
Glossary of Terms and Abbreviations

Last update: December 5, 2003

Please e-mail suggestions or requests for additional definitions to grover@ece.ualberta.ca.

Add/Drop Multiplexer (ADM) A network element with two high-speed (also called line-rate) interfaces capable of extracting or inserting lower-rate signals from or to the higher-rate multiplexed line-transmission signal.

AIS (Alarm Indication Signal) Also called an Alarm Inhibit Signal. A special bit pattern sent by equipment at the far end to indicate that an alarm system exists upstream in a circuit leading to the downstream equipment.

APS Automatic Protection Switching.

Asymmetric Digital Subscriber Line or ADSL A technology that allows a high data rate to be sent over existing copper telephone lines. ADSL supports data rates of from 1.5 to 9 Mbps when receiving data (known as the downstream rate) and from 16 to 640 Kbps when sending data (known as the upstream rate).

(Line) Amplifier A device used to boost the strength of an electronic or optical signal, which is weakened (attenuated) as it passes through the transport network. Amplifiers add gain to the signal by an amount roughly equal to the loss in the previous section of the network since last amplification.

ATM (Asynchronous Transfer Mode) The CCITT (now ITU) standard for cell relay wherein information for multiple types of services (voice, video, data) is conveyed in small, fixed-size cells. ATM is a connection-oriented technology used in both LAN and WAN environments. ATM permits several applications to one high-speed digital line or connection through

the network by adapting each native signal format into a series of ATM cells and statistically multiplexing the cells. Routing is accomplished by label switching.

Attenuation A term used for expressing the total loss of an optical system, normally measured in decibels (dB) at a specific wavelength. The decrease in magnitude of optical power of a signal as it travels along a fiber.

Attenuation Coefficient The rate of optical power loss with respect to distance along the fiber, usually measured in decibels per kilometer (dB/km) at a specific wavelength.

Attenuator A passive optical component that intentionally reduces the optical power propagating in a fiber.

Avalanche Photodiode (APD) A photo diode that includes internal amplification so that very weak light pulses are easily detected. It is used in receivers requiring high light sensitivity.

Backbone Network The main artery or link for a private or public network. Typically, the backbone is capable of carrying significant bandwidth and transmits the lion's share of traffic (data, voice and video). It is the network to which small/remote networks/links are attached.

Band A range of frequencies between two defined limits. Bands are often predefined and referred to by an agreed name, for example the C-band of optical wavelengths.

Bandwidth A measure of the range of frequencies that a transmission medium will pass without exceeding predefined limits on loss, delay, distortion, noise or other performance measures. Bandwidth has units of Hertz. See Related Narrowband, Wideband.

Bandwidth on Demand (BoD) Dynamic allocation of line capacity to active users.

Baseband Transmission In baseband transmission the entire bandwidth of a medium (such as coaxial cable) is utilized with frequencies beginning near 0 Hertz and up as required by the signals power spectrum. In the electrical domain the binary digit sequences carried on fiber optic networks are baseband signals. Once these pulses drive a laser to convert them to the optical domain the payload signal resides on an optical carrier wavelength and is then considered as a narrow pass-band signal rather than a baseband digital signal.

BFS Bread-first Search.

Bit Error Rate (BER) Specifies the expected frequency of binary transmission errors. It is the ratio of incorrectly transmitted bits to correctly transmitted bits. On fiber systems 10^{-12} is a typical BER requirement for a system in normal operation. An increase in BER to 10^{-9} or 10^{-6} can be very rapidly detected in the receiver and other than loss-of-signal, is the main form of detecting degradation that would trigger an alarm and related protection switching or restoration actions.

BGP or Border Gateway Protocol A routing protocol used in inter-domain routing in large networks to maintain integrity of the network. It allows the routers to exchange only pre-specified information with pre-specified routers in other domains.

BLSR (Bidirectional Line Switched Ring) A BLSR is a type of protected transmission system in which each span, arranged in a ring, has 1:1 APS loopback access to an identical bidirectional protection ring.

Bridge A data communications device that connects two or more network segments and forwards packets between them. It also amplifies the carrier signal, and accepts data packets, (perhaps buffering them during periods of network congestion) and forwards them.

Broadband A transmission channel usually carrying information at transmission speeds of 44.736 Mbps (DS-3) or 34.368-Mbps (E3). 45 Mbps or greater.

Broadband ISDN (B-ISDN) A set of standards that supports switched, semi-permanent and permanent point-to-point and point-to-multipoint connections and provides on-demand, reserved and permanent services at speeds higher than T-1 (1.5 Mbps). The physical layer transmission standard for B-ISDN is SONET.

Capacity The information-carrying ability of a transmission system or span as defined by its design and its deployed equipment and measured in bits per second or multiples of standard transmissions rates such as DS-3s, STS-1s or wavelengths, for example. In practice the capacity of a transmission system is incremented in discrete units, such as DS-3's and STM-1's.

Carrier A third party provider of communications services by wire, fiber or radio. Common Carrier: A private company offering facilities or services to the general public on a non-discriminatory basis and regulated as to market entry, practices, and rates by various governing authorities.

Central Office (CO) A local telephone company building that houses switching equipment to route telephone calls and/or cross-connect equipment for transmission networking. Central Office Equipment (COE): Telecommunications equipment, such as switches, cross-connected, power generators, etc., located in the CO.

Channelization The process of subdividing the bandwidth of a circuit into smaller increments called channels. This process is accomplished through a multiplexer, such as dense wavelength division multiplexers.

Channel A communication path. Multiple channels can be multiplexed over a single cable in certain environments. With services such as ISDN, T-1 and T-3, multiple channels share the same one or two pairs of wires.

Channel Spacing A measure of the frequency by which channels are spaced. This number can be measured in units of frequency or in units of wavelength. For example, a 50-GHz channel spacing in frequency corresponds to approximately 0.4 nm channel spacing in wavelength, based upon a conversion using the speed of light.

Chromatic Dispersion This refers to the spreading (in time) of a light pulse caused by the difference in refractive indices at different wavelengths. In an optical fiber different wavelengths of light travel at different velocities. The chromatic dispersion of a fiber is measured as the dif-

ference in delay over a range of wavelengths per unit distance (ps/nm-km). Although the optical carrier wavelength may be very narrow, the simple act of modulating information on the carrier spreads out the optical signal spectrum, causing smearing in time between successive pulses due to chromatic dispersion. This effect is one of the main reasons electrical 3R regeneration is eventually required. Chromatic dispersion is the sum of material and waveguide dispersion. Dispersion can be positive or negative because it measures the change in the refractive index with wavelength.

Churn The term used to describe turnover in subscribers of various media such as magazines, newspapers, cable and telephone services. The notion of churn in the transport network relates to how dynamic or frequently changing the connection requirements are (and, hence, how accurate any given forecast of future demand can actually be).

Circuit Switching Switching system in which a dedicated physical circuit path must exist between sender and receiver for the duration of the “call.” Used heavily in the telephone company network, circuit switching often is contrasted with contention and token passing as a channel access method, and with message switching and packet switching as a switching technique. Circuit switching or its cell-based label-switched virtual-circuit analogy is so far the basis of all transport networking. Circuit switching at the voice-call level is, however, being increasingly replaced by packet switching (see VoIP).

Common Channel Signaling 7 (CCS7) An ISDN signaling protocol that allows for fast call setup and transaction capabilities such as call forwarding, call waiting, call screening and call transfer outside the switch to the full network. The CCS7 signalling network has especially high requirements for availability and survivability because it is used to signal the setup and takedown of all 64-kb/s network connections as well as additional routing and management functions crucial to operation of the public switched telephone network (PSTN).

Common Language Equipment Identifier (CLEI) Codes assigned by Telcordia Technologies to provide a standard method of identifying telecommunications equipment in a uniform, feature-oriented language. It is a text/barcode label on the front of all equipment installed at Regional Bell Operating Company (RBOC) facilities that expedites inventory, maintenance, planning, investment tracking and circuit maintenance processes.

Common Language Facility Identification (CLFI) Codes that provide unique identification of facilities (cables and carrier systems) between any two interconnected CLLI-coded locations.

Common Language Location Identification (CLLI) L Pronounced “silly” codes, these are standard identifiers for physical locations and equipment such as buildings, central offices, poles and antennae. It is used by telcos to identify and order private lines, and to trap and trace annoying or threatening calls. In the book nodes and spans of networks are typically just given arbitrary numbers for reference. In the real world nodes have CLLI codes and transmission facilities have CLFI codes.

Consultative Committee for International Telegraph and Telephone (CCITT) The former name of an international organization that develops communications standards such as Recommendation X.25. Now called International Telecommunication Union –Telecommunication Standardization Sector (ITU-T).

Cross Connect 1. Historically, and still in common use when wiring telephone or LAN cabling in a building this refers to the process of joining or connecting cabling runs, subsystems and equipment, using patch cords or jumpers that attach to connecting hardware on each end. Cross-connection is the attachment of one wire to another. This is usually done by anchoring each wire to a connecting block, and then placing a third wire between them so that an electrical connection is made. 2. In the more recent context of transport networking cross-connection is the process of automatically making electrical, digital, or optical connections between the signals going on and off of transmission facilities at a node.

CR-LDP Constrained-Route Label Distribution Protocol

Customer Premises Equipment (CPE) Terminating equipment, such as terminals, phones, routers, modems, and/or access multiplexers which are supplied by the phone company, installed at customer sites, but connected to the phone company network.

Dark Wavelength, Dark Fiber Refers to a virtual channel in a fiber optic system utilizing DWDM. Each virtual channel is supported through a specific wavelength of light, with many channels riding over the same fiber. Once the fiber system is deployed and the DWDM equipment is activated, some of the wavelengths may be activated immediately and others may be left dark for future needs. When the need arises, those dark wavelengths are lit up. Dark fiber refers to optical fibers that are physically installed and ready for use but to which no optical payload signal has yet been applied.

Data Centric A network design that is oriented more toward carrying data traffic than carrying voice traffic.

Data Communications Channel (DCC) A SONET term that refers to the channels within section and line overhead, used as embedded operations channels to communicate to each network element.

dBm T10 times the logarithm of the ration of some signals power relative to 1 milliwatt.

Deinterleaver A device used for separating a range of wavelengths from one fiber into odd- and even numbered wavelengths on separate fibers. See also Interleaver.

Demodulation The opposite of modulation; the process of retrieving data from a modulated carrier wave.

Demultiplex The process of separating optical channels. A demultiplexor separates several data streams (or constituent TDM or WDM signals) that were previously combined to share one transmission medium or higher speed channel.

Dense Wavelength Division Multiplexing (DWDM) The higher-capacity version of Wavelength Division Multiplexing (WDM), which increases the capacity of fiber-optic data transmission systems by using different light wavelengths to send multiple streams of data simultaneously over a single fiber. DWDM employs many more than one light source and detector operating at different wavelengths and simultaneously transmits optical signals through the same fiber while message integrity of each signal is preserved.

Digital Signal 0 (DS-0) Worldwide standard transmission rate (64 Kbps) for Pulse Code Modulated (PCM) digitized voice channels. Twenty four DS-0s exist in each DS-1 (T-1) signal.

Digital Signal 1 (DS-1) North American Digital Hierarchy signaling standard for transmissions at 1.544 Mbps. Supports 24 simultaneous DS-0 signals. Term often used interchangeably with T-1, although DS-1 signals may be exchanged over other transmission systems.

Digital Signal 3 (DS-3) Equivalent to 28 T-1 channels, and operating at 44.736 Mbps. It is also frequently called T-3.

Digital Subscriber Line (DSL) A copper-loop transmission that enables high-speed access in the local loop.

Digital Subscriber Line Access Multiplexer (DSLAM) A technology developed to concentrate traffic in ADSL implementations through a process of Time Division Multiplexing (TDM) at the CO or remote line shelf.

DFS Depth-first search.

DW Digital Wrapper. A scheme that adds many SONET-like overheads for advanced signaling and control function to an optical carrier signal. Unlike SONET however, DW overheads include FEC and are applied in a way that retains digital payload transparency.

Dynamic Range In a transmission system, the difference between the launch signal level at the interface to the fiber under test and the sensitivity or noise floor level of the receiver. The ratio of the specified maximum level of a parameter (e.g. power, voltage, frequency or floating point number representation) to its minimum detectable or positive value, usually expressed in decibels.

E-1 Similar to the North American T-1, E-1 is the European format for digital transmission. E-1 carries signals at 2.048 Mbps (32 channels at 64Kbps), versus the T-1, which carries signals at 1.544 Mbps (24 channels at 64Kbps). E-1 and T-1 lines may be interconnected for international use.

EDFA (Erbium-Doped Fiber Amplifier) A purely optical (as opposed to electronic) device used to boost an optical signal. It contains several meters of glass fiber doped with erbium ions. When the erbium ions are excited to a high energy state, the doped fiber changes from a passive medium to an active amplifying medium. The EDFA is currently dominant technology for all-optical signal amplification. Because EDFAs provide gain over a wide band of

optical frequencies, transmission rates and optical carrier numbers can be upgraded without replacing the entire transmission system.

ELT Expected (usually Annual) Loss of Traffic.

Ethernet A baseband Local Area Network (LAN) specification invented by Xerox Corporation and developed jointly by Xerox, Intel and Digital Equipment Corporation. Ethernet networks operate at 10Mb/s using Carrier Sense Multiple Access/Collision Detect (CSMA/CD) to run over coaxial cable. Ethernet is similar to a series of standards produced by IEEE, referred to as IEEE 802.3.

Extra Traffic A term referring to the feature or practice of allowing lower-priority services to ride on the protection capacity of a protected transmission system. The unused standby capacity for protection is used for the “extra traffic” but the latter may be bumped off if the intended main working channels need the protection capacity to recover from a failure.

Fault Tolerance The ability of a system to respond gracefully to an unexpected hardware or software failure. There are many levels of fault tolerance, the lowest being the ability to continue operation in the event of a power failure.

Federal Communications Commission (FCC) The federal organization in Washington, D.C., set up by the Communications Act of 1934. It has the authority to regulate all interstate (but not intrastate) communications originating in the United States. The FCC is the U.S. federal regulatory agency responsible for the regulation of interstate and international communications by radio, television, wire, satellite and cable.

FDDI, Fiber Distributed Data Interface An ANSI standard for a 100Mb/s fiber-optic LAN backbone system, using a Token Ring passing access method.

Fiber Kilometers The number of route kilometers installed multiplied by the number of fiber strands along the path.

FEC (Forward Error Correction) A technique of error detection and correction, in which the transmitting host computer includes a number of redundant bits in the payload (data field) of a block or frame of data. The receiving device uses these bits to detect, isolate and correct any errors created in transmission. The idea of forward error correction is to avoid retransmitting information that incurred errors in network transit. FEC is used as part of the system design of virtually all fiber optic transmission systems at the OC-192 (10 Gb/s) or higher rate because of the latitude it gives in terms of power margin and the elimination of error-rate floors due to laser noise, clock recovery jitter and other practical imperfections in implementing circuits and devices to operate at such high speeds.

FEC (Forwarding Equivalence Class) In a router, an FEC is effectively a list of all IP destination addresses for which the forwarding decision is to send packet out via the same local egress port. All such IP addresses are locally equivalent in that the action of the router is the same—to send them out the same local port.

Full Duplex The simultaneous transmission of data in both directions, used when communicating between two computers.

Gbps (Gigabits per second) A data rate of 1 Gbps corresponds to 1,000 million bits per second.

GLBN Generalized Loopback Network.

GMPLS Generalized Multi-protocol Label Switching

Head-End Bridge In APS systems (or in BLSR rings), the head-end is a reference to the upstream end of signal flow in each direction at the entry to a protection section. To set up a head-end bridge means to copy the signal going into a normal working channel onto the protection or standby channel at the same time. Bridging does not interrupt the main working signal.

High Level Data Link Control or HDLC A generic link layer protocol standard for point-to-point and multi-point communications that is bit oriented and in which control codes differ according to their bit positions and patterns.

High Performance Parallel Interface or HIPPI HIPPI is used to network supercomputers, high-end workstations and peripherals using cross-bar type circuit switches. It provides for transfer rates of 800 megabits a second over 32 twisted pair copper wires (single HIPPI) and 1600 megabits a second over 64 pairs (double HIPPI).

IP Internet Protocol.

IP Integer Programming. Note because of the confusion between IP as Internet Protocol and Integer Programming (as well as Intellectual Property), a recommended use is ILP instead of IP for Integer Programming.

ILP Integer Linear Programming.

ISP Internet Service Provider. ITU (International Telecommunications Union) The ITU is an intergovernmental agency of the United Nations within which the public and private sectors cooperate for the development of telecommunications. The ITU adopts international regulations governing the use of the radio spectrum and develops standards to facilitate the interconnection of telecommunications systems on a worldwide basis. It is headquartered in Geneva, Switzerland. In 1996, the ITU comprised 185 Member States and 363 members (scientific and industrial companies, public and private operators, broadcasters, regional and international organizations active in three sectors: Radio communications, Standardization and Development).

ksp k-shortest paths. Usually loopless is implied.

Latency The amount of time it takes a packet to travel from source to destination. Together, latency and bandwidth define the speed and capacity of a network.

LMP Link Management Protocol.

Local Loop The physical facility, leased from a local exchange carrier (LEC), which provides connectivity between the customer's location and the carrier's point of presence.

LCAS Link Capacity Adjustment Scheme. A proposed extension to SONET protocols that allow the total payload capacity of an OC-48 transport system to be more flexibl partitioned and allocated to different end applications.

LP Linear Programming.

MCMF Multi-commodity Maximum Flow.

Mbps (Megabit per second) One Mbps corresponds to a data rate of 1,000,000 bits per second.

MPLS Multi-protocol Label Switching.

MP λ S "Pronounced MP lambda S. MPLS where the switched connection resource is specifically a wavelength-channel.

Multicasting The ability of one network node to send identical data to a number of end servers on the multicast backbone. For large amounts of data, IP multicasting is more efficient than normal Internet transmissions because the server can broadcast a message to multiple recipients simultaneously.

Multiplexing An electronic or optical process that combines two or more lower bandwidth transmissions onto one higher bandwidth signal by splitting the total available bandwidth into narrower bands (frequency division) or by allotting a common channel to several transmitting sources one at a time in sequence (time division).

Multipoint Pertaining or referring to a communications line to which three or more stations are connected. It implies that the line physically extends from one station to another until all are connected.

MultiProtocol Label Switching or MPLS MPLS is a widely supported method of speeding up data communication over combined IP/ATM networks. This improves the speed of packet processing and enhances performance of the network⁴

Narrowband: (1) In telecom contexts, Less than or equal to 64-kbps. (2) In circuit design or signal theory, a signal with spectral occupancy (or bandwidth in Hz) that is small relative to its absolute center frequency in Hz.

OXC Optical Cross-connect.

OADM Optical Add-drop Multiplexor.

O.R. Operations Research.

OSPF Open Shortest-Paths First protocol. This is the main protocol used in the Internet for topology discovery, synchronization of link state databases in every node, and Link State Advertisements (which drive topology discovery). Once a global topology view is obtained in each

OSPF-enabled node a local computation of the shortest path from the current node to all other nodes is performed and used as the basis of defining the Forwarding Equivalence Classes that constitute the local routing table. Open refers only to the fact that the protocol is based on open source implementation code.

OSPF-TE An extension to OSPF to include “traffic engineering” considerations. Whereas OSPF involves only the existence of links and a single routing cost associated with each link, OSPF-TE disseminates much more specific information about available capacity and local resources on links such as multiplexing and protection options associated with links. The intent is to allow “capacity aware” applications such as lightpath provisioning or protection routing context, in contrast to simple routing decisions in the IP context.

OC-n A SONET STS-n rate signal in the optical carrier domain. Example OC-48 refers to an optical SONET-format signal with STS-48 format, equivalent in capacity to 48 STS-1s.

O/E, o/e, or O-E, o-e Opto-electronic (conversion).

OEO pronounced “oh-e-oh”: Optical-Electronic-Optical. Usually to describe an OXC in which switching of optical paths is done via an electronic switching matrix.

OOO or ooo: pronounced “oh oh oh” stands for Optical-Optical-Optical, in other words in comparative reference to OEO, it refers to an all-optical switch or all-optical OXC.

Packet Generic term for a bundle of data, organized in a specific way for transmission. A packet consists of the data to be transmitted and certain control information, including the destination address.

Packet Switching A process where messages are broken into finite-sized packets that are always accepted by the network. The message packets are sent across different circuit paths. The packets are reassembled into the original message at the end of the circuit.

PDH Plesiochronous Digital Hierarchy. A reference to the original (pre-SONET) hierarchy of DS-0, DS-1, DS-2, DS-3 signal formats using bit-stuffing pulse justification for multiplexing. The respective line rates are 64 kps, 1.544 Mbps, 6.312 Mbps and 44.736 Mbps.

Point of Presence (POP) The physical location within a LATA where an interexchange carrier's circuits interconnect with the local lines of telephone companies in that LATA.

Protocols Computer rules that provide uniform specifications so that computer hardware and operating systems can communicate.

Repeater 1. Equipment that receives a low-power signal, possibly converting it from light to electrical form, amplifying it or retiming and reconstructing it for transmission. It may need to be reconverted to light for retransmission. 2. An opto-electrical device used at each end and occasionally intermediate points of exceptionally long fiber optic span. Optical input is converted to electrical form to restore a clean signal, which drives lasers that fully restores the optical signal at the original signal strength.

Regeneration (3R Regeneration) “3R” stands for Retime, Reshape and Retransmit. These are the three main functions of a digital or optical repeater. Amplification with output limiting is sometimes called “2R” regeneration because the limiting action reshapes the pulse stream and it is then retransmitted. Optical amplification today is, however, intended to be as linear a process as possible. If optical output limiting (saturation starts to occur there can be nonlinear intermodulation effects between signals of different carrier wavelengths.

Reversion Following a failure and protection or restoration actions, reversion is the process of returning the restored signal to the ordinary (pre-failure) signal path following physical repair of the original failure element. In other words it is part of the return-to-normal process.

RPR Resilient Packet Ring.

ROADM Reconfigurable Optical Add-drop Multiplexor.

RWA Routing and wavelength Assignment.

SBPP Shared Backup Path Protection.

SLSP Short-leap Shared Protection.

STM (Synchronous Transfer Mode) A term for traditional TDM switching used to distinguish it from ATM. Basic SONET is an STM technology.

STM-1 The largest standard circuit unit of capacity, which consists of 155,500 kbps (equal to 155 Mbps). Thus, each Gbps contains enough capacity for 6.4 STM-1 circuits. While capacity is sold to the largest telecommunications companies in minimum investment units equal to one STM-1 unit, most telecommunications companies buy smaller units at a price higher than the equivalent STM-1 price.

SRLG Shared-risk Link Group. A set of channels used for provisioning working path that share a common risk of failure due to a common-cause physical element failure such as a fiber, cable, duct, or bridge crossing, as examples.

Tail-end Transfer In an APS system, tail-end transfer is the process of substituting the signal from the receiving or downstream end of a protection span for the (normally working but now failed) signal out of some regular working channel.

Time Division Multiplex or TDM A technique for transmitting a number of separate data, voice and/or video signals simultaneously over one communications medium by quickly interleaving a piece of each signal one after another.

ULE Unit Lost Erlangs.

UPSR Unidirectional Path-switched Ring.

VoIP VoIP stands for “voice over IP,” which is voice communications transmitted over the Internet.

VC Virtual Concatenation. A form of SONET inverse multiplexing that provides an end-to-end service that is functionally equivalent to any desired STS-n rate where n is any desired number of STS-1 channels, not constrained to be only 3, 12, 48 or 192 as per the dominant conventional transport system offerings.

VP Virtual Path.

VWP Virtual Wavelength Path

Wavelength The distance between two crests of a signal or a carrier and is measured in terms of meters, millimeters, nanometers, etc. In lightwave applications, because of the extremely high frequencies, wavelength is measured in nanometers.

Wavelength Division Multiplexing or WDM A way of increasing the information-carrying capacity of an optical fiber by simultaneously operating at more than one wavelength. With WDM you can multiplex signals by transmitting them at different wavelengths through the same fiber.

WP Wavelength Path. A path through an optical network which has the same wavelength channel on all spans along its route.

Wideband: Digital rates between 64-kbps and 1.544 Mbps (DS1) or 2.048-Mbps (E1)-LANs, bulk files transfer, video conferencing, and multimedia.