Bandwidth is the capacity of a wired or wireless network communications link to transmit the maximum amount of data from one point to another over a computer network or internet connection in a given amount of time -- usually one second. Synonymous with capacity, bandwidth describes the data transfer rate. Bandwidth is not a measure of network speed -- a common misconception.

While bandwidth is traditionally expressed in bits per second (bps), modern network links have greater capacity, which is typically measured in millions of bits per second (megabits per second, or Mbps) or billions of bits per second (gigabits per second, or Gbps).

DS0: The One True Standard

Name	Speed	Consists Of
DS0	64Kbps	1 DS0
DS1	1.544Mbps	24 DS0s
DS2	6.312Mbps	96 DS0s
DS3	44.736Mbps	28 DS1s

DS0 rate was introduced to carry a single digitized voice call. For a typical phone call, the audio sound is digitized at an 8 kHz sample rate, or 8000 samples per second, using 8-bit pulse-code modulation for each of the samples. This results in a data rate of 64kbit/s.

To limit the number of wires required between two involved in exchanging voice calls, a system was built in which multiple DS0s are multiplexed together on higher capacity circuits. In this system, twenty-four (24) DS0s are multiplexed into a DS1 signal. Twenty-eight (28) DS1s are multiplexed into a DS3. When carried over copper wire, this is the well-known T-carrier system, with T1 and T3 corresponding to DS1 and DS3, respectively.

DS1 is a collection of 24 DS0 “channels” packed together in a bundle. That’s 24 separate telephone conversations. The bandwidth for this bundle is 1.536 Mbps. When you add 8 Kbps for synchronization, the total bandwidth is 1.544

Mbps. It's commonly referred to as 1.5 Mbps. A T1 line is a DS1 digital signal package carried on a very specific physical network consisting of 2 pair of twisted pair telco wires with a defined voltage and waveform characteristic.

DS3: If you bundle 28 DS1 signals, the equivalent of 672 DS0 voice channels, you get a DS3. The bandwidth of this signal is 44.736 Mbps, often referred to as 45 Mbps. A T3 line carries a DS3 signal on coaxial cable, although T3 service may also be sent by microwave.

PCM T-Carrier Hierarchy

Digital Signal Designation	Line rate	Channels (DS0s)	Line
DS0	64 kbit/s	1	
DS1	1.544 Mbit/s	24	T1
DS1C	3.152 Mbit/s	48	T1C
DS2	6.312 Mbit/s	96	T2
DS3	44.736 Mbit/s	672	T3
DS4	274.176 Mbit/s	4032	T4
DS5	400.352 Mbit/s	5760	T5

The **DS** in DS1 and DS3 stands for Digital Signal level. It is a designation that is used to specify the capacity of a digital line in the T-carrier system. You know the most popular T-carrier service as T1. Another popular service is T3. In simple terms, DS1 goes along with T1 and DS3 goes along with T3.

There is a very fine point of technical difference between the two. You can get DS1service without a T1 line but if you have a T1 line, you've got DS1. ... A T1 line multiplexes or aggregates 24 of these DS0 channels into a DS1 with a total bandwidth of 1.536 Mbps. But a T1 line runs at 1.544 Mbps.

You can generate the DS digital signal protocol but not necessarily use a T1 line or T3 line for transport. In a process called multiplexing, multiple DS1 and DS3 signals can be combined and transported over fiber optic cable. The SONET fiber optic services were designed to directly accommodate this. The lowest bandwidth SONET service generally available is OC3, which carries 3

multiplexed DS3 signals with a total bandwidth of 155.52 Mbps. When the signals get to where they are needed, they are separated or demultiplexed to get back the 3 DS3 signals, which might be constructed of 28 DS1 signals each.

DSL and T1

A Digital Subscriber Line or DSL is offered to residences in the form of an Asymmetric DSL which means that the download speed is much faster than the upload speed. This type of connection works for a residence because you typically download more than you upload. However, for businesses a symmetrical DSL line is typically used since both the download and upload time are the same.
T1 is similar to symmetric DSL because the upload and download speed are the same. The difference is that a Digital Subscriber Line utilizes Discrete Multitude Modulation which is capable of adapting to a telephone cable where it is shared. The speed of data transfer depends upon how much interference may be present on the line and how far away you are from the central office of the DSL provider. A T1 line remains constant however the cost is significantly higher than DSL the farther away you are from the Internet Service Provider.

DS3 and T3

DS3 is also known as Digital Signal Level 3 and is synonymous with the term T3 so both terms are used to define this type of Internet connection. They both originate from the T-carrier system which was the original system that was used to provide high speed lines between telephone companies. With a digital signal line everything is measured from level 0. A level 0 or DS0 is defined as a single channel running at the speed of 64K bits per second. If you combine 24 of these channels together this makes up a DS1 connection and if you combine 28 DS1 channels this is what constitutes a DS3 line which runs at 44 Mbps (megabits per second). Once you connect the DS3 line to a circuit this is known as a T3 line which provides 672 channels.

OC

OC is also known as Optical Carrier bandwidth and the term “optical carrier” refers to a broadband network that is based on fiber optics. OC bandwidth is offered in a hierarchy due to the measurement of circuit levels in usual increments of 4. Each level of OC bandwidth offers different speeds of data transfer through a difference in the megabits of transfer per second (Mbps).

Optical Carrier lines are typically used for large corporations and Internet Service Providers that require a dedicated Internet connection. The Optical Carrier Level circuits which are offered in different speeds accommodate operations that require high bandwidth such as data centers, educational institutions, research institutions, and any other organization that requires high speed connectivity and a large amount of bandwidth to run daily operations. Here is an overview of the different types of OC bandwidth to provide you with an idea of what it is and how it works.

- **OC-3:** More often than not OC-3 is confused with a T3 connection but the two are actually quite different. T3 utilizes copper wires and a coaxial cable to accommodate the higher data transfer speed as opposed to using telephone wires. An Optical Carrier 3 connection is one of the circuit levels that are defined by the Synchronous Optical Network which is also referred to as SONET. The Synchronous Optical Network is a system that defines fiber optic transmission. OC-3 runs at a speed of 155 Mbps (megabits per second) where a T3 line runs at 45 Mbps which is a significant difference in the speed of data transfer.

- **OC-12:** To understand Optical Carrier 12 bandwidth you must first understand what was explained under OC-3. OC-12 is known as a flexible connection because you can add bandwidth as an organization grows. OC-12 operates at a speed of 622 Mbps and is the equivalent of four OC-3 lines. This is what makes this type of connection ideal for a point-to-point Internet Protocol connection.

- **OC-48:** An Optical Carrier 48 connection is typically used as a backbone for large networks due to its large capacity to accommodate data, voice and video. OC-48 is capable of transmitting data at a speed of about 2.50 Gbps (gigabits per second) which is significantly faster than the two previously discussed OC connections. The speed of an OC-48 connection is the equivalent of 48 T3 lines combined.

SONET Optical Carrier Level	SONET Frame Format	SDH level and Frame Format	Payload Bandwidth Kbps (kilo bits per second)	Line Rate Kbps (kilo bits per second)
OC-1	STS-1	STM-0	50,112	51,840
OC-3	STS-3	STM-1	150,336	155,520
OC-12	STS-12	STM-4	601,344	622,080
OC-24	STS-24	–	1,202,688	1,244,160
OC-48	STS-48	STM-16	2,405,376	2,488,320
OC-192	STS-192	STM-64	9,621,504	9,953,280
OC-768	STS-768	STM-256	38,486,016	39,813,120
OC-3072	STS-3072	STM-1024	153,944,064	159,252,240

 Synchronous Digital Hierarchy or the acronym SDH
 Synchronous Optical Networking or SONET for short is the standard defined by T1.

Fast Ethernet is a term to describe various ethernet services that have a speed of 100Mbps. Traditionally the most common speed of ethernet was 10Mbps, thus the term FAST ethernet. However nowadays ethernet speeds of 1000Mbps (a gigabit) are also possible.

ACTL – Access Customer Terminal Location

ACTL is an 8- or 11-character code that identifies the CLLI Code (Common Language Location Identifier) of the customer facility terminal location.

11-character CLLI Code Format:

Positions 1 through 4 describe the designation for a single geographical locality within a state, province, territory, country, or distinct region of the world (e.g., municipality) (4 alpha characters).

Positions 5 and 6 describe the designation of a state or territory of the United States, a province or territory of Canada, another country having a national federal government, or a unique designation (2 alpha characters).

Positions 7 and 8 describe the Network Site Code or the designation of a site of an existing or proposed structure within a geographical location where there is a need to identify one or more telecommunications equipment entities, facility terminations, nodal locations, or administrative operations (2 alpha or 2 numeric characters).

Positions 9 through 11 describe the Network Entity Code or functional category of equipment or work center that is contained in a structure. Equipment categories, including central office switching and ancillary equipment or non-switching or access terminations, are associated with a building or network site for purposes of maintaining equipment inventories and for identifying facility and circuit terminations and nodal locations (3 alpha/numeric characters). Positions 9-11 denote whether the ACTL is at a Collocation Arrangement or a POP.

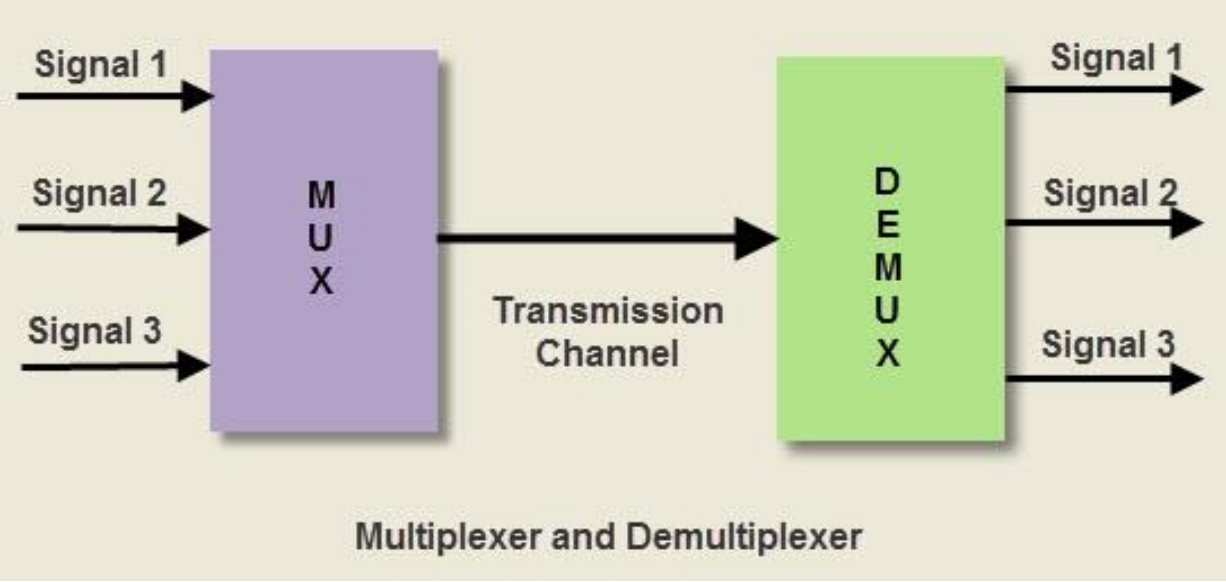
ACTL CLLI Code Breakdown Example

Position 1-4: Municipality – New York City, Manhattan	Position 5 & 6: State – New York	Position 7 & 8: Wire Center – West St	Position 9, 10 & 11: Switching Equipment – Facilities/circuit termination
NYCM	**NY**	**WS**	**HP2**

Serving Wire Center CLLI Code Breakdown Example

Position 1-4: Municipality – Morristown	Position 5 & 6: State – New Jersey	Position 7 & 8: Wire Center – 37 Maple Ave	Position 9, 10 & 11: Switching Equipment – Facilities/circuit termination
MRTW	**NJ**	**MR**	**DS5**

Multiplexer and De-multiplexer



Multiplexer and Demultiplexer

Multiplexer

Multiplexer is a device that has multiple inputs and a single line output. The select lines determine which input is connected to the output, and also to increase the amount of data that can be sent over a network within certain time. It is also called a data selector.

De-multiplexer

De-multiplexer is also a device with one input and multiple output lines. It is used to send a signal to one of the many devices. The main difference between a multiplexer and a de-multiplexer is that a multiplexer takes two or more signals and encodes them on a wire, whereas a de-multiplexer does reverse to what the multiplexer does.