Bandwidth – How Much is Enough?

A white paper from PLATO Support Services

June 2, 2005

- PLATO® Web Learning Network
- Client Hosted PLATO® Web Learning Network
- PLATO® courseware

Real learning. Real results.™

Bandwidth -- How Much is Enough?

What is bandwidth?

Bandwidth refers to the amount of information that can be carried in a given time period (usually a second) over a wired or wireless communication link. In digital systems, bandwidth is expressed as bits per second (bps). For example, a modem that runs at 56,000 bps has twice the bandwidth of a modem that runs at 28,800 bps. The higher the bandwidth, the more data can be transferred in bits per second.

A good analogy is to think of your Internet connection as a pipe. The term *bandwidth* describes the diameter of the pipe and how much water (data) can flow through it. If you don't have enough available bandwidth, then the pipe becomes clogged and data does not flow properly.

Available bandwidth becomes very important when you're running web-based products. PLATO® courseware running through PLATO® Web Learning Network is more sensitive to low bandwidth than other web pages. This is because PLATO Learning uses higher production values for graphics and audio that support and engage learners while they are working in PLATO courseware.

If your network does not meet the system requirements for the PLATO products you own, you may have inadequate bandwidth. This can be further complicated when workstation system requirements such as CPU processing speed, memory, and 100 Mbps LAN cards are also not met. If data does not flow fast enough or freely enough, the performance of PLATO Web Learning Network will suffer and the end user may see error messages. But what if your equipment and network do meet or even exceed system requirements and the performance of Web Learning Network is still very slow?

Bandwidth bottlenecks

A communication path for information that travels to and from your location and PLATO Learning's location is typically made up of several communication links, each with its own bandwidth. If one of these communication links is much slower than the rest, it is a ***bandwidth bottleneck***. A bottleneck results in data transmission delays. Delays typically occur when bandwidth cannot support the amount of information being relayed at the speed it is being processed. Data cannot flow through the pipe fast enough. If data cannot flow through the pipe fast enough, PLATO Web Learning Network will run very slowly and web pages will take a long time to load.

Because *the lowest bandwidth at all communication links dictates your effective, available bandwidth,* you may have less available bandwidth than you think. How much of your bandwidth is already being utilized before you run PLATO web-based products?

Have you taken a close look at your actual network capacity and performance? The following variables affect your network performance and available bandwidth:

- Proxy servers and caching
- Firewalls and content filtering
- Using daisy chain hubs instead of switches
- Quality of bandwidth provided by your Internet Service Provider

But I have plenty of bandwidth!

Are you sure the amount of bandwidth you think you have is really what is available?

Let's take a look at a case study at one school.

The school connects to the District Technology Center, which has an OC3 connection to the Internet. The connection speed of an OC3 connection is 155.52 Mbps (megabits per second). The network administrator wants to connect 50 workstations to PLATO Web Learning Network simultaneously. The administrator knows that Web Learning Network requires an average data transfer speed of 40 kbps (kilobits per second) for each workstation connecting simultaneously. The administrator does the math and believes he has more than enough bandwidth to run PLATO Web Learning Network and courseware on 50 workstations simultaneously:

1. The administrator converts the unit of measurement for data transfer speed from Mbps to Kbps: 155.52 Mbps is equal to 159,252 Kbps. (You can use the bandwidth calculator in PLATO Support's knowledge base to easily convert units of measurement: http://support.plato.com/26959)

2. The administrator divides the Kbps transfer speed by the number of workstations to get the data transfer speed available for each workstation: 159,252/50 = 3,185 Kbps available per workstation.

It looks like the school has more than enough bandwidth to run 50 workstations simultaneously; 3,185 Kbps is available for each workstation when only an average of 40 Kbps is required. But does the school really have enough?

A closer look

Let's take a closer look.

The lowest bandwidth at all communication points dictates your effective bandwidth—the bandwidth you actually have available to run PLATO Web Learning Network and courseware.

Although the school has an OC3 (155.52 Mbps) connection from the District Technology Center to the Internet, the connection *from the school to the Technology Center* is a *T1 connection*, which only connects at a speed of 1.544 Mbps.

The T1 connection reduces the available bandwidth to 1.544 Mbps, or 1,581 Kbps (1.544 Mbps = 1,581 Kbps).

The T1 connection from the school to the Technology Center is already being 60% utilized *without running PLATO Web Learning Network*. Approximately 949 Kbps of the 1,581 Kbps total is already being used. This reduces bandwidth available for PLATO Web Learning Network from 1,581 Kbps to 632 Kbps.

Subtract utilized bandwidth from the total bandwidth:
1,581 Kbps - 949 Kbps = 632 Kbps available

The school's network has half-duplex hub architecture, which further delays the transmission of data. Why? A ***hub*** is a device that connects segments of a network. It can transmit or receive data, but it can't do both simultaneously. Data can only flow in one direction at a time, which greatly reduces ***throughput***, or the rate at which data can be transferred.

With less than 632 Kbps of bandwidth available, and 40 Kbps calculated for each simultaneous workstation connection, the school can only run about 15 workstations simultaneously -- not 50:

632 Kbps/40 Kbps = 15 workstations

The calculation of 15 workstations doesn't include the effects of using half-duplex hubs, which reduce throughput because data can only flow in one direction at a time. Therefore, an estimated range for the number of workstations that can effectively run PLATO web-based products is **10 to 14**.

Bandwidth solutions

After consulting with one of PLATO Learning's Field Engineers, here's what the network administrator did to increase the school's available bandwidth and the number of workstations they could run simultaneously:

- The administrator made sure that the school's network and computers met all of the system requirements to run PLATO Web Learning Network.
- The school was using filtering software, which slowed the delivery of data from PLATO Learning. The administrator reconfigured the content filtering system to trust all content from PLATO Learning's domain.
- The administrator disabled the caching of PLATO web pages at the proxy server so that users would receive dynamic, current content at all times.
- The administrator reduced the utilization of the T1 connection from the school to the District Technology Center by no longer allowing students to surf the Internet or run non-essential applications when PLATO Web Learning Network classes were in session.
- The administrator installed 100 Mbps switches instead of using passive daisy chain hubs. A ***switch*** is a device that routes data between network segments, and it allows data to flow both ways. Data can be transmitted and received at the same time.

We're here to help

We realize that not all schools or facilities have the resources or time to do capacity planning and evaluate their network's performance. Many schools have a limited number of network administrators to serve the entire district, or have to outsource for technical help or network administration when needed. PLATO Learning's certified, highly trained Field Engineers can help by providing fee-based technical support onsite, customized for your needs.

Onsite technical services provided by PLATO Learning's Field Engineers include the following:

- Hardware installations
- Software installations
- Network installations
- Network evaluation and troubleshooting
- Onsite tech support
- Specialized consulting

For more information about Field Engineer Services, or to arrange for a Field Engineer to provide technical services at your site, call **800.44.PLATO** or e-mail **info@plato.com**.

You can also ask your Account Manager about Field Engineering Services, and the possibility of trading training days for a Field Engineer service day.

Troubleshooting resources

If you suspect you have insufficient bandwidth or want to make sure the amount you have available is what you really think it is, you may find the information in the following appendix helpful.

Appendix: Troubleshooting Resources

What are PLATO Learning's system requirements?

The latest system and configuration requirements for PLATO products are published online at the PLATO Support Center (http://support.plato.com). On the home page, click the System Requirements link. Make sure your workstations and network meet the latest requirements, including the specifications for processor speed, RAM, and network cards.

In general, PLATO Learning recommends 1.2 Mbps of available bandwidth for every 40 workstations that connect simultaneously to PLATO Web Learning Network. Most PLATO courseware requires an average connection of 40 Kbps per workstation; PLATO® Life Science requires 128 Kbps per workstation. The following guidelines for bandwidth requirements are for concurrent users at one location:

# of Users	Minimum Requirements	Connection type
25	750 Kbps	Half T-1 line
50	1.5 Mbps	Full T-1 line
75	2.25 Mbps	Full T-1 and half T-1 lines
100	3 Mbps	Two full T-1 lines
125	3.75 Mbps	Two full and one half T-1 lines
150	4.5 Mbps	Three full T-1 lines
175	5.25 Mbps	Three full and one half T-1 lines
200	6 Mbps	Four full T-1 or one DS-2 line
500	15 Mbps	10 full t-1 lines

Do your home users need DSL or cable?

Before you have students connect to PLATO Web Learning Network from home, find out if they have a dialup modem. Analog, dialup modems utilize nearly the full bandwidth of the present day phone system. A speed of 33.6 Kbps is pushing the speed limit of the current analog phone system. Many users who have 28.8 or 33.6 Kbps modems will never achieve connections at those rates due to phone line conditions. Many phone connections do not support speeds this high, so buying a 56K modem may not bring substantial improvement.

A connection speed of 28.8 Kbps is not fast enough to run PLATO courseware at a satisfactory performance level. Most PLATO courseware requires an average connection speed of **40 Kbps**. PLATO® Life Science courseware requires a **128 Kbps** *minimum* connection speed – a speed much faster than a dialup modem can reach. For these reasons, students who are home users may need a DSL or cable Internet connection instead of a dialup modem to run PLATO courseware. DSL and cable Internet connections are capable of much higher data transmission speeds than a modem and telephone line.

How fast is a cable modem?

Here's how the download speeds compare for a 1 megabyte file for a cable modem, ADSL modem line, and dialup modem.

- Cable modem, 1 Mbps: 7 seconds
- ADSL modem line, 256 Kbps: 32 seconds
- Dialup modem, 28.8 Kbps: 277 seconds

When you purchase broadband Internet connection services through an Internet Service Provider (cable modem) or a phone company (DSL), your provider can give you an estimate of how fast your Internet connection will be or how much bandwidth you will have available. The important thing to remember is that your bandwidth is is *shared* with other users. Your effective bandwidth may be different than the published bandwidth, depending on how many users are sharing the connection at one time.

Find your connection type and speed

How fast is fast? This chart puts into perspective line speeds used in Internet backbones, LANs, and WANs. Find the potential connection speed (data transfer rate) for your connection type.

Speed	Connection type
155.52 Mbps	OC-3, STS-3
100.0 Mbps	CDDI, FDDI, Fast Ethernet, Category 5 cable
51.84 Mbps	OC-1, STS-1
44.736 Mbps	T-3, DS-3 North America
34.368 Mbps	E-3 Europe
20.0 Mbps	Category 4 cable
16.0 Mbps	Fast Token Ring LANs
10.0 Mbps	Thin Ethernet, category 3 cable, cable modem
8.448 Mbps	E-2 Europe
6.312 Mbps	T-2, DS-2 North America
6.144 Mbps	Standard ADSL downstream
4.0 Mbps	Token Ring LANs
3.152 Mbps	DS-1c
2.048 Mbps	E-1, DS-1 Europe
1.544 Mbps	ADSL, T-1, DS-1 North America
128 Kbps	ISDN
64.0 Kbps	DS-0, pulse code modulation
56.0 Kbps	56flex, U.S. Robotics x2 modems,
33.6 Kbps	56flex, x2 modem communications rate

Units of Measurement

In digital systems, bandwidth is expressed as bits (of data) per second (bps). Here are the units of measure for bandwidth or data transfer speeds:

bit= smallest unit of digital information (ones and zeros)
byte= a set of 8 bits
bps= bits per second
Kbps= kilobits per second =1000 bits per second
Mbps = Million bits per second =1,000,000 bits per second
Gbps = Gigabits per second = 1,000,000,000 (one billion) bits per second
Tbps = Terabits per second = 1,000,000,000,000 (one trillion) bits per second

Bandwidth calculators

Use this tool to convert any bandwidth unit of measurement into equivalent units of measurement:

Bandwidth Calculator

Use this tool to determine how long it will take to download or transfer a file:

File Size Bandwidth Calculator

How to check your connection speed and bandwidth

Speed and traffic tests

The web offers free tools that you can use to check your Internet connection speed and bandwidth, or monitor the flow of Internet traffic. Speed tests can tell you if certain regions of the Internet are currently slowed down, which helps you determine if your Internet connection speed is a global or local problem.

AnalogX offers NetStat Live (NSL), a free utility you can download and install to see your exact throughput for both incoming and outgoing data – whether you're using a modem, cable modem, DSL, or local network. NSL also graphs your system's CPU usage. This is especially helpful in identifying if it's your computer that is slowing things down, or if it's the Internet. Download NetStat Live

Find out how fast your Internet connection speed is at YourSpeed, a speed test used frequently by PLATO Learning's Field Engineers. You may also find their throughput tips helpful.

The Internet Traffic Report site monitors the flow of data around the world. It displays values between zero and 100 for various continents. Higher values indicate faster and more reliable connections.

Talk to your Internet Service Provider

If you consistently get bandwidth speed test results that are substantially below your expectations, you may need to talk to your Internet Service Provider.

Make sure you're getting the connection speed you're paying for. Your ISP's connections are combined into one or more shared connections. If your ISP overbooks too many connections into one combined connection that becomes overwhelmed by normal customer demand, your speed can slow to a crawl during peak hours.

If your Internet connection speed is consistently much slower than you expect, discuss the problem with your Internet Service Provider. Your ISP has incentive to maintain reasonable overbooking ratios in order to be competitive.

If the problem can't be resolved, you may need to switch to another service provider with a better track record.

Contact us

Onsite technical services provided by PLATO Learning's Field Engineers include the following:

- Hardware installations
- Software installations
- Network installations
- Network evaluation and troubleshooting
- Onsite tech support
- Specialized consulting

For more information, or to schedule onsite technical services from a Field Engineer, call or e-mail us:

Phone: **800.44.PLATO**
E-mail: **info@plato.com**.

PLATO LEARNING

Bandwidth–How Much is Enough?

A white paper from PLATO Support Services

Cindy Coffin, Technical Writer

Last updated: June 2, 2005