximum of bandwidth available between nodes.

Broadband

In contrast with "baseband," it refers to the ability of a system to transmit or provide for multiple signals simultaneously by modulation of a higher-frequency carrier. The term also is used more generally to refer to the higher-bandwidths associated with video services.

Building Backbone

This refers to a network segment between at least two equipment closets or between a closet and the network interface for the building. According to EIA/TIA 568-A Commercial Building Wiring Standards, the maximum distance for building backbone segments is up to 300 meters. KMI assumes average lengths of 200 meters for each link in building backbone segments in a fiberoptic network.

Campus Backbone

This refers to a network region between at least two buildings. According to EIA/TIA 568-A Commercial Building Wiring Standards, the maximum distance for campus backbone segments is up to 2000 meters. KMI assumed average lengths of 500 meters for each link in campus backbone segments in a fiberoptic network.

CAP

Competitive access provider. Refers to a company that offers local-access or local telecom services in competition with the local exchange carrier. Example are MFS, Intermedia, and MCI Metro. The CAP industry started in the U.S. during the mid-1980s and has expanded to other markets in the 1990s.

CAT-5

Category 5. High-bandwidth transmission twisted pair copper wire cable.

CATV

Cable television. The initials derive originally from Community Antenna Television. The CATV industry or its networks also are sometimes referred to as "cable," which can be confusing in discussions of cable markets.

CCITT

Comite Consultatif Internationale de Telegraphique et Telephonique. Refers to the organization responsible for international telecom standards. The CCITT has numerous standards committees that deliberate on, draft, and approve standards on switching, transport, interfaces, cable types, fiber performance, etc.

CDMA

Code Division Multiple Access. A form of digital cellular phone service that features a spread-spectrum technology that assigns a code to all speech bits, sends a scrambled transmission of the encoded speech over the air and reassembles the speech to its original format.

Cellular

Cellular communication transmit voice or data by radio frequencies. A service area is divided into cells - each served by a radio transmitter/receiver. Cells are connected to a mobile telephone switching office, which is connected to the telephone network.

Cellular Network

The cellular system including the mobile telephone switching office (MTSO), radio transmission facilities and cell sites.

Channel

Refers to an electrical or, in the case of fiberoptics-based transmission systems, a photonic communications path between two or more points of termination.

CLEC

Competitive local exchange carrier. This term has become commonplace after the 1996 Telecom Act in the U.S. It refers to companies that will offer local telecom services in competition with the previously established local exchange carrier, which would be either a Bell operating company or an independent.

CO

Central office. Refers to a phone company's switch or exchange location or the building that houses the switch. Also called "serving office" and "exchange."

Coaxial Cable

Coaxial cable consists of an insulated central wire ("axis") within a metal cylinder. Used for CATV and has great potential for voice and data.

Core

The term "core" refers to the light carrying portion of the fiber, while the "cladding" is the outer portion of the fiber. In the industry standards for a given fiber type, such as 62.5/125, the 62.5 μm refers to the core diameter and the 125 μm refers to the diameter. Fiber diameter measurements are commonly expressed in microns (μm) or 10^{-6} meters.

CT

Central tube. Refers to the type of cable that has the fibers housed in a central buffer tube. The fibers can either be bundled together with a binder yarn, or loose within the central tube. The bundled approach usually is used for counts of 12, 18, or more. Most central tube cables usually have two strength members on opposite sides of the central tube.

Dark Fiber

Unused fiber through which no light is transmitted, or installed fiber optic cable not carrying a signal. The dark fiber is sold without light communications transmission equipment, and the customer is expected to install electronics and signals on the fiber and light it.

Data communications

Digital transmission of information over wired or wireless networks, usually linking computers.

DCS

Digital cross-connect system. Refers to electronic digital cross-connects, which perform signal demuxing, routing, grooming, and other functions. The DACS (digital

access and cross-connect system) from AT&T is an example. Sometimes the terms DCS and DACS are used interchangeably, but DACS is actually AT&T's product name.

DWDM

Refers to wavelength division multiplexing systems with two or more optical channels in the same transmission window. Systems being deployed in 1999 generally can transmit from 8 channels up to 128 channels in the 12550-nm window, and channel spacing ranges from 1.6 nm (200 GHz) to 0.4 nm (50 GHz). See also WDM.

EDFA

Erbium-doped fiber amplifier. Refers to a product that utilizes a doped fiber as to gain medium with another optical source. The amplification in an EDFA takes place in the 1550-nm "window" of the fiber. Thus the use of EDFAs can have an impact on the type of fiber used in future cable installations. EDFA technology has had an increasing role in U.S. and international markets since 1993.

E-1

The European equivalent of the North American 1.544 Mbps T-1, except that E-1 carries information at the rate of 2.048 Mbps. This is the rate used by European capital CEPT carriers to transmit 30-64 Kbps digital channel for voice or data calls, plus a 64 Kbps channel for signaling, and a 64 Kbps channel for framing (synchronization) and maintenance. CEPT stands for the Conference of European Postal and Telecommunications Administrations.

ELED

Edge-emitting LED. Refers to a semiconductor light source with a structure similar to that of a laser but without the reflective facets to produce a resonator cavity and a single spectral line. ELEDs are contrasted with surface-emitting LEDs, which are commonly used in multimode applications. ELEDs offer better power and beam characteristics than surface emitters, and are used as alternatives to laser diodes in some single-mode applications. See also SOURCE.

ESCON

Enterprise Systems Connection. This refers to a proprietary parallel signal-processing transmission protocol as well as a data network architecture, which were developed and commercialized by IBM in the early 1990s. ESCON is characterized by non-stop high-bandwidth data transfer across distances up to 9 km with multimode technologies, and up to 60-km with single-mode technologies.

Ethernet

This IEEE transmission protocol standard uses Carrier Sense Multiple Access/Collision Detection (CSMA/CD) to transmit data in a network. There are three different network topologies that support Ethernet transmissions: active ring, passive star, and active star.

FCC

Federal Communications Commission. U.S. Agency that implements and oversees telecom regulatory policies.

FDDI

Fiber distributed data interface. Refers to a 100-Mbps LAN standard that was developed specifically for fiber. The standards organization is ANSI. The standard's specifications at the physical layer include the optoelectronic component footprint and interfaces.

Feeder

The segment of telecom networks that includes equipment, cable, and other hardware for transporting traffic from the switch location into the loop, usually to an outside plant equipment location where there is a passive cross-connect or an active demultiplex function. Feeder cables can include high-count copper pair cables, where each pair supports one circuit, as well as cables carrying electronically derived circuits. Such electronic feeder technologies include "pair gain" and "digital loop carrier." "Fiber optic feeder equipment" usually refers to DLC or other access multiplexers.

FiberOptics

Thin filaments of glass or plastic through which light beams are transmitted over long distances and which can carry enormous amounts of voice and data traffic. Benefits include high capacity, relatively low cost, low power consumption, small space needs, insensitivity to electromagnetic interference (EMI) and improved privacy.

Fibre Channel

An interface standard for serial data transmission developed for communications between workstations and file servers, between computers and storage systems, and between other hosts and peripherals. The standard defines bi-directional point-to-point channels so that the communications path or medium is not shared between multiple nodes. A circuit or packet switching technology can be used to achieve multimode networking. The standard defines a hierarchy of serial data-transfer bit rates and several families of transmission media and sources. The lowest speeds can be implemented on twisted pair, coax, and multimode fiber. The highest speeds can be implemented on multimode and single-mode fiber. The bit rates range from 132 Mbps to 1.06 Gbps.

FITL

Fiber-in-the-loop. Refers usually to local exchange carrier use of fiber in residential or small business distribution applications.

Forward Path

Transmission from the head end toward the subscriber, also known as "downstream."

FRP

Fiber-reinforced plastic. A material used as an alternative to aramid yarns (Kevlar) for strength members in some cables, either as central strength members or other strengthening elements. The material is a resin with filaments of fiberglass (not optical fiber). It is also known as glass reinforced plastic (GRP).

FSN

Full-service network. Another term for multimedia or broadband interactive networks. "FSN" was used by Time-Warner (a CATV MSO) for a multimedia service offering that supports voice, video, and data services. Other carriers have adopted the term.

FTTB

Fiber-to-the-business or fiber-to-the-building. Refers to a version of FITL, in which the optical network unit (ONU) is located in a multi-tenant business or residential building.

FTTC

Fiber-to-the-curb. Refers to a FITL architecture with the optical network unit shared among two or more drops, typically up to a maximum of 64 lines. The optical network unit may be located in a curbside pedestal, hand-hole, or enclosure, or it may be in a cabinet in a multi-tenant building.

FTTH

Fiber-to-the-home. Refers to a FITL architecture with one optical network unit for each subscriber.

Gbps

Gigabits per second. Gig is one million.

General Purpose Cable

This type of cable meets specifications for general purpose ratings (UL-1581), and is one of three types of installed in premises networks. Multimode general purpose cables usually have loose-tube construction and are suitable for outdoor installation in campus network segments.

GRP

Glass-reinforced plastic. A strength member material, see FRP.

GSM

Global System for Mobile Communications. The first pan-European digital mobile standard was introduced for commercial use in 1991. It has since been adopted by countries in Asia and Oceania.

Headend

Facility in a CATV network where the broadcast video signals are transmitted into the feeder and distribution network. Headends are linked together with supertrunks and are linked to satellite downlink facilities with supertrunks.

HDSL

High-bit-rate digital subscriber line. Refers to a technology that uses copper wire in the local loop for transmission at rates up to 1.5 Mbps.

HDT

Host distribution terminal. Refers to the equipment in an FITL system that launches the optical signals onto the distribution fibers. The HDT is typically a rack of equipment located in the central office or in a remote terminal. One HDT supports multiple ONUs.

HFC

Hybrid fiber coax. Refers to a FITL architecture with the fiber terminated at a node that serves hundreds of homes. The homes are served from this node by one or more coaxial "bus" cables.

Hub

Refers to the facilities where all customer facilities are terminated for purposes of interconnection to trunks and/or cross-connection to distant ends.

IC

Integrated circuit. Refers to semiconductor electronic devices. This technology has been used to fabricate devices to support a wide number of functions in single-mode transmitters and receivers, including laser drive or modulation, multiplex/demultiplex, clock recovery and timing, etc.

IEEE

Institute for Electrical and Electronics Engineers. This refers to a standards writing organization that organizes committees and oversees the development and publication of standards, including standards for network interfaces, communications protocols, and other communication technologies.

ILECs

The incumbent local exchange carriers

III-V

"Three-five." Refers to compound semiconductors fabricated with elements having three and five valence electrons - elements from groups III and V of the periodic table. Examples include the GaAlAs and GaAs material systems used to fabricate lasers in the short-wavelength window of fiber (about 800 nm) and the InGaAsP material system used to fabricate "long-wavelength" semiconductor lasers and detectors for use in the 1300 and 1550 windows of optical fibers.

IM-DD

Intensity modulated direct detection. Refers to a system in which the laser is directly modulated by varying the injection (input) current above threshold and the signal is directly received by a photodetector-based unit. This is the conventional modulation and detection scheme in commercial single-mode systems. Alternatives used in some applications include external modulation of lasers and coherent detection.

Intrastate Access Service

Provides for a two-point communications between a customer's premises or a collocated interconnection location and an end user's premises for originating and terminating calls within the same state.

IOF

Interoffice facilities. Refers to cable and equipment installed for transmission between switches in U.S. local exchange carriers' networks. "IOF" is a Bellcore term and is usually used in reference to the regional Bell companies networks.

ISDN

Integrated services digital network. Refers to a standard for the simultaneous transmission of voice and data, including digital video, over telecom networks. ISDN is a switched service, and the technology was developed to use existing copper-based loop facilities.

ITS

Intelligent transportation system. Formerly referred to as "intelligent vehicle highway systems" (IVHS). ITS is a broad group of systems for monitoring and controlling traffic flow on highways, bridges, tunnels, parking areas, airport access, and others. The technology includes a communications backbone which can utilize fiberoptic transmission, as well as remote video cameras, sign controls, and other systems that can be operated remotely from a control center via fiber.

IRU

Indefeasible Right of User. A measure of currency in the underseas cable business. Someone owning an IRU means he has the right to use the cable for the time and bandwidth the IRU applies to. An IRU is to a submarine cable what a lease is to a building.

ITU

International Telecommunications Union. An international organization dating back to 1865 and rechartered in 1947 as an agency of the UN. It is responsible for international regulations, standards, technical R&D, and various types of planning and support for its members, which include PTTs, government organizations, and other telecom organizations. The ITU publishes various reports summarizing the status of worldwide telecom developments, including documentation of telecom "indicators."

IXC

Interexchange carrier. Refers to long-distance companies such as AT&T, MCIWorldCom, and Sprint in the U.S., and refers to facilities-based inter-LATA carriers.

Kbps

Kilobits per second. One thousand bits per second.

LADT

Local Area Data Transport. A method by which customers will send and receive digital data over existing customer loop wiring.

LAN

Local area network. Refers to an on-premises data communication network, usually for linking PCs together or linking PCs to a file server and other data processing equipment.

LATA

An acronym for Local Access and Transport Area established pursuant to the Modification of Final Judgement entered by the United States District Court for the District of Columbia in Civil Action No. 82-0192 for the provision and administration of communications services.

Long-haul Network

Long-distance telecom network or installations. The long-distance application typically uses the highest performance equipment and cable.

LEC

Local exchange carrier. The local phone companies, which can be either a regional Bell Operating Company (RBOC), or an independent (e.g., GTE) which traditionally had the exclusive, franchised right and responsibility to provide local transmission and switching services. With the advent of deregulation and competition, LECs are now known as ILECs (Incumbent Local Exchange Carriers).

LED

Light Emitting Diode. A semiconductor light source without the coherent properties of a laser diode.

L-H

Long-haul. Used to refer to long-distance telecom network carriers or installations. In the U.S., also called interexchange. The long-distance application typically uses the highest performance equipment and cable.

Loop

The connection between a telephone company's exchange or serving office and the subscriber's premises. The loop facilities include all cable, structures, and equipment

needed to provide this connection. Fiber can be used for part of the loop, such as the link to a remote terminal in fiberoptic feeder systems, to a node in HFC systems, or to an ONU in FTTC systems. Fiber also can be used for the entire loop, so that there is no copper transmission path between a CO and the subscriber—a home or business. The expression “fiber-in-the-loop” sometimes is used for just residential or just HFC/FTTC/FTTH architectures.

LT

Loose tube. Refers to cable type with an oversized buffer tube that typically holds up to 12 fibers, with multiple tubes stranded around the center axis. In OSP cables, the buffer tubes usually are stranded around a central strength member.

LSI

Large Scale Integration

MAC

Media Access Control

MAN

Metropolitan Area Network. Refers to networks linking different buildings or locations within the same city. Can refer to a service offering of the local exchange carrier or a CAP, or it can be a private network based on dedicated or leased facilities.

Mbps

Megabits per second. Million bits per second.

Mobile/Wireless Communications

Services that include cellular, wireless data and personal communications services.

MMDS

Multichannel multipoint distribution service. Refers to a microwave technology for delivering television or other entertainment video programming as an alternative to fiber or coaxial based cable systems. In 1995 it was being pursued as an alternative to HFC deployment by some telephone companies seeking a cost-effective technology for competing with cable TV operators.

MOCVD

Metal organic chemical vapor deposition. A semiconductor deposition process used for epitaxially “growing” wafers by depositing layers of compound semiconductor materials, such as the III-V compounds in diode lasers. The epitaxial layers result from a chemical reaction between gas-state compounds of the constituent III and V elements.

MPEG

Moving Pictures Experts Group. Refers to group responsible for standardizing video compression technology under ISO and IEC supervision. Also used to refer to the standard itself, which defines the algorithm used to compress digital video so that less bandwidth is needed to transport full-motion video. MPEG-1 defines a standard for delivering video and audio on a compact disk, which bitrates of 1.2 Mbps for video and 250 kbps for stereo audio. MPEG-2 is for higher-quality images in transmission applications not limited to CD-system bandwidth. MPEG-2 supports interlaced video in systems with bit rates of 3 Mbps or higher. MPEG-1 was published in 1993. The MPEG-2 standard has been adopted and as of November, 1998, MPEG-4 reached the application identification phase of standards review.

MQW

Multi-quantum well. Refers to a semiconductor device technology used to fabricate diode lasers and other optoelectronic active devices. The devices consist of stacked quantum-well layers, which are fabricated by building semiconductor layers with a thickness as little as 1 μm to achieve quantum traps for electrons or holes. Typical devices have active layers and blocking layers stacked up. MQW technology can offer advantages in efficiency and therefore cooling.

MSO

Multiple system operator. Refers to companies that own and operate more than one CATV system. Examples include TCI, Time Warner, Cox, Cablevision, etc.

Multimedia

A system, or a service, or a set of services characterized by two-way communications, interactive services, and the ability to combine data, voice, and video.

Multimode

This refers to the propagation quality of transverse electromagnetic waves in a medium. Inside an optical fiber, multimode refers to the simultaneous transmission of several electromagnetic waves that interact with each other. Emerging from an active device, multimode refers to the multiple wavefront spatial quality of the electromagnetic beam.

NEC

National Electrical Code. In the U.S., the National Fire Protection Association has established fire and safety requirements known as the National Electrical Code (NEC). One "article" of the NEC code establishes three levels of safety codes for fiberoptic cable as follows:

- 1) OFN - General purpose cables that are satisfactory for use in building wiring but not in plenums or riser shafts. The cables satisfy a test known as UL 1581 Vertical Tray Flame Test.

- 2) OFNR - Riser-rated cables, that are designed to prevent the spread of fire from one floor to another floor in a multi-story building. The cables satisfy a test known as UL 1666.
- 3) OFNP - Plenum-rated cables, that are designed for use in ducts and plenums without the use of conduit. The cables satisfy a test known as UL 910, the "Steiner Tunnel Test," and are suitable for fire-resistance, low-smoke, and low-toxicity.

Network Access

Linkage to a wired or wireless network.

NGDLC

Next generation digital loop carrier. Refers to DLC systems developed in the late 1980s with the ability to connect directly to a digital switch using high-bandwidth digital interfaces. This eliminates the use of channel banks or terminals for converting from analog to digital in the central office. In the U.S., NGDLC systems comply with key Bellcore specifications (TR-008 or TR-303) for the interface to the switch. Another key feature of NGDLC systems is the use of SONET technology for transporting the multiplexed carriers into the loop, to the remote terminal.

Node

Device in a hybrid fiber-coax (HFC) system which converts optical signals on fiberoptic cable to electrical signals on coaxial cable to the subscribers' premises. Placed at the end of the fiberoptic cable in a local serving area, typically with 200 to 2,000 homes.

Non-zero DS

Refers to an improved type of dispersion-shifted fiber in which dispersion at 1550 nm is substantially reduced compared with conventional single-mode fiber, but dispersion is not zero at 1550 nm. This fiber was designed to overcome the possible risk of "four-wave mixing," which is an effect that can degrade transmission quality in WDM systems having multiple channels in the 1550-nm window.

NVOD

Near video-on-demand. Refers to a service offering being developed for providing a menu of video selections without having to switch each channel to each user. One strategy is to start the same program at intervals (say 10 or 15 minutes) on different channels. If a network operator has hundred of channels available, he can offer a menu with many programs. Each program would have enough channels allocated to it so that it can be shown at the various start times.

OC-1

Optical carrier level one. Refers to the basic line-rate in the SONET hierarchy of line rates. All higher-speed rates are integral multiples of OC-1, which is 51.84 Mbps.

OLT

Optical Line Terminal. Terminal equipment residing in a central office or in a remote terminal of a digital loop carrier system located some distance from the central office. It transmits signals to and receives signals from the Optical Network Units (ONUs) in a Fiber-to-the-Curb system. Signals are transmitted in digital format via fiberoptic cable connecting the OLT and the ONUs. "OLT" is used in the Full-Service Access Networks Initiative of which NTT is a member. In the U.S., the OLT is known as the "host digital terminal" or "HDT."

ONU

Optical network unit. Refers to the equipment in an FITL system where the fiber is terminated and the optical signal is converted to an electronic signal. The ONU is located at the home for FTTH and at the curb for FTTC.

OPGW

Optical fiber ground wire. Refers to an aerial cable designed for use on high-voltage transmission towers of electric power companies. Such high-voltage spans operate with a static wire or ground wire to carry lightning or other spikes to ground. OPGW is a fiber-containing alternative to conventional static wire. OPGW adds a communications capability to the grounding function.

Opto-Electronics

The range of materials and devices that generate light, detect light, or control light.

OSP

Outside plant. Refers to all telephone company cable and equipment outside of the central office and operations centers.

OTDR

Optical time domain reflectometer. An instrument for analyzing fiber that can be used to locate faults and to assess splices and connector interfaces. It operates by launching a pulsed laser input into the fiber under test, then detecting and analyzing the return signal that results from reflections and backscattering phenomena.

PBX

Private Branch Exchange. A private phone system owned by a customer, which allows communication within a business and between the business and the outside world.

PCS

Personal communications services. Used commonly to refer to portable/mobile technology based on micro-cell technology. Also called personal communications network. (PCN).

PDFA

Praseodymium-doped fiber amplifier. An optical amplifier based on the use of a fiber-gain medium doped with praseodymium to achieve use gain characteristics in the 1300-nm wavelength region.

PDH

Plesiochronous digital hierarchy. Refers to multiplexed transmission systems that operate without a uniform source of signal timing, as do synchronous systems, such as SONET and SDH. The plesiochronous hierarchy has no detailed line-interface standard, and different hierarchies have been used in different regions and countries. Further, there is no bit rate defined above 140 Mbps in the plesiochronous hierarchy. For these reasons, SDH (SONET) is considered an improvement, and SDH is replacing PDH for high-bit-rate telecom transport systems throughout the world. The European digital hierarchy is based on the E-1 standard bit rate of 2.048 Mbps. The widely used transmission speeds in this hierarchy are 2, 8, 34, and 140 Mbps.

PHS

Personal Handyphone Service. Refers to a PCS technology developed in Japan and introduced to the Japanese telecom market in 1995.

Pigtail

A length of fiber attached to a device so that it can be spliced into the network. The pigtails on some active devices also may have a connector interface. If one is comparing the cost of pigtailed devices, it is important to check the specifications to see if a connector is included, and if so what the connector specifications are.

PIN

Positive-intrinsic-negative. Refers to a junction diode structure with p-type and n-type doping that is used for a wide family of light-detection devices. Such detectors are often called "PIN diodes."

Plenum Cable

This type of cable meets specifications for plenum ratings (UL-910 or FT6), and is one of three types installed in premises networks. Multimode plenum cables have tight-buffer construction and are suitable for installation in horizontal and building backbone network segments.

POF

Plastic Optical Fiber.

PON

Passive optical network. Refers to a fiber-in-the-loop system technology that uses passive optical splitters to share the cost of the downstream transmission laser among many subscribers. High split ratios—up to 128:1—have been achieved, and even higher ratios have been researched and demonstrated using EDFAs. The technology

includes a time-division-multiple access scheme for combining the upstream transmissions together on the passive optical network.

POP

Point-of-presence. Refers to a facility with equipment for putting communications traffic onto a long-distance network or for taking traffic off the network and routing it to its local destination. POPs can have switches, cross-connects, or add/drop multiplexers. An add/drop mux is typical for most POPs.

PORT

The access point for competitive carriers to get a connection to the switch and a telephone number. A combination of office equipment and software are used to provide the connection to the network.

POTS

Plain old telephone service.

PSTN

Public switched telephone network.

PTO

Public Telephone Operator. Refers to former PTTs that have been partially or fully privatized; i.e., the national government has divested (sold) part or all of its ownership interest in the PTT to public shareholders, other investors, and/or foreign telecom operators.

PTT

Post, Telephone, and Telegraph. Refers to government-owned or government-run network operators, usually monopoly operators. An example is Deutsche Telekom in Germany. A dominant trend that began in the 1980s is the privatization of the PTTs, meaning that the government divests its interest and "sells" ownership to public shareholders or other investors. This is typically accompanied by "liberalization" of the telecom market, meaning that guidelines for competition are established.

RBOC

Regional Bell Operating Company.

Repeater

Refers to a unit of equipment in a fiberoptic transmission route for boosting the optical signal so that a longer distance can be spanned.

Resale of Service

The process of purchasing telephone lines and facilities, usually in bulk, and reselling those facilities to individual customers. While some restrictions exist for the resale of residential local service, there are fewer restrictions for business service or long-distance.

Return Path

Transmission from a node in the distribution network toward the head-end. Also known as "upstream."

RF

Radio frequency. Refers to analog signal processing and transmission technology for applications that include CATV. The term "RF" is sometimes used to refer to electronic or coaxial part of hybrid fiber coax systems in CATV and other broadband applications.

Riser cable

Cable designed for use in elevator shafts, utilities columns, or other vertical shafts in multi-story buildings. Because the cable connects different floors of multi-story buildings, it must be designed to meet safety codes that specify a low level of flammability. Riser cables are also used in telephone company central offices to connect the equipment with the outside-plant cable, which enters a "vault," which is usually below grade.

SDH

Synchronous digital hierarchy. The international standard for synchronous optical transmission, defined by CCITT to be technically comparable to the North American SONET standard. SONET and SDH technology has several consequences on the cable market. One is that add/drop multiplexers and other units of equipment have been developed for use in a cable system configured as a ring, which can mean more fibers per cable, or more route km to link two points. Also, SONET and SDH standards are defined for high bit rates where dispersion-modified fibers may be necessary, depending on the distance spanned.

SDV

Switched digital video. Refers to technology for providing video services in loop or distribution networks. Typically, SDV is associated with fiber-to-the-curb and contrasted with HFC networks. This contrasts with HFC, which "broadcasts" the signal to all subscribers.

SONET

Synchronous optical network. A standard - or more specifically a set of standards - for synchronous transmission. The standards include signal rates, formats, and optical and electrical interface specifications. The standards organization is ANSI. The international counterpart of the SONET standards is SDH. See "SDH" for reference to the impact of SONET / SDH technology on cable markets.

Source

Short for "optical source." Used to refer to a light source used with single-mode fiber—mainly to acknowledge that not all applications use lasers. Some use ELEDs. Therefore, the term "source" in most cases can be understood as "lasers plus ELEDs."

Switched access

Access to the switched network of an exchange for the purpose of originating or terminating communications. Switched access is available to carrier only.

Switching Equipment

Equipment that makes connections on a per-call basis between two or more circuits, services, or communications systems.

TDM

Time-division multiplexing. Signaling technology in which two or more signals can be transmitted over the same path by using different time slots or intervals for each signal. In telecommunications, this is done with digital signals so that packets from two or more lower-speed digital signals are interleaved into time slots on a higher-speed multiplexed signal. In TDM fiberoptic systems, the digital signals are multiplexed electronically so that resulting aggregated or multiplexed high-bit-rate signal is transmitted over fiber as a single high-speed signal. After it is received and converted to an electronic signal, it is demultiplexed electronically into the two (or more) original signals.

Telco

Telephone company. A term from the telephone industry jargon. It usually refers to a local exchange carrier but it is not precise and also can refer to long-distance carriers.

Teledensity

An indicator that shows the extent that a country's telecommunications infrastructure has been built up to serve the country's populace. It is usually expressed as the number of lines per 100 population.

Telephone network

A system of electronic switching devices, computers and lines that provide voice, data, and video communication among customers throughout the world.

Token ring

This IEEE transmission protocol standard connects each end user to a node, and transfers data packets around to each node on the ring network using a bus to avoid the collisions associated with Ethernet.

Transceiver

A module containing both a transmitter and receiver. A "transceiver" is an example of a "transmitter/receiver pair" but other examples have separate packaging for the transmitter and the receiver.

Trunk

Connections between telephone company offices or switch locations. The application usually is a long-distance application of fiberoptics. The term also used in the CATV industry to refer to links between head-ends.

Twisted pair

Phone wiring consisting of two copper wires twisted around each other. Modern technology can load it up with lots of data and video over short distance. See TWP.

TWP

Twisted pair. Refers to a wide class of copper communication cables.

Tx/Rx pair

Transmitter/receiver pair. An abbreviation used to note the number of "transmitter/receiver pairs" in the market for a specific application or customer group. A transmitter/receiver pair consists of one transmitter (laser) plus one receiver (detector). They can be in a combined "transceiver" module or packaged separately.

Upstream

Transmission direction from the subscriber towards the central office or headend.

VCSEL

Vertical cavity surface-emitting laser. Refers to a laser diode structure designed to emit the optical radiation in a vertical direction relative to the plane with the active region. Most diode lasers emit from end facets in the plane of the active region. Vcsels are credited with multiple innovations in the fiberoptic industry.

VOD

Video on demand.

VPN

Virtual Private Network

WAN

Wide area network. Refers to a network that uses switched long-distance, dedicated, or leased facilities to link two or more locations in different cities for data or other applications.

WDM

Wavelength-division multiplexing. The simultaneous transmission of more than one optical signal through an optical fiber with each signal having a distinct wavelength. WDM technology is typically used to increase system capacity by adding channels at different wavelengths. WDM devices are the multiplexers that combine the multiple optical input channels into a single fiber and the demultiplexers that separate the signals of different wavelengths at the receive end. See also "DWDM".

Wireline

Describes telecommunications network or links based on cable—either copper, coax, or fiberoptic—to differentiate such networks from cellular, microwave, PCS, satellite or other “wireless” networks.

Zero Dispersion Wavelength

The wavelength at which a fiber’s chromatic dispersion equals zero.