ADSL technology

Overview, line qualification and service turn-up

Executive summary

Asymmetric digital subscriber line (ADSL) uses existing twisted pair telephone lines to create access paths for high-speed data communications and transmits at speeds up to 8.1 Mbps to a subscriber. This exciting technology is in the process of overcoming the technology limits of the public telephone network by enabling the delivery of high-speed Internet access to the vast majority of subscribers' homes at a very affordable cost. This Acterna white paper provides an overview of ADSL technology and a description of testing procedures used to qualify lines for DSL and verify service. The standard loop architecture is illustrated in figure 1.

ADSL overview

Delivery of ADSL services requires a single copper pair configuration of a standard voice circuit with an ADSL modem at each end of the line, creating three information channels – a high speed downstream channel, a medium speed upstream channel, and a plain old telephone service (POTS) channel for voice. Data rates depend on several factors including the length of the copper wire, the wire gauge, presence of bridged taps, and cross-coupled interference. The line performance increases as the line length is reduced, wire gauge increases, bridge taps are eliminated and cross-coupled interference is reduced.

The modem located at the subscriber's premises is called an ADSL transceiver unit-remote (ATU-R), and the modem at the central office is called an ADSL transceiver unit-central office (ATU-C). The ATU-Cs take the form of circuit cards mounted in the digital subscriber line access multiplexer (DSLAM). A residential or business subscriber connects their PC and modem to a RJ-11 telephone outlet on the wall. The existing house wiring usually carries the ADSL signal to the NID located on the customer's premises (see figures 1 and 2).

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figure 1 ADSL loop architecture
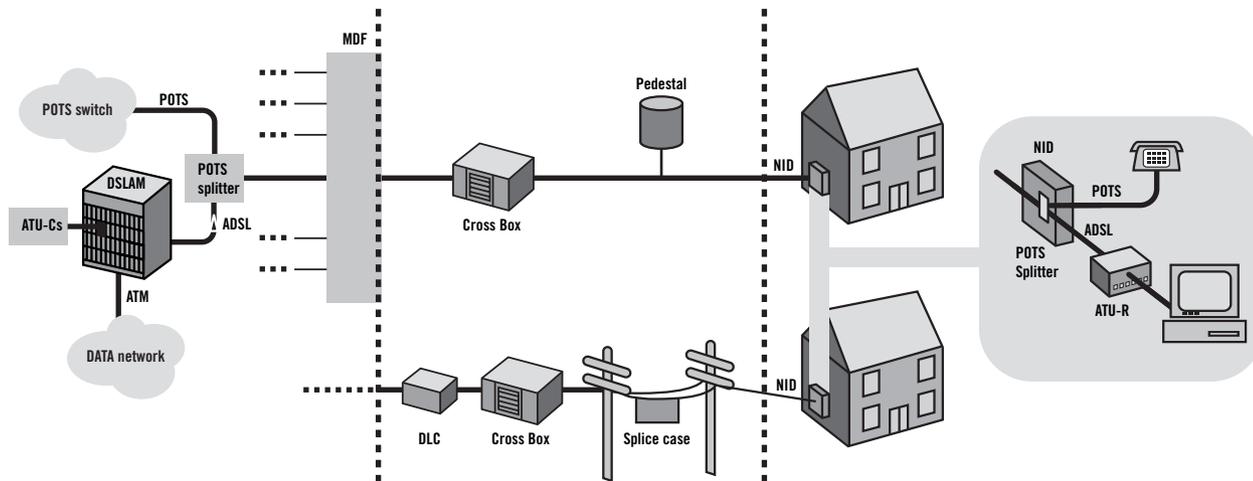
Physical connectivity

At the central office, a main distribution frame collects the cables from many subscribers and uses a splitter to distribute the data traffic to a DSLAM and routes the regular telephone traffic over an E1/T1 connection to the public switched telephone network (PSTN). The DSLAM mixes DSL services from different subscribers into ATM virtual circuits. Often, a DSLAM concentrator is used in cases where an ILEC or CLEC has many DSLAMs distributed over a large geographic area. The DSLAM contains ATU-Cs where ADSL signals are multiplexed onto a high-speed interface connected to an ATM network. This ATM network provides access to the internet through internet service providers (ISPs). The DSL provider bundles the traffic destined for a given ISP and sends it over an E3/T3 or an STM-1/OC-3c connection. A broadband remote access server (BRAS) terminates the subscriber's IP session and directs it to the Internet backbone.

figure 2 Signal at the customer premises
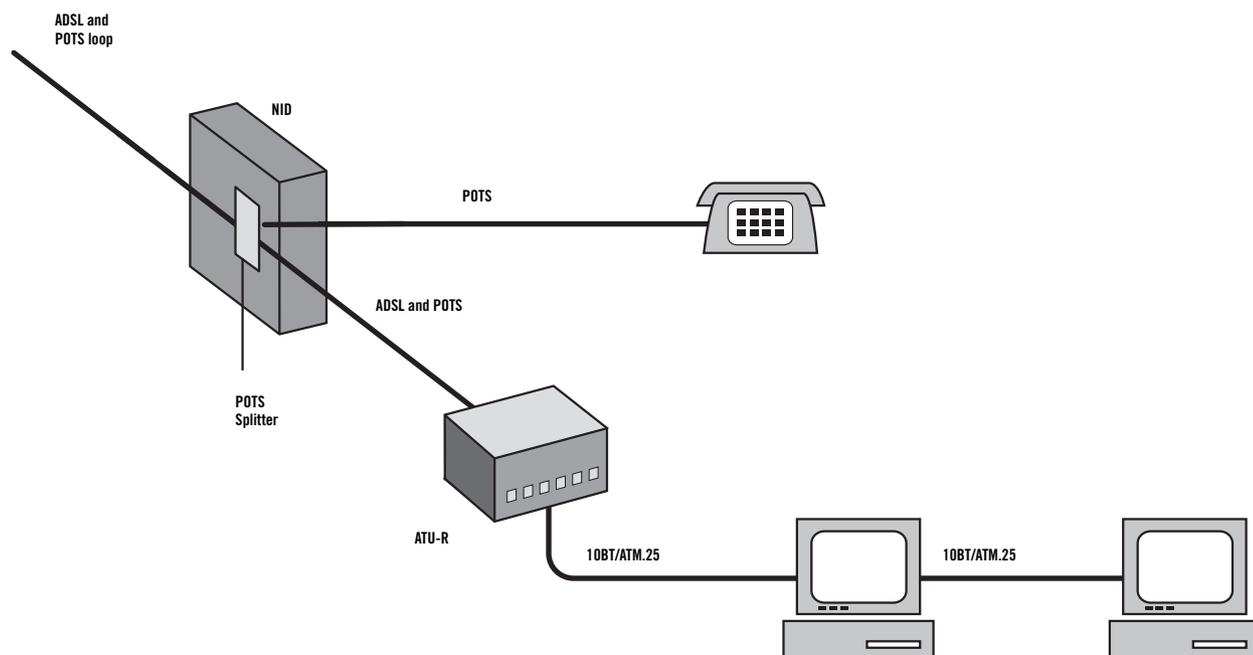
In most cases, POTS splitters at the network interface device (NID) and central office allow the copper loop to be used simultaneously for high-speed ADSL and POTS service. The POTS channel is split from the ADSL channel by a passive, low-pass/high-pass filter that separates the signals – low frequency for POTS and high frequency for ADSL – routing each to a separate wire pair. The splitter also protects the ADSL signal from POTS transients originating from handsets going on-hook and off-hook. ADSL service may be installed without using a "splitter" at the NID. Instead, micro filters are placed in-line with the phone jack at each telephone location.

While this configuration sacrifices some level of performance, it allows the customer to self-install the CPE. Typically, micro filters are packaged with the ADSL modem in a self-install kit. Figure 3 illustrates various test points for ADSL service.

figure 3 ADSL network layers
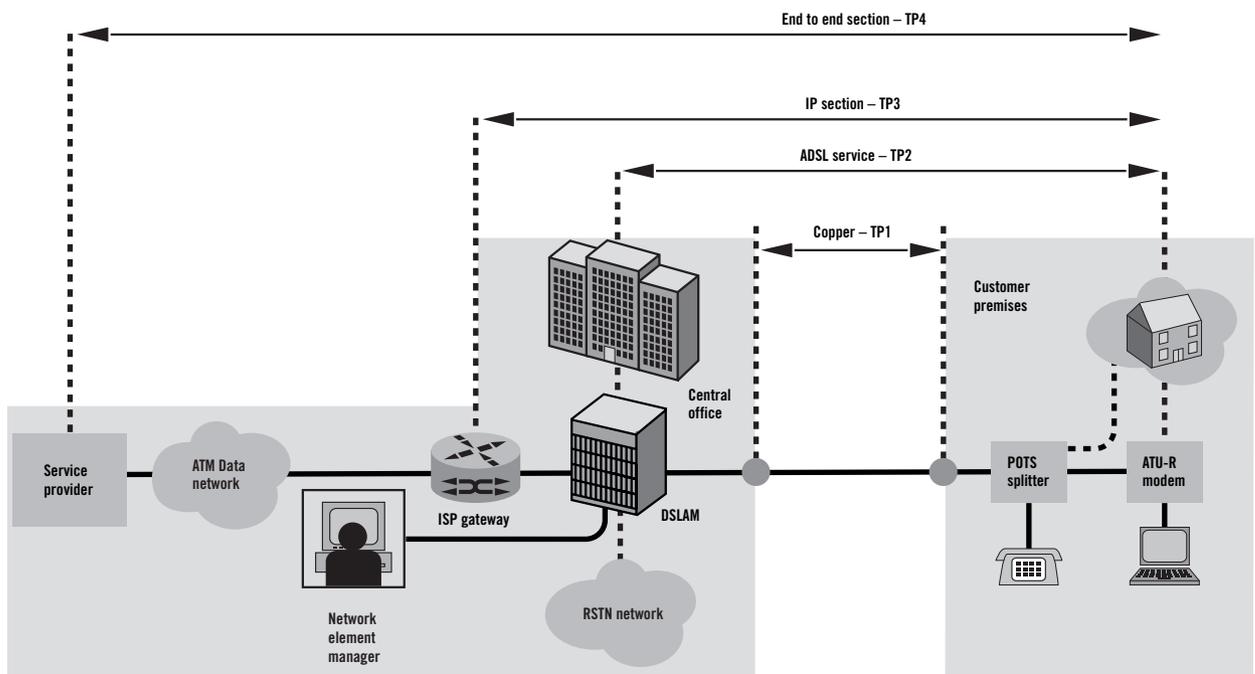
ADSL signal encoding

Traditional POTS uses a narrow 4-kHz base band frequency to transmit analog voice signals. This means that even with sophisticated modulation techniques, current modem technology can only achieve throughput of up to 56 kbps (downstream 56 K; upstream 32 K). To attain much higher throughput (up to 8 Mbps), ADSL uses a frequency range from approximately 20 kHz to 1.2 MHz. Frequency division multiplexing (FDM) creates multiple frequency bands to carry upstream and downstream data. The lower 0 to 4 kHz frequency range is reserved for POTS service. The frequency band from 25 K to 138 K is used to transmit upstream data, and the larger, higher frequency band from 138 K to 1.1 MHz is used for downstream data (see figure 4).

The American National Standards Institute (ANSI) and the International Telecommunication Union (ITU) chose discrete multitone (DMT) modulation as the standard line code for ADSL. DMT, as its name implies, divides the data bandwidth into 256 sub-channels, or tones, ranging from 25 kHz to 1.1 MHz. Upstream data transfer frequencies range from 25 kHz to 138 kHz, whereas downstream data transfer frequencies range from 139 kHz to 1.1 MHz (see figure 4 and 5). Guardbands divide the three frequency bands. Each tone has a bandwidth of 4 kHz and a spacing of 4.3 kHz; each supporting a maximum number of 15 bits, as limited by its signal-to-noise ratio. Since the tones in higher frequencies are more susceptible to attenuation and noise, higher frequen-

cies usually carry fewer bits per tone than lower frequencies. In addition to the normal data bits, an embedded operations channel (EOC) is provided as a part of the ADSL protocol for communications between the DSL modem and DSLAM. This device is used to provide in-service and out-of-service maintenance, retrieve a limited amount of status information, and monitor ADSL performance. The EOC may be used in the future to extend maintenance and performance monitoring.

ADSL is a fixed quality (fixed BER of 10^{-7}), variable rate service. During training, the ADSL system (ATU-R and ATU-C) evaluates the quality of the line by measuring the SNR and attenuation/gain per tone. It can then decide on the maximum data rate sustainable on the
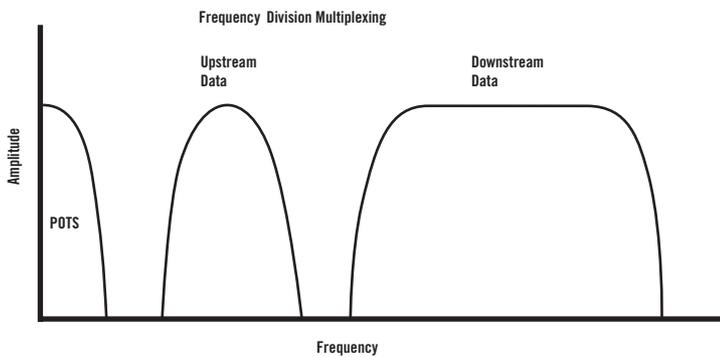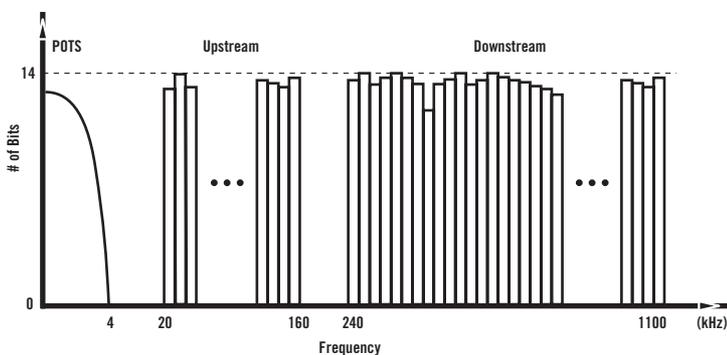

figure 4 Frequency bands

figure 5 Data bandwidth tones

Bit Value	Amplitude	Phase Shift
000	1	None
001	2	None
010	1	1/4
011	2	1/4
100	1	1/2
101	2	1/2
110	1	3/4
111	2	3/4

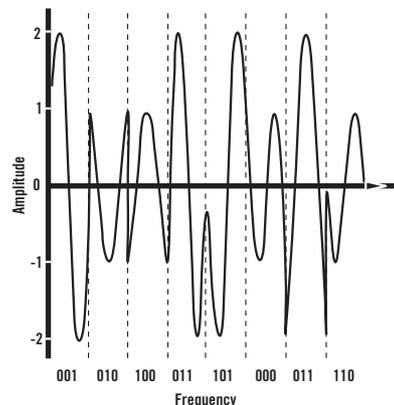table 1 Quadrature amplitude modulation

figure 6 Example of QAM encoding

copper loop and still maintain a BER of less than 10^{-7}. This differs from most other digital transmission technologies (ATM, ISDN, etc.) which are fixed rate, variable quality services (variable BER). So, to evaluate the QoS for ADSL, examine line capacity and noise margin. The lower the capacity and higher the noise margin, the better the signal. In adaptive mode, BER will always be 10^{-7} or slightly less, depending on the fixed minimum noise margin. After the line is evaluated, the max bandwidth is further reduced by the minimum noise margin (set at the DSLAM). This is usually -6 dB to allow for changes in SNR and becomes the upper limit for the data rate. Remember, the limiting factor is the BER and as long as BER remains less than 10^{-7}, ADSL service requirements are met and synchronization will occur. The data rate may be less than desired but it still meets specification requirements.

Quadrature amplitude modulation

ADSL uses quadrature amplitude modulation (QAM) (see figure 6) to achieve the 15-bit maximum that any single tone can carry. This technique employs a combination of amplitude modulation and phase shift keying. For example, a signal that transmits at three bits per baud requires eight binary combinations to represent the signal. This example assumes two possible measures of amplitude and four possible phase shifts, which allow for eight possible waves. Table 1 shows the correspondence between each binary combination and amplitude and phase shift. Using the above technique, a large bit stream can be broken down into three-bit words, as shown in the following example:

001-010-100-011-101-000-011-110

Figure 6 illustrates QAM-encoded signals of the above bit stream with each wave shifted in relation to the wave that immediately precedes it.

Protocol stack

Data communications between the CPE, CO and ISP (refer to figure 3) take place using rules or protocols that govern every aspect of the communications process. Protocols come in stacks made of layers with each layer defining a specific portion of the communications process. The lower layers, which deal with the reliable transfer of data from source to destination, are most critical for ADSL commissioning. The lower layers are from bottom to top:

1. The physical layer which is concerned with the establishment of the physical circuit between two devices. The ADSL specification defines the physical layer, including the wire gauge, span lengths, acceptable bridge tap length, etc.
2. The data link layer provides for transport of data over the physical layer.
3. The network layer is concerned with routing data through an overall network.

Encapsulations
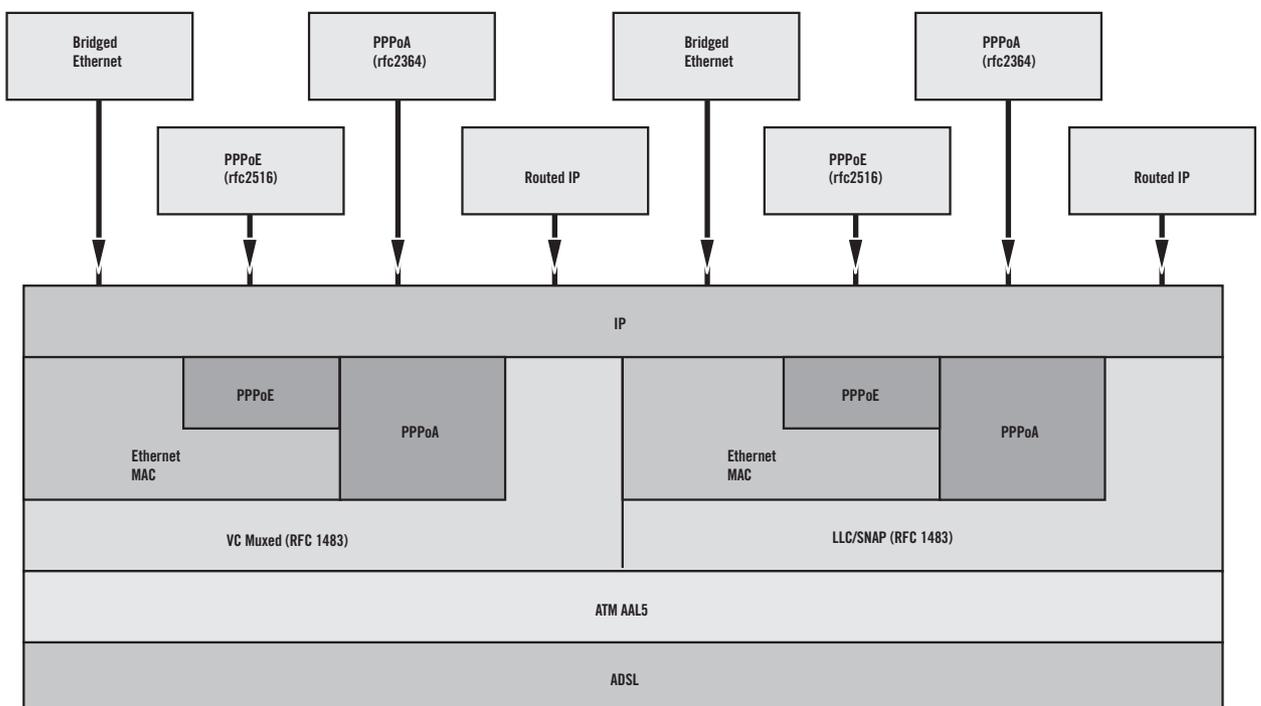**– All mainstream encapsulations need to be supported**

figure 7 Encapsulation stacks

Defining ADSL as the target physical layer raises the question of how to define the link layer so as to bridge the gap between the physical layer and the well defined layer 3 specification known as the internet protocol (IP). The requirements for a personal broadband service include handling timing-sensitive transmission of video and audio services while efficiently transferring large and variable blocks of data involved in traditional data communications tasks such as web browsing and file downloads. Asynchronous transfer mode (ATM) meets these requirements by using a short, fixed-length frame called a cell to hold data passed from higher layers. This short, fixed length allows ATM to transport both data and realtime information. Realtime traffic has to wait no more than one 53-byte cell for processing while in conventional data communications networks a realtime packet could be trapped behind several large data packets. This makes it possible to transmit realtime traffic methodically, slipping it into a stream of data carrying cells. ATM also offers the advantage of making it easy to interleave different user data streams into a common connection with no impact on the individual users.

ATM encapsulation
The 48 bytes of payload available in an ATM cell is insufficient for most applications so ATM uses adaptation layers to take the packets from a higher level protocol such as IP and carry them in ATM cells. In almost all cases ATM adaptation layer 5 (AAL5) is used to carry Internet traffic. AAL5 has no header but has a trailer that provides error correction. Also, some way of identifying to which protocol a particular packet belongs is needed so that it can be passed to the correct application at the higher layer. Three widely used options are HDLC, VC-Mux and LLC-SNAP, which are described in RFC1483. Many providers have determined that the most cost-effective method for connecting to the customer premises access device is via Ethernet, so this protocol also often runs on layer 2. Finally, the point-to-point (PPP) protocol is often used on layer 2 because of its ability to connect a network of hosts over a simple bridging access device to a remote access concentrator. With this model, each host uses its own PPP stack, presenting the user with a familiar interface (see figure 7).

The ADSL connection from the customer premises equipment to the internet service provider is always on; therefore, unlike analog or ISDN modems, ADSL requires no dial-up. When an end user turns on the ATU-R, synchronization is established with the ATU-C. When the connection is made, a permanent virtual connection (PVC) is established between the ATU-R and the service provider's ATM network. Each PVC is configured to connect the DSL line to the ATM network, which is then configured to route traffic to an ISP. As a result, the end user has a direct link to the internet via the ISP as long as the ATU-R is turned on.

Network management system
The network management system (NMS) (see network element manager figure 3) acts as the control center for the ADSL system. The NMS is used to analyze the network's quality and performance, based on system parameters such as minimum and maximum bit rates. When a new line is commissioned, the NMS is used to set end user configurations, which include bit rate settings, that limit throughput. For example, if the end user is paying for a 1 Mbps service, the NMS is set to a maximum bit rate of 1 Mbps. Likewise, if another end user is paying for a 3 Mbps, the NMS bit rate is set accordingly. The NMS is also used to control system settings, such as interleaved bit rates, noise margins and power settings that affect service quality.

Rate adaptation

Because ADSL is implemented over a normal copper twisted pair, it must adapt to various conditions associated with the traditional analog phone line. The quality of the local loop varies dramatically, depending on gauge, installation practice, proximity to noise influences and other factors. A rate-adaptive ADSL (RADSL) system attempts to deliver the best throughput by adjusting the connection to compensate for these problems. There are three possible modes in a rate-adaptive ADSL system, which is provisioned by the NMS. Each mode deals with startup and operations – or initial synchronization – in a different manner, as described below.
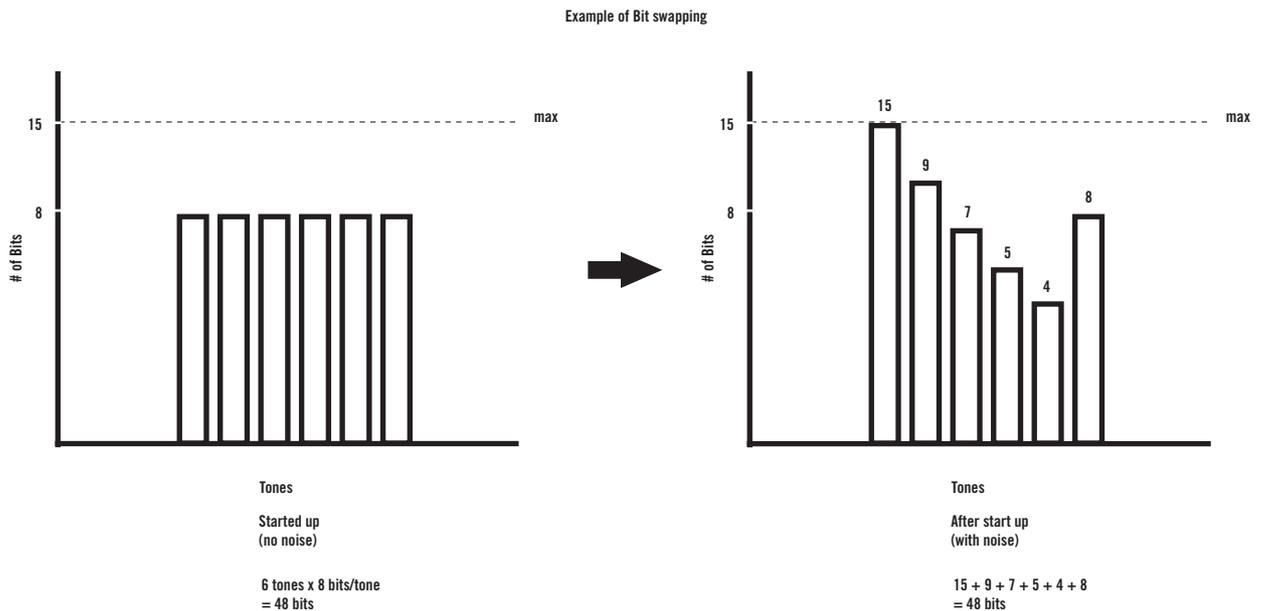
In manual rate adaptation, the NMS specifies at startup the desired bit rate that the ATUs must support. If conditions are not satisfactory to achieve this rate, the synchronization between the ATUs fails and resynchronization is attempted. During the period after synchronization occurs, called Showtime, the ATUs maintain the NMS-specified bit rate. In rate adaptation at initialization, the NMS specifies at startup the desired minimum and maximum bit rate range that the ATUs must support. The ATUs attempt to maximize throughput up to the maximum bit rate setting. If conditions are not satisfactory to achieve the minimum bit rate, synchronization between the ATUs fails and resynchronization is attempted. Once the bit rate is established, the ATUs maintain the NMS-specified bit rate. In dynamic rate adaptation, the ATUs attempt to maximize throughput at startup, as is the case with the previous model. During Showtime, the system monitors the line condition, and continuously attempts to achieve the maximum bit rate possible based on the NMS settings.

Bit swapping

When implemented, bit swapping occurs during the synchronization process in all three rate-adaptive modes. The ADSL system adjusts signal parameters to compensate for network problems, such as attenuation, crosstalk or noise. As the system operates, the quality of each 4-kHz sub-channel is monitored constantly. Adjustments are made to the bits-per-tone distribution to maintain performance. If the noise margin for a particular tone degrades below the minimum noise margin and compromises system performance, one or more bits on that tone are moved automatically to another tone that can support additional bits. This monitoring results in higher performance and more robust communications by allowing the ADSL system to adapt continually to changing channel and noise characteristics (see figure 8).

figure 8 Bit swapping

Example of Bit swapping

Started up
(no noise)

6 tones x 8 bits/tone
= 48 bits

After start up
(with noise)

15 + 9 + 7 + 5 + 4 + 8
= 48 bits

ADSL transmission techniques make it possible to leverage the existing outside plant (OSP) to provision high-speed voice and data services rapidly. This eliminates the need for major investments to upgrade the OSP, as would be required for alternative architectures such as fiber in the loop or hybrid fiber/coax. On the other hand, ADSL service is dependent on the quality and design of the OSP, so prequalification of copper loops is necessary to determine if the loop is capable of supporting ADSL transmission.

OSP requirements
Typical ADSL implementations are designed to work at loop lengths up to 18,000 feet in length at 26 AWG with a downstream speed of 1.5 Mbps and at a duplex speed of 128 Kbps. But other factors in the local loop do interfere with ADSL service. Load coils cause problems because they are designed to suppress exactly the signal that DSL modems need to transmit high-speed data. The effect of a load coil is equivalent to adding about 20,000 feet to the line length, making the line unusable for DSL service. In most cases, load coils must be identified and removed from lines supporting ADSL.

Bridge taps also interfere with DSL service because they act as a transmission line stub with adverse effects at high frequency. As a general rule, the length of all bridged taps on the span should total less than 2,500 feet, with no single tap exceeding 2,000 feet.

For instance, eight 60-foot bridged taps are acceptable, but one 2,400-foot tap is unacceptable. The closer the bridged tap is to the ATU-R, the more likely it is to impair performances by returning reflections that contain more energy than incoming data pulses from the ATU-C. If this occurs, the circuitry is unable to distinguish between data and unwanted reflections. For example, a bridged tap within 300 to 600 feet of

an ATU-R can dramatically impair the ADSL signal. For these reasons, it is recommended that bridged taps be removed within 1,000 feet of the ATU-R for best performance.

One approach to ADSL qualification of the local line involves using the operations support system (OSS) to measure loop length and determine the line length and check for the presence of bridge taps and load coils. The problem with this approach is that the OSP may have been modified so many times over the past decades that the OSS is not accurate enough to qualify a local loop for ADSL service. This gap is filled by testing tools such as the Acterna HST-3000 that tests all local loop elements needed to qualify the circuit for ADSL and other xDSL variants. The HST-3000 has a precision digital volt/ohm meter (DVOM) with resistance to measure AC continuity as well as find shorts and grounds. It measures loop length using tip-to-ring capacitance measurements. The HST-3000 includes a time domain reflectometer (TDR) that makes it easy to measure the length and location of a bridge tap, wet sections and load coils. With the TDR's dual trace mode a known good pair can be compared to a faulty pair. If the problem is intermittent, tracing will continue until the problem reappears. A load coil counter determines the number and type of load coils in the line. The HST will also quickly and accurately identify cable faults such as shorts, grounds, crosses, splits, opens and high-resistance faults. Tests can be performed at the CO or the CPE or anywhere in between.

To physically qualify a copper line for digital service, it is recommended that the technician run a series of tests that check for physical faults as well as the line's ability to support digital data transmission. These tests are referred to as the "Good Pair Check" which runs AC/DC voltage, resistance and opens to

check for faults and the "5-Point Close Out" test which runs in series current, loss, noise, power influence and longitudinal balance to verify line quality. These tests can be run easily with the HST-3000 simply by selecting the applicable script. The results are compared to predetermined parameters and results given with pass, marginal or fail. The reason these tests are run is because digital signals typically run at higher frequency than voice and are more easily attenuated or are more sensitive to noise, impairments and faults. By verifying the digital quality of a copper line, the technician can eliminate the need for repeat truck rolls after service is commissioned.

For the "Good Pair Check", AC/DC voltage obviously determines the presence of an AC signal and battery on the line. Resistance measurements determine the presence of shorts, which can stop or impair signal transmission and grounds, which can add noise. Opens verify loop length and the presence of one-sided opens which affect balance and signal quality.

The "5-Point Close Out" test measures the parameters against known good thresholds to determine line quality or the ability of the copper to support a digital signal. Current is typically > 23mA, loss < 8.5 dBm, noise < 20 dBrnc, PI < 80 dBrnc and balance > 60 dB. Results that are out of specification require further testing with WB TIMS, TDR, RFL or load coil detector to determine type and location of faults or impairments.

Service turn-up
Before the provider commissions the DSL service, technicians need to test all the connections of a DSL network, from the CPE through the network. The technician validates and confirms several protocol layers to confirm the network can transport data

and voice signal payloads. Since the failure of any transport, network or service layer causes the service to fail, testing the customer's entire service, not just synchronization between the NID and the DSLAM eliminates the need for repeat truck rolls to trouble-shoot the network connection and CPE.

An efficient method to accomplish this task is with a test set that simulates the ADSL modem and communicates with both the DSLAM and the sub-scriber's PC. This validates and confirms all protocol layers from the PC into the ATM cloud.

Technicians can use such an instrument to determine if a complete path or circuit exists from end-to-end at the ATM layer and if the ATM cells are aligned with the upper protocol layers. The Acterna HST-3000 establishes and maintains the connection through the network by establishing a permanent circuit at network layers 2 and 3, making it possible to check the network end-to-end from the customer's site through the network. The test set also includes the PPP protocol making it possible to look past the DSLAM into any service provider's network and verify correct mapping and connectivity.

Testing the customer's PC
The HST-3000 when used on the LAN side of the network tests the Ethernet connectivity of the subscriber's equipment. As more ADSL networks are commissioned, experience shows many problems result from CPE configuration errors and network provisioning. Quickly identifying these problems and informing the subscriber saves time otherwise wasted on troubleshooting the ADSL connection.

The test set quickly and easily confirms DSL physical layer performance by emulating DSL transceiver unit modems. In this mode of operation, the test set verifies the actual DSL signal rate for the current connection and the connection's maximum possible rate. It checks the signal-to-noise margin to evaluate the DSL signal strength over the loop, pointing to future performance capabilities and limitations. Technicians synchronize the DSL Services Tester at different points on the loop to segment faults on the physical layer. The test set connects the line and establishes synchronization with the DSLAM. The ADSL tester evaluates line quality by measuring signal-to-noise ratio (SNR) and attenuation/gain per tone. It then decides on the maximum data rate

sustainable from the copper loop while maintaining a bit error rate of less than 10^{-7} based upon a minimum noise margin, typical −6 dB, which is set at the DSLAM.

The test set then measures the maximum rates at which the ADSL service can operate on this particular loop, under current operating condi-tions. Line capacity is calculated by comparing actual and maximum rates as an indication of robustness or "spare" capacity. If the maximum data rate set by the DSLAM falls below the available bandwidth, the link shows a higher noise margin or lower capability. When maximum rates exceed actual rates by a significant margin, the line should be immune from future degradation and is upgrad-able. Capacity values of 95 percent or higher indicates a low tolerance to noise, and do lead to future problems.
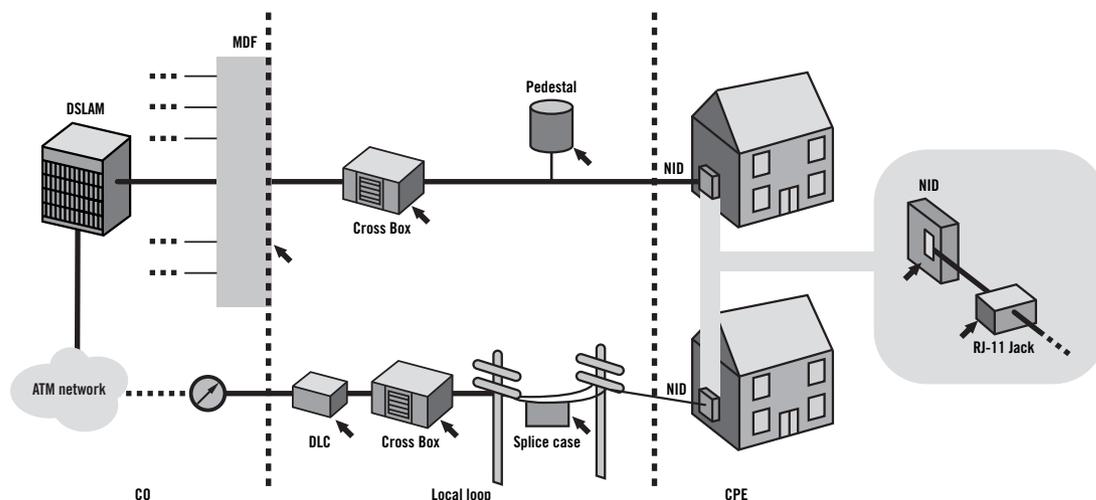

figure 9 Physical layer for test access points

Troubleshooting qualification and synchronization problems

If the service qualification fails, or if the system does not synchronize, the following systematic trouble isolation procedures are recommended. First, replace the ATU-R with the test set to perform emulation and attempt to synchronize with the installed ATU-C. If you are able to synchronize with the test set but not with the ATU-R, a check of the minimum bit rate setting at the NMS is recommended. If the minimum rate is set too high, the ATU-R does not synchronize. If the NMS settings are correct, the ATU-R should be replaced. If you cannot synchronize at the NID, check for a dial tone to determine if the network is connected to the central office. If there is no dial tone, check for an open using a loop-troubleshooting tool with a TDR. If a dial tone is available, check for load coils on the span. If there are none, move up the loop to the next access point, typically the pedestal. Disconnect the connection from the pedestal to the customer premises equipment, and connect the test set to the loop facing the central office or digital loop carrier. If synchronization is successful, isolate the problem on the loop between the pedestal and the NID. Continue this process, as needed, along the complete copper span, checking the splice case, cross box, and main distribution frame.

If synchronization is successful at the NID, the inside house wiring is most likely the cause of the problem. Typically, this problem is isolated with a simple digital volt ohmmeter. An alternate solution is to install a home-run line directly from the NID to the wall outlet. If synchronization is possible in the house but the performance is poor, move the test set to the NID to check for improved performance. If performance shows an improvement, the cause of the problem is probably faulty inhouse wiring. If synchronization is possible at the NID but performance is poor, the source of the problem is most likely on the span. Perform a wide-band frequency sweep and look at the bits carried per DMT tone. Compare the bits per DMT tone to the SNR per DMT tone (see figure 10).
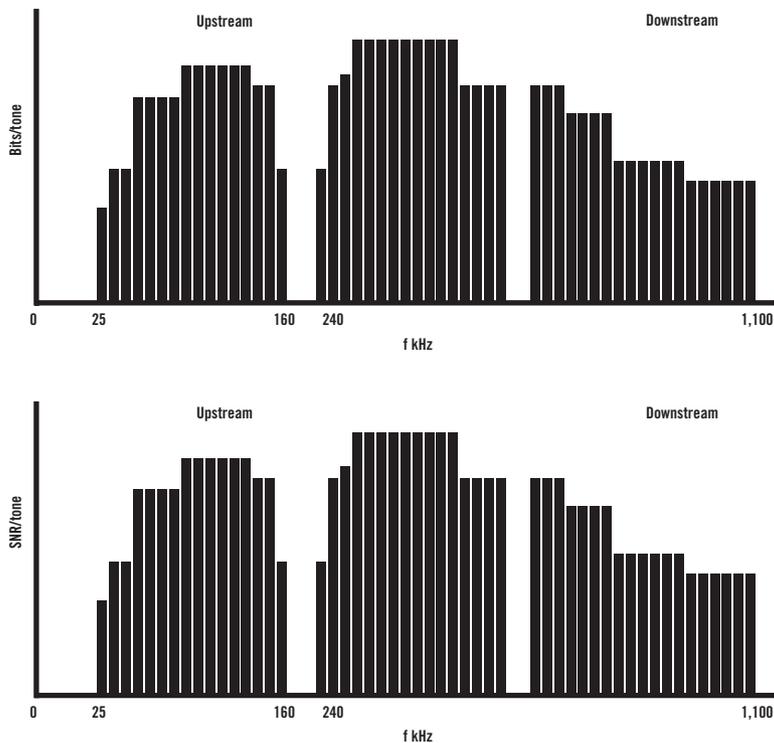
Measuring ADSL performance

Once the line synchronizes, the test set measures items such as noise margin, actual up and downstream rates, maximum up and downstream rates, signal attenuation, and line capacity. A high noise margin, 14 dB in this example, suggests a high quality line. The noise margin indicates how much noise can be tolerated before degrading the line below a BER of 10^{-7} performance level.

If slow service is indicated, technicians can look at the bits per tone measurement. Dips in the bit per tone graph indicate interference. Checking the frequency of the interference often makes it possible to identify its cause. The accompanying chart shows the frequencies associated with common interference sources, such as T1, E1 and HDSL. If the bits per tone are taking a hit and it is determined that noise is not the cause, then the cause could be a DC fault, such as a bridge tap or a wet section. Very low or nonexistent bits per tone in the high frequency band indicate the presence of a long loop. If there is a major dip in the bits-per-tone graph but the noise power-per-tone graph does not show any abnormalities, the most likely troubles are bridged taps or wet sections on the span. Use a loop-troubleshooting tool with a TDR to find and fix these problems. If the bits per tone are low across the whole bandwidth, the cause is most likely DC troubles on the loop, such as shorts or grounds.

A major dip in bits per tone indicates AC trouble on the loop. To verify the type of AC trouble, compare the bits per tone to SNR. If the noise influence and bits-per-tone dip occur at the same frequency, the degraded performance is most likely due to a transmission influence. The particular frequency will help identify the source of influence or crosstalk. An example of possible shared frequency zones could be T1 centered at 770 kHz or HDSL at 196 kHz.

figure 10

Configuring the PPP client

The password authentication protocol (PAP) or challenge handshake authentication protocol (CHAP) username and password are entered into the PPP client. Depending on the implementation, this client either resides within the ADSL modem/router or on the PC. Since the username and password are not always obvious at the time of installation, the technician needs to obtain this information (PAP or CHAP password) before commissioning a PPP-based service.

Whatever the encapsulation type, an IP source address needs to be configured in the PC and ADSL router (but not for an ADSL bridge). There are several ways of finding the needed source IP address, so that a technician can authenticate and perform a PING from a tester:

– **Static** – Manually type in the IP source address and Subnet Mask.
– **DHCP** – Automatically configures the CPE by requesting the information from a DHCP server in the network. This is typically used in Bridged Ethernet.
– **IPCP** – Automatically configures the CPE by requesting information from part of the PPP-based stacks, similar to the DHCP method.

PPP naturally includes the use of PAP or more CHAP. When all this information is correct, the tester, such as an Acterna HST-3000 automatically authenticates, and declares "Network Up". This means the service to the BRAS was verified successfully.

Verifying end-to-end service

A true test of end-to-end service requires verifying access to that service. ATM cells must be synchronized from end-to-end for the network to reliably transport data and voice signal payloads. Technicians use the instrument to determine if a complete path or circuit exists from end-to-end at the ATM layer and if the ATM cells are aligned with the upper layer protocols. The test set is used in the IP PING mode to verify the routing connectivity across the network to an IP host or server while assessing packet loss rates and packet delay to and from the PING destination. The instrument checks the IP layer by verifying if another host device is alive and able to echo back, uses a flood mode to gauge network congestion, and determines the minimum, maximum and average packet delay time of IP packets. Tracking packet delay and loss helps determine whether delays and slow service are due to provider error or CPE problems.

Since users can only reach the ISP end of the service with the correct username, password, and encapsulation, test tools must support the appropriate IP encapsulations and authentication protocols for effective IP PING support. When setting up a test tool, enter the following information:

– IP Encapsulation stack (for example PPPoA)
– RFC1483 option (LLC-SNAP or VC-Mux) (now superseded by RFC2684)
– ATM Channel identifier (VPI-VCI)
– Username (if using a PPP-based stack)
– Password (if using a PPP-based stack). Once the ATM channel (VPI-VCI) and encapsulation type are known, it is a good idea to save the setup, because they are often common to all subscribers.

Troubleshooting connection problems

If pinging a public web address is not successful, the ISP is not in service, or the address is unknown, you can enter the IP router or switch address. Simply enter the IP address as shown on the WAN setup screen that was downloaded automatically using IPCP or DHCP. This procedure verifies network connectivity. Once authenticated, only a destination address is needed. For Internet services, it is a good idea to choose a public Web address, since this proves the subscriber's service is attainable. The choice of a destination address determines the results to be expected from the PING statistics. If a PING test is conducted on the BRAS or primary DNS server, a better than 90 percent success rate and a short delay is expected. However, if PING is conducted on a public IP address outside the domain, results vary. It is important that the tester in use shows these statistics, to provide a complete picture of the network environment. Figure 11 provides a typical troubleshooting or installation flowchart.

By offering high speed and economical use of the installed local loop base, ADSL provides the access technology needed to deliver true converged services including voice, data and video over one infrastructure. The test methods described help to identify and fix ADSL problems quickly, making it possible to deliver ADSL service economically to large numbers of subscribers.

figure 11 Turn-up and troubleshoot scenario
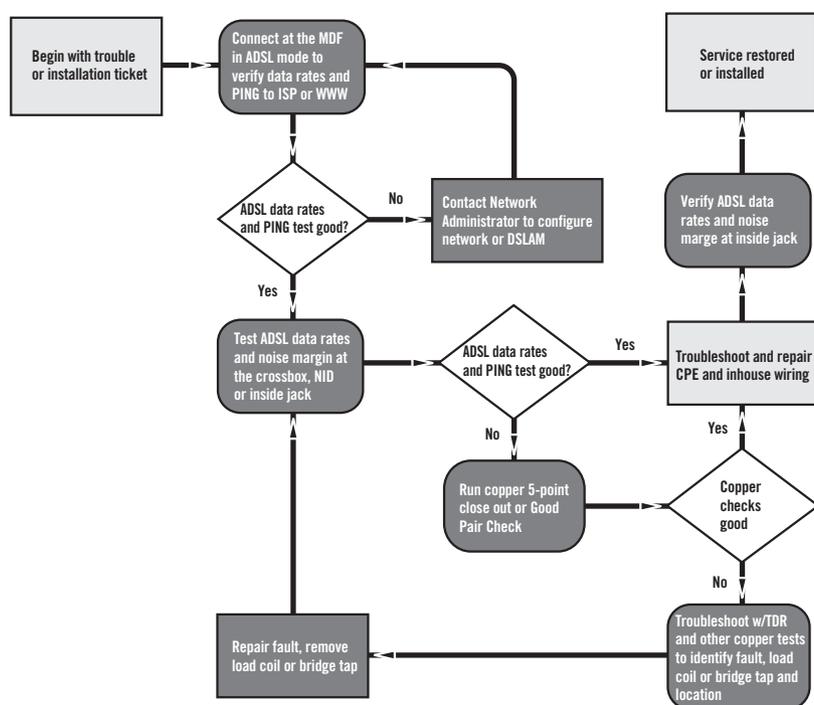
Acterna is the world's largest provider of test and management solutions for optical transport, access and cable networks, and the second largest communications test company overall. Focused entirely on providing equipment, software, systems and services, Acterna helps customers develop, install, manufacture and maintain optical transport, access, cable, data/IP and wireless networks.

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