WHITE PAPER

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diagnostics

technicians

ADSL2

advanced

modem

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service

monitor

qualify

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Technician Dr. DSL®

ADSL2 Modem Diagnostics Software for Field Testing

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Technician Dr. DSL®

ADSL2 Modem Diagnostics Software for Field Testing

While much of the focus on ADSL2 and ADSL2+ has been on their extended reach and increased data rates, these standards include impressive physical layer diagnostics designed to qualify customers for new services, troubleshoot failures and monitor ongoing performance. ADSL2 and ADSL2+ modems will likely become an efficient method of inexpensively equipping technicians with physical layer test functionality for resolving troubles and testing if and how a line can be conditioned to reliably support service.

Need For Diagnostics

ADSL2+ builds on the success of ADSL to offer higher data rates on longer loops, allowing carriers to expand the bundle of services to include IP TV, multiple lines of voice over IP, as well as higher Internet rates. With these new revenue opportunities, however, come new operational challenges.

A typical ADSL line in 2000 would be a conservatively short loop, served from a major central office to a customer who knew what microfilters looked like, why they were required, and how to install them. Minor physical layer errors went unnoticed on best-effort 1.5 Mbps data service. If there was a problem, the carrier had sophisticated test equipment in the central office to troubleshoot the line and could dispatch field technicians with expensive test sets.

Today, the average ADSL line is longer – partly due to improved ADSL2 equipment and partly due to the need to expand the sales area – or is served by a remote central office with limited test capability. Moreover, this line must deliver reliable performance in order to support high bit-rate services, such as multi-channel video and voice over IP. Problems and service complaints are naturally more common, while the tools and technicians are less so.

The ITU included specific diagnostics requirements in the ADSL2 standards in order to address such an issue. In a purely ADSL2 environment, these diagnostics allow broad, comprehensive line monitoring and network planning. In initial deployments, they can turn an off-the-shelf modem into an advanced outside plant test set for technicians, capable of identifying and determining the data rate impact of bridged taps, spectral interferers and in-home problems.

ADSL Standards

ADSL2 and ADSL2+: Better Performance Requires Better Diagnostics

The ADSL2 and ADSL2+ (ITU G.992.3/5) standards define three diagnostic functions and six performance scalars that standard-compliant modems must collect and present in their Management Information Base (MIB).

These functions include channel characteristics, quiet line noise, and signal-to-noise measurements for each of the 256 or 512 subcarriers in the ADSL2 and ADSL2+ standards, respectively. Channel characteristics of the source and load impedance yield valuable information about the physical condition of the copper loop and its topology. Quiet line noise shows the levels of noise on the line when the ADSL connection is inactive, providing a wideband spectral analysis function. Lastly, the signal-to-noise ratio can be used to derive the impact of topology or spectral issues on a line showing, for example, that a 300-foot bridged tap is causing 500 kbps of data rate loss. ▶▶

The ADSL2 diagnostic mode also reports six performance scalars, including the total line attenuation and signal attenuation values, the signal to noise margin, the attainable net data rate, and both far- and near-end aggregate transmit power. Trends among these values can be telltale signs of specific problems on the loop and can reveal opportunities for line conditioning.

The process of obtaining this data has been included in the standard, allowing interoperability between manufacturers. To begin this process, one or both of the DSL transceivers requests to enter diagnostics mode. During this mode, the physical media dependent sublayers of the central office DSLAM and the CPE collect information on the state of the connection and the loop as they pass through the initialization process. Once collection is complete, the two transceivers exchange the raw statistics they have obtained using a robust, low bit rate "diagnostics link," which can be established even in cases where the modems do not normally sync. This information is then available to the modem or DSLAM management software using the standard G.ploam (G.997.1) MIB fields.

Interpretation Challenge

Although the ADSL2 standards provide for the collection and retrieval of the diagnostic data, they do not include procedures or algorithms to convert the measurements into meaningful results. This needs to be done either manually by a technician—much like insertion loss or wideband spectral analysis data from a handheld test set is analyzed today—or automatically with analysis software, such as Aware's Dr. DSL®, running on the technician's laptop, making the statistics meaningful and putting them in a context that is useful to service personnel. Figure 1 shows the category of test and the results that can be derived from it.

Reviewing the noise floor raw data, for example, allows a technician to determine the presence of T1, HDSL or other data service crosstalk as well as AM radio ingress. Interpretation software enhances this by automatically identifying the type of crosstalk, its magnitude and, most importantly, its data rate impact on the ADSL line under test.

Similarly, dips in the signal attenuation raw data (transmitted by the DSLAM, received by the modem) are indicative of bridged taps. Manual analysis clearly shows tap presence, while interpretation software can provide the length of multiple taps and their data rate impact. ▶▶

ADSL2 Diagnostics: Test Capabilities

Test Category	*Dr. DSL® Interpreted Results*
Loop Topology	✔ Loop length ✔ Bridged taps
Spectral Analysis	✔ Intrinsic crosstalk noise, such as HDSL, T1, ISDN, ADSL ✔ Extrinsic noise such as AM and EMI interference
Training, Operating Statistics	✔ Current / maximum data rate ✔ Operating efficiency

Figure 1.
ADSL2 Diagnostics Test Capabilities

In both cases, the interpretation software is able to provide the data rate impact of the problem by utilizing the modem's training and operating statistics. This allows a technician to quickly determine which problem—bridged tap, crosstalk, or AM ingress—is having the greatest impact on performance and whether the remedy will be sufficient to resolve the trouble.

Technician Dr. DSL®

Aware's Dr. DSL interpretation software brings together all of the raw test data collected from a transceiver's MIB and uses powerful algorithms to scan for physical layer impairments and interferers. Dr. DSL reports in plain text problems in three categories: loop topology, wideband noise analysis, and in-home analysis.

Loop Topology

Dr. DSL converts multi-segment, multi-gauge wire into a single-gauge, equivalent length that is more relevant for calculating expected loop performance. Dr. DSL can also accurately and consistently identify up to two short taps, independent of their location on the loop.

Wideband Noise Analysis

Dr. DSL analyses the spectral noise data up to 1.1 MHz or 2.2 MHz for ADSL2 and ADSL2+, respectively, and identifies the type and power level of common disturbers, such as T1, ISDN, HDSL and ADSL. Dr. DSL also reports external noise ingress from AM or HAM radio.

In-home Analysis

Dr. DSL scans the home for missing or incorrectly installed microfilters. Problems are only reported if there is a data rate impact. While most phones need microfilters, newer cordless phones often don't and Dr. DSL doesn't report "non-problems."

SmartRx™ Analysis

Dr. DSL reports the data rate reduction due to bridged taps, crosstalk and AM radio. A typical report may show a data rate reduction of 2.5 Mbps due to a bridged tap, 1.2 Mbps due to ISDN crosstalk, and 512 kbps due to AM ingress. Immediately the technician knows the primary cause and can determine what, if any, resolution will provide the requested service.

Aware's Technician Dr. DSL allows field service personnel to use these powerful analysis technologies within a simple one-click test interface. The detailed, yet easy to read reports that are created show loop topology, throughput, CO information, in-home interference, missing microfilters, and other operating statistics including the type of disturbers present as well as their impact on the data rate in kilobits per second. For more advanced technicians, graphical output of the signal, wideband noise, and bit allocations per tone allow in-depth analysis. All of this information is vital to service personnel trying to identify the many problems that can exist in the field.

Field Tests

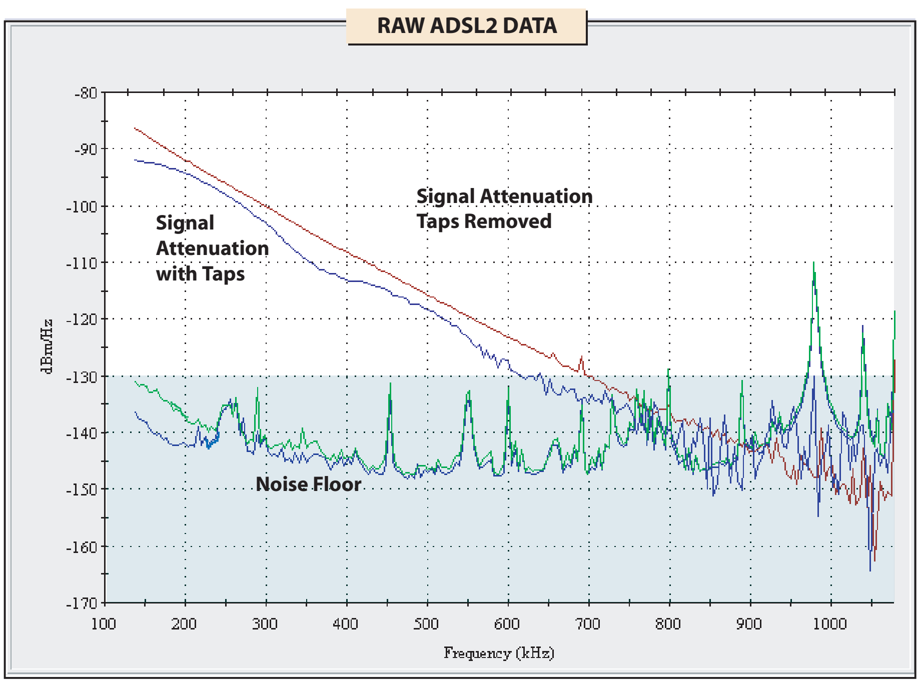
During an extensive field trial conducted in cooperation with a North American service provider, ADSL2 diagnostics proved highly or moderately useful on 75 percent of the troubles by either identifying a correctable problem or by showing that the physical layer was testing OK and no further conditioning would improve service.

ADSL2 diagnostics were particularly good at identifying DSL's classic problems of short taps on long loops, crosstalk from adjacent data services, and missing microfilters. Two examples taken from this field trial demonstrate the value of ADSL2 diagnostics. ▸▸

Field Case #1: The Bridged Tap

After upgrading a business DSL line from 1.5 Mbps to 2.5 Mbps, the customer complained of “slow speeds” and did not notice an overall performance improvement. Figure 2 shows the ADSL2 diagnostic data captured on this line.

Figure 2.
Troubleshooting a Bridged Tap



Dr. DSL® INTERPRETATION SOFTWARE ANALYSIS

BEFORE

Data Rates		
Actual Downstream	:	1536 kbps
Max Downstream Rate	:	1536 kbps
In-Home Analysis		
Microfilter Needed	:	no
Downstream Data Rate Reductions		
Crosstalk Disturbers	:	160 kbps
AM and NB Disturbers	:	128 kbps
Bridged Tap	:	2432 kbps
Loop Estimate		
Equivalent Gauge	:	26 awg
Loop Length	:	13500 feet
Number of Bridged Taps	:	1
Bridged Tap Length	:	1300 feet

AFTER

Data Rates		
Actual Downstream	:	2528 kbps
Max Downstream Rate	:	3776 kbps
In-Home Analysis		
Microfilter Needed	:	no
Downstream Data Rate Reductions		
Crosstalk Disturbers	:	256 kbps
AM and NB Disturbers	:	128 kbps
Bridged Tap	:	0 kbps
Loop Estimate		
Equivalent Gauge	:	26 awg
Loop Length	:	13600 feet
Number of Bridged Taps	:	0

The first test verified the customer’s complaint of slow service, showing a trained rate of just over 1.5 Mbps. In addition, the signal attenuation graph showed a broad dip at 150 kHz and 350 kHz, indicative of bridged taps. The noise floor was relatively clean with only minor spikes and nothing above -130 dBm/Hz—a very good floor for field loops. This immediately suggests that the bridged tap is affecting service.

Additional detail was provided by Dr. DSL’s interpretation software, which analyzed the signal attenuation data to determine a loop length of 13,500 feet—reasonable for the requested service, but with a 1,300-foot tap. The rate reduction analysis showed the tap had a significant 2.4 Mbps impact on the line’s maximum capacity, while the crosstalk and AM ingress accounted for only 160 kbps and 128 kbps, respectively.

Within minutes of connecting to the line the technician knew several important facts. First the line was training below the requested service level. Second there was a bridged tap significantly impacting service. And third, the other likely culprits of degraded service—noise and microfilters—were not an issue.

After changing the customer over to an untapped pair, the line trained at the requested 2.5 Mbps with a healthy maximum capacity of 3.8 Mbps, providing a buffer against future noise.

Roughly a quarter of the troubles during the trial involved bridged taps. ADSL2 diagnostics with Dr. DSL allowed quick identification without difficult and error-prone TDR measurements. Moreover, with interpretation software, ADSL2 diagnostics showed whether removing the tap would significantly improve service, preventing costly “false fixes” when the taps had only a secondary impact on performance. ▶▶

Field Case #2: Crosstalk

Upwards of 10 percent of the troubles in the field trial were due to other data services in the binder group causing crosstalk—the ADSL equivalent of hearing two conversations on the same telephone call. In one case a customer had noticed repeated "dropped service" where the DSL line would retrain periodically.

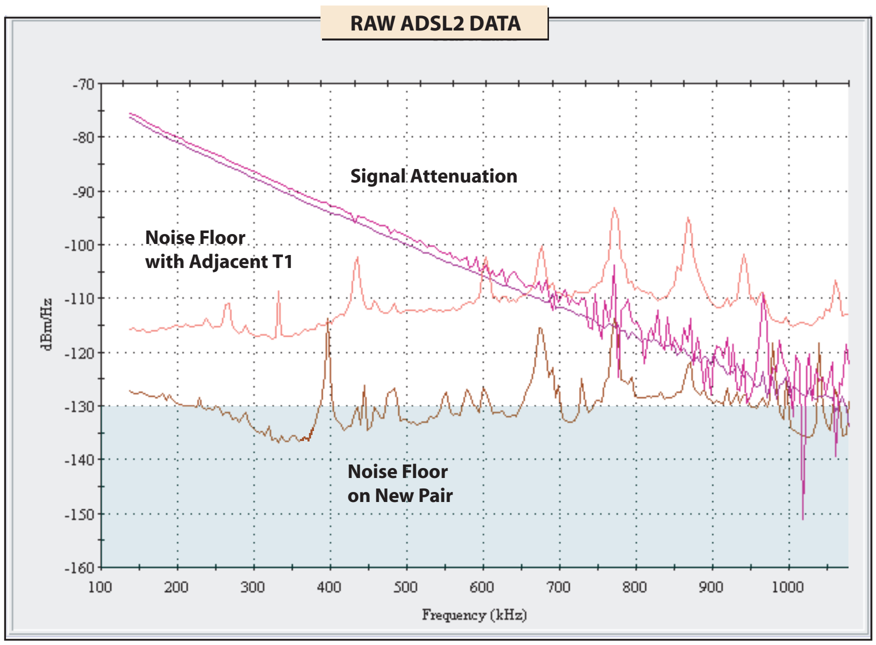
As had happened on two previous truck rolls, the technician first power-cycled the customer's modem, which then retrained at roughly 900 kbps. Both technician and customer knew, however, that the line's performance would gradually decline, and both wanted a solution that didn't involve retraining each time the customer wanted to use his "always-on" DSL service.

Reviewing the ADSL2 diagnostic raw data showed significant crosstalk, with noise well above the nominal -130 dBm/Hz field noise floor. The crosstalk's shape, or Power Spectral Density (PSD), suggested that a T1 was causing the interference. Unlike the previous case, however, the signal attenuation did not show any bridged tap dips.

Dr. DSL interpretation software automatically identified the crosstalk as T1 with a power level of -49.1 dBm and a significant 7 Mbps rate reduction due to the crosstalk. Rate reduction due to AM ingress was minimal, and there were no taps on the line. Clearly the only way to increase the reliability of this customer's service was to reduce the crosstalk.

The technician accomplished this by changing the pair in the binder group. The new pair was far enough away from the T1 disturber that the impact was cut by half, allowing the line to train at the requested 1.5 Mbps service with a maximum achievable rate of 3.4 Mbps, again providing a buffer against future noise and increasing reliability.

Figure 3. Troubleshooting crosstalk



Dr. DSL® INTERPRETATION SOFTWARE ANALYSIS

BEFORE

```
Data Rates
Actual Downstream      :   896 kbps
Max Downstream Rate    :  1120 kbps

In-Home Analysis
Microfilter Needed     :    no

Downstream Data Rate Reductions
Crosstalk Disturbers   :  5104 kbps
AM and NB Disturbers   :    72 kbps
Bridged Taps           :     0 kbps

Crosstalk Disturbers
Type                            Power
-------------------------------------
ISDN  (DSL NEXT)                none
HDSL                            none
T1                              -49.1 dBm
ADSL Full-Rate                  none
Unknown Type                    none
```

AFTER

```
Data Rates
Actual Downstream      :  1536 kbps
Max Downstream Rate    :  3360 kbps

In-Home Analysis
Microfilter Needed     :    no

Downstream Data Rate Reductions
Crosstalk Disturbers   :  3360 kbps
AM and NB Disturbers   :   256 kbps
Bridged Taps           :     0 kbps

Crosstalk Disturbers
Type                            Power
-------------------------------------
ISDN  (DSL NEXT)                none
HDSL                            none
T1                              -70.4 dBm
ADSL Full-Rate                  none
Unknown Type                    none
```

Solving the Problems

New Services, New Troubles, New Tools

Such problems will become increasingly common with the introduction of ADSL2's new capabilities for high-bandwidth video, extended reach, and bonding. Crosstalk, taps or missing microfilters that might go unnoticed on a best-effort 1.5 Mbps service will almost certainly interfere with multi-channel video service. And multiple truck rolls will quickly eliminate already thin profit.

Fortunately, ADSL2's diagnostics capabilities provide technicians with standard, repeatable tests for the most common ADSL troubles. Interpretation software further improves testing by automatically identifying the problem and its data rate impact, allowing a technician to quickly segment problems to the loop, crosstalk or external noise or to quickly verify that the physical layer is performing well.

ADSL2 modems can't completely replace standard volt-ohm meters and special services test sets. Identifying foreign voltage, capacitive imbalance or load coils cannot be done with a modem alone. But few other solutions offer a less expensive or more effective method of combating common ADSL troubles.

Conclusion

With so many options in the broadband market for consumers to choose from, competition will remain fierce for a long time to come. The number of broadband subscribers worldwide is growing daily and these customers will stand for nothing less than high-performance. The only companies that will be capable of meeting these expectations are those who recognize the value of advanced service offerings such as video and take the steps necessary to improve the care and monitoring of their infrastructures.

Through the implementation of Technician Dr. DSL in normal maintenance practices, carriers will not only be able to decrease repair times and minimize their costs, but also will gain valuable insight into their network's strengths and weaknesses. This more accurate and detailed understanding of their capabilities will help them remain a strong competitor in the ever-changing broadband world. ■

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