

## Understanding Broadband Performance Factors: All Mbps Are Not Created Equal

The most common way that consumers compare the performance of data connections is by evaluating a network's speed (which is measured in bits per second, and is typically discussed in units of Mbps or 1,000,000 bits per second). However, this measurement can be quite deceptive. For example, a 30 Mbps cable modem connection may cost a residential consumer \$50 per month, while a business-grade 10 Mbps Metro Ethernet service can exceed \$500 per month.

Why would a service with one-third the speed cost 10 times as much as the "faster" alternative? The answer is that all Mbps are not created equal. Factors such as latency, the availability of the connection speed, and the network's Internet oversubscription rate affect the connection's overall performance. In the example above, the 10 Mbps Metro Ethernet service's total set of performance attributes provides a more robust and secure connection than a 30 Mbps cable modem.

Key attributes that impact performance include:

- *Symmetry*: Cable modem and DSL services are typically "asymmetrical," meaning that their upload<sup>1</sup> and download<sup>2</sup> speeds are different. The download speed is generally greater than the upload speed by a factor of 10. Metro Ethernet services, on the other hand, are typically "symmetrical," meaning that the upload and download speeds are the same. For businesses that transfer large data or video files, "asymmetrical" services often present a bottleneck to both internal users and external customers.

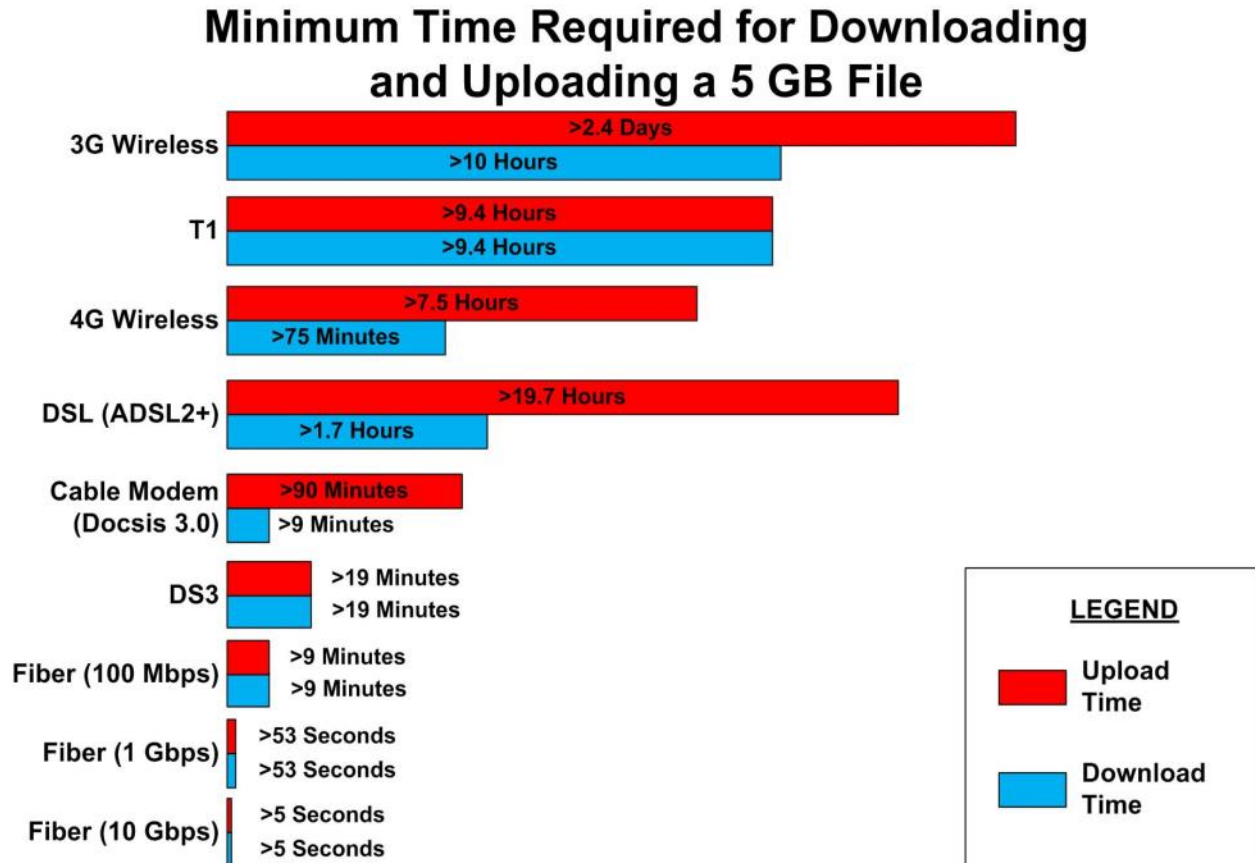
An example of the impact of service symmetry is shown in the figure below. A user on a typical cable modem service can download a 5 Gigabyte (1,000,000,000 Bytes, or GB) file in less than 10 minutes, but it would take more than 90 minutes to upload the same file—which would not be acceptable to a business creating and distributing large files.

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<sup>1</sup> Transfer of data from the users' devices.

<sup>2</sup> Transfer of data to the users' devices.

Figure 1: Impact of Speed and Symmetry on Download Times



- Oversubscription to the Internet:** Internet service providers (ISP) recognize that users in a given area do not all access the Internet at the same time; therefore, ISPs only subscribe to a portion of their networks' total potential demand. For example, an ISP that has 1,000 subscribers with 10 Mbps service might contract for a 100 Mbps connection rather than the maximum 10,000 Mbps Internet connection its users might require. The ratio of a network's maximum potential demand to its contracted rates is its oversubscription ratio. In this example, the oversubscription ratio is 100:1.

Cable modem and DSL providers often have a 100:1 or greater oversubscription ratio for residential users and a 50:1 ratio for business users. If an ISP bundles Internet access with a Metro Ethernet service, the oversubscription ratio is often 10:1 or less. In addition, with a Metro Ethernet service, users often will contract for specified Internet connections, thus defining their own performance. At times, users will not notice the oversubscription, while at other times oversubscription brings the user's connection to a crawl—no different than traffic on the weekend vs. traffic during a weekday rush hour.

- *Availability<sup>3</sup> of the Data Transport Rate:* Metro Ethernet providers will specify a committed interface rate (CIR), which is the guaranteed transport speed of the circuit connecting the users' location(s). Cable modem and DSL services are often "burstable," meaning that users may at times experience the advertised data rates but that the average speed realized will vary greatly based on the traffic being generated over the provider's distribution network. Performance parameters on a given burstable service are rarely publicized or realized. Often the network operator cannot change this parameter without changing the network physical connections. During periods of heavy network use burstable subscribers will experience the same traffic discrepancies as do drivers on the road during rush hour.
- *Capacity:* A connection's data rate specifies the speed (in bytes) at which data is transferred, whereas capacity is the measure of how much data is transmitted in a given period. Many wireless service data plans specify the number of Gigabytes that users can transmit during the month. These plans will carry extra fees for exceeding the limit and will actually slow down your connection speed as you approach your capacity limit. Cable modem and DSL providers have raised the possibility of adding capacity limits on their services (e.g., Comcast has trials of bandwidth limits), but implementation of such policies have so far been limited.
- *Latency:* This is the delay between the instant a message is sent and the instant it is received. Latency occurs on a provider's network; if a connection is made over the Internet, additional delays are added there. Latency is not an attribute that users can specify with cable modem and DSL services. For Metro Ethernet and other higher end transport services, latency is often a quality-of-service (QoS) feature for which a user can contract (at an added price). At times networks with high latency will prevent users from running certain applications. For example, satellite-based ISP services have an extremely high latency due to propagation delays (i.e., the time it takes for a signal to reach the satellite). These delays will prevent effective use of interactive services such as voice calls or interactive video.
- *Overhead:* This is not typically an option that a user can specify. Each transaction over the network will contain data regarding how to handle the message and where to deliver it (i.e., network control and operation). For cable modem services, overhead is typically part of each transaction; for Metro Ethernet, overhead is not part of a user's bandwidth.
- *Connection Type:* This attribute describes how a connection is made with other locations. For example, on a cable modem or DSL service, all connections to other locations are made through the Internet with Internet addressing schemes. This includes

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<sup>3</sup> Availability is often confused with oversubscription to the Internet. Oversubscription applies to the Internet connection, whereas availability applies to the connection or transport between user locations or the access point to the Internet.

any Virtual Private Networks (VPNs) set up between user locations. With higher end data services a user might be able to “route” traffic over the provider’s network without connecting to the Internet, set up direct point-to-point connections, or specify which locations will connect among each other (e.g., point-to-point, multipoint-to-multipoint).

- *Security:* Although security is primarily a function of encryption and other techniques applied by the user or the application sites accessed, traffic over a private network is inherently more secure than traffic on a network that establishes connectivity over the Internet. For example a cable modem or DSL user with multiple sites will transmit packets over the Internet to connect between sites. With a higher end service such as Metro Ethernet connecting user sites, the transport would remain on the network. In addition, higher end services often have encryption options at the transport layer.
- *Port Rate:* Not all connections are equal. The network connection, drop, and customer premises equipment (CPE) will define the potential connection speed at the customer site. The port rate is the maximum speed that the demarcation point to the customer can support. For cable modem services this is defined by the network’s DOCSIS version.

An example of the impact of capacity (Bytes) and speed (Mbps) for selected services and network architectures is shown in the figure below. As indicated, fiber-to-the-premises (FTTP) architecture offers far superior performance (capacity and speed) as compared to cable modem or DSL services.

**Figure 2: Capacity and Speed of Broadband Technologies**

