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(54) **SYSTEM AND METHOD FOR OPTIMIZING DIGITAL SUBSCRIBER LINE BASED SERVICES**

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(58) **Field of Classification Search** ..... None
See application file for complete search history.

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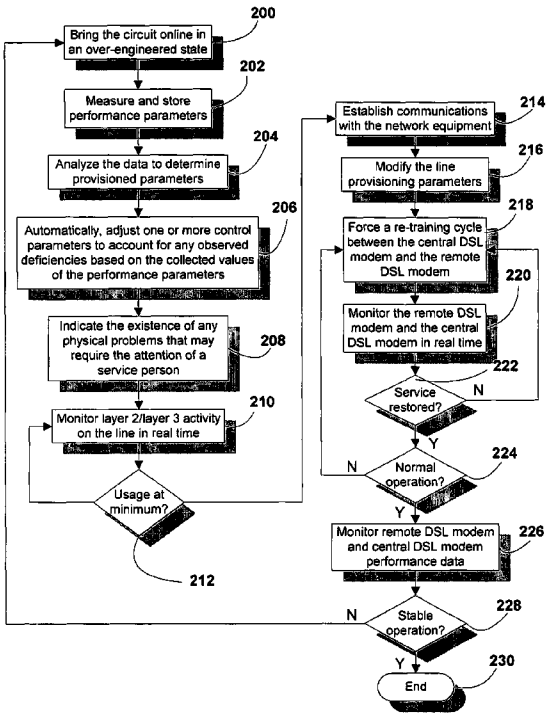
(57) **ABSTRACT**

A method is provided that can be used for modifying a control parameter associated with a digital subscriber line (DSL) service. Initially, a real-time performance parameter is received from a first termination unit that is coupled to an DSL circuit. The real-time performance parameter is measured at the termination unit after the termination unit is provisioned and after the DSL circuit is placed in-service. A value of a control parameter associated with the DSL circuit can be modified based on the measured real-time performance parameter. Further, activity over the DSL circuit can be monitored in real-time and when usage of the DSL circuit is below a threshold, the provisionable service parameter that corresponds to the control parameter is modified. Moreover, a first re-provisioning cycle between the first termination unit and a second termination unit coupled to the DSL circuit can be initiated using the provisionable service parameter.

58 Claims, 2 Drawing Sheets



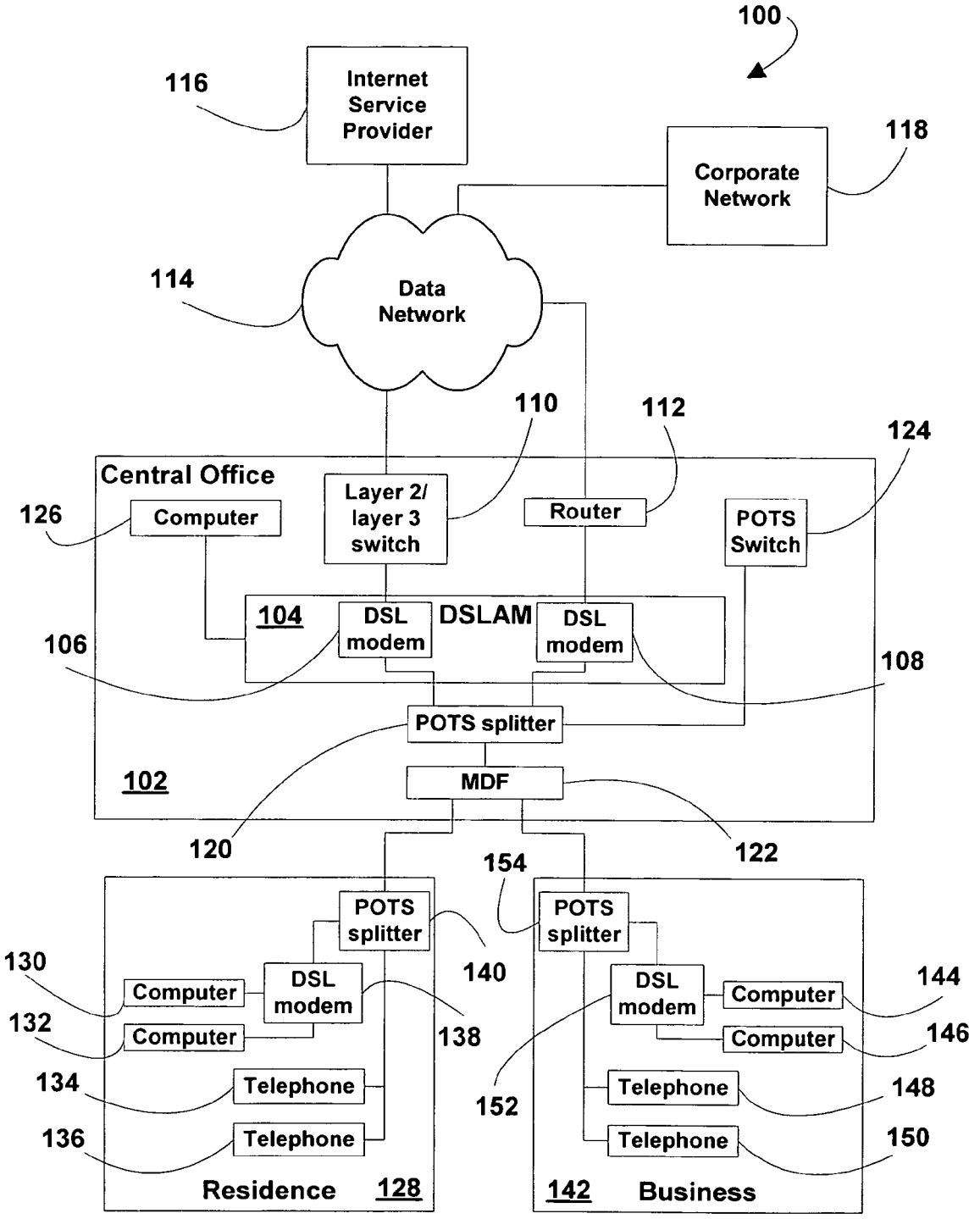

100
116
Internet Service Provider
118
Corporate Network
114
Data Network
110
112
124
Central Office
126
Computer
Layer 2/ layer 3 switch
Router
POTS Switch
104
DSL modem
DSLAM
DSL modem
106
108
POTS splitter
102
MDF
120
122
154
POTS splitter
POTS splitter
130
Computer
DSL modem
140
DSL modem
Computer
144
132
Computer
138
Computer
146
134
Telephone
152
Telephone
148
136
Telephone
Telephone
150
Residence
128
142
Business

FIG. 1

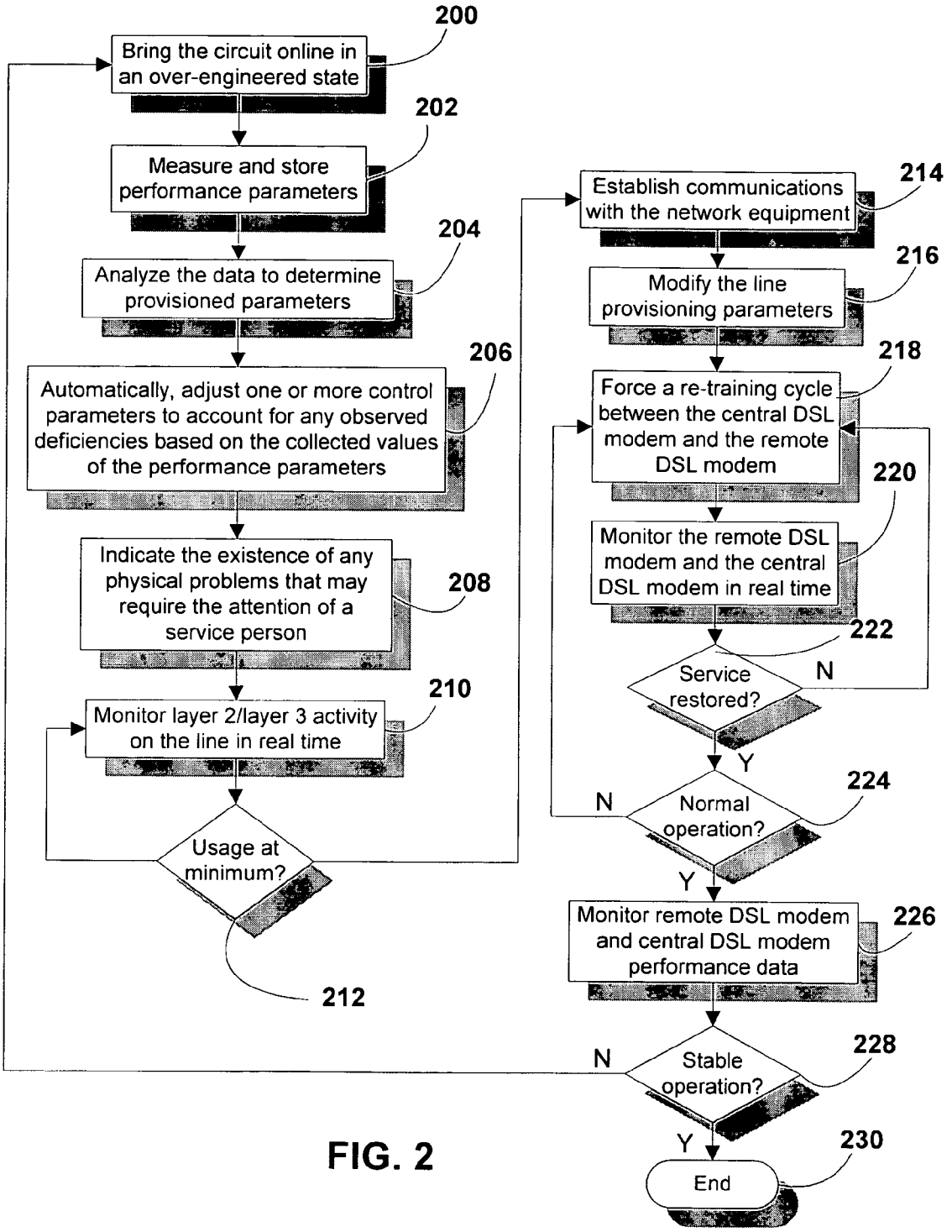

200
Bring the circuit online in an over-engineered state
202
Measure and store performance parameters
204
Analyze the data to determine provisioned parameters
206
Automatically, adjust one or more control parameters to account for any observed deficiencies based on the collected values of the performance parameters
208
Indicate the existence of any physical problems that may require the attention of a service person
210
Monitor layer 2/layer 3 activity on the line in real time
Usage at minimum?
212
214
Establish communications with the network equipment
216
Modify the line provisioning parameters
218
Force a re-training cycle between the central DSL modem and the remote DSL modem
220
Monitor the remote DSL modem and the central DSL modem in real time
222
Service restored?
N
Y
224
Normal operation?
N
Y
226
Monitor remote DSL modem and central DSL modem performance data
228
Stable operation?
N
Y
230
End

FIG. 2

SYSTEM AND METHOD FOR OPTIMIZING DIGITAL SUBSCRIBER LINE BASED SERVICES

FIELD OF THE DISCLOSURE

The present disclosure relates generally to the optimization of digital subscriber line data service.

BACKGROUND

Digital subscriber line (DSL) has quickly emerged as a high quality solution for high speed Internet access and other services associated with high speed Internet services, such as, voice over Internet protocol (VoIP) and streaming video services. DSL can transmit both voice and data simultaneously over an existing, single copper pair up to 18,000 feet long. Since DSL can utilize existing copper telephone lines, the service costs associated with DSL is relatively low for service providers and for customers. Moreover, since data can be transmitted relatively quickly using DSL, it is a very attractive option for providing high-speed access to end users.

Traditional plain old telephone service (POTS) uses a narrow 4-kHz baseband frequency to transmit analog voice signals, and current modem technology can achieve a data transmission rate of up to 56 kb/s. DSL, e.g., asymmetric DSL (ADSL), can increase the usable frequency range from 4 kHz to 1.1 MHz and can provide a data transmission rate up to 8 Mb/s. Further, frequency division multiplexing (FDM) can allow ADSL to create multiple frequency bands that can be used to carry data simultaneously with POTS signals over the same copper pair. The lower 4-kHz frequency range is reserved for POTS, the middle frequency band is used to transmit upstream data and the larger, higher frequency band is used to transmit downstream data.

Discrete multi-tone (DMT) modulation is the American National Standards Institute (ANSI) standard T1.413 line code. DMT modulation is used to divide the data bandwidth into 256 subchannels, or tones, that range from 20 kHz to 1.1 MHz for ADSL. Upstream data transfer frequencies range from 20 kHz to 160 kHz and downstream data transfer frequencies range from 240 kHz to 1.1 MHz. The remaining tones are used as guard bands for dividing the three frequency bands, and one pilot tone is used in each data stream, both upstream and downstream, for timing purposes. Each tone, or channel, has a spacing of 4.3 kHz and each tone supports a maximum number of 15 bits, which is limited by the signal-to-noise ratio on the channel. Since the tones in the higher frequencies are subject to higher attenuation and noise, the number of bits per tone can be fewer than that in the lower frequencies.

In addition to the normal data bits, an embedded operations channel (EOC) is provided as part of the ADSL protocol for communication between the ATU-C and the ATU-R to provide in-service and out-of-service maintenance, to retrieve a limited amount of ATU-R status information, and to monitor ADSL performance.

Typically, the optimization of the data transmission channels used for DSL data transport, e.g., VoIP and video, is largely ignored due to technical and economic factors. Without optimization, DSL circuits are either over-engineered or under-engineered for performance. Over engineered circuits operate at sub-optimum rates and deliver less performance to the customer. Under-engineered circuits experience frequent data errors that result in increased peer-to-peer communications required to perform re-transmissions of data packets. This yields a reduced throughput to the customer. Some under-engineered circuits experience error rates severe enough to cause service interruption or the inability to establish the data channel when initially requested by the customer.

Accordingly, there is a need for a system and method for optimizing digital subscriber line data service.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is pointed out with particularity in the appended claims. However, other features are described in the following detailed description in conjunction with the accompanying drawings in which:

FIG. **1** is a diagram of an exemplary DSL network; and

FIG. **2** is a flow chart to illustrate an exemplary method for optimizing a DSL network.

DETAILED DESCRIPTION OF THE DRAWINGS

A method is provided that can be used for modifying a control parameter associated with a digital subscriber line (DSL) service. Initially, a real-time performance parameter is received from a first termination unit that is coupled to a DSL circuit. The real-time performance parameter can be measured at the termination unit after the termination unit is provisioned and after the DSL circuit is placed in-service. In a particular embodiment, a value of a control parameter associated with the DSL circuit can be modified based on the measured real-time performance parameter.

In another particular embodiment, activity over the DSL circuit is monitored in real-time. Further, a determination is made to ascertain when usage of the DSL circuit is below a threshold. The provisionable service parameter corresponding to the control parameter can be modified when the usage is below the threshold. In still another particular embodiment, a first re-provisioning cycle between the first termination unit and a second termination unit coupled to the DSL circuit can be initiated using the provisionable service parameter.

In yet another particular embodiment, the first termination device is a DSL modem. Further, the second termination device is a DSL modem. Also, in another particular embodiment, a determination is made in order to determine whether operation of the DSL circuit is within an acceptable operating range. The provisionable service parameter is modified after determining that the operation of the DSL circuit is not within the acceptable operating range. Further, performance data of the termination unit is monitored and a determination is made in order to ascertain whether operation of the DSL circuit is stable based on the monitored performance data.

In another embodiment, a digital subscriber line (DSL) network is provided and includes a first modem at a central office and a second modem at a remote site. A DSL channel is established between the first modem and the second modem. Further, a computer communicates with the first modem and the second modem. The computer includes a program for modifying a provisionable service parameter associated with the DSL channel based on measured in-service performance parameters received from the first modem or the second modem.

In yet another embodiment, a method for modifying a data network is provided and includes provisioning a data circuit within the data network with a first set of provisioning parameters. Thereafter, a first set of in-service performance data is acquired from a terminating unit coupled to the data circuit. A second set of provisioning parameters is determined based on the first set of performance data. The data circuit can be re-provisioned with the second set of provisioning parameters.

Referring to FIG. **1**, an exemplary, non-limiting embodiment of a DSL network is shown and is generally designated **100**. In a particular embodiment, the DSL network can be an ADSL network, an ADSL 2 network, an ADSL 2+ network, or a very high data rate DSL (VDSL) network. As illustrated in FIG. **1**, the DSL network **100** includes a central office (CO) **102** in which a DSL access multiplexer (DSLAM) **104** can be located. A first central DSL modem **106** and a second central DSL modem **108** are located in the CO **102**. In the case in which the DSL network is an ADSL network, each DSL modem in the CO **102** can be an ADSL terminating unit—central office (ATU-C). In a particular embodiment, the first DSL modem **106** and the second DSL modem **108** are installed in the DSLAM **104**.

In an illustrative embodiment, a layer **2**/layer **3** switch **110** is connected to the first DSL MODEM **106** and a router **112** is connected to the second DSL MODEM **108**. In a particular embodiment, the layer **2**/layer **3** switch **100** is an asynchronous transfer mode (ATM) switch or an Ethernet switch. As shown, the layer **2**/layer **3** switch **110** and the router **112** are connected to a data network **114**, e.g., the Internet. As such, in a particular embodiment, the layer **2**/layer **3** switch **110** and the router **112** provide data network connectivity to the first DSL MODEM **106** and the second DSL MODEM **108**. In an illustrative embodiment, an Internet service provider (ISP) **116** is connected to the data network **114**. Moreover, a corporate network **118** is connected to the data network **114**. For simplicity, only one ISP **116** and only one corporate network **118** is shown connected to the data network **114**, but any number of ISPs and any number of corporate networks **118** can be connected to the data network **114**.

FIG. **1** further shows that the CO **102** includes a plain old telephone service (POTS) splitter **120** that can be connected to the first DSL MODEM **106** and the second DSL MODEM **108**. Also, a main distribution frame (MDF) **122** is connected to the POTS splitter **120**. A POTS switch **124** can be connected to the POTS splitter **120** in order to switch incoming telephone calls received at the CO **102**. Additionally, the CO **102** includes a managing computer **126** that can be connected to the DSLAM **104**. In a particular embodiment, the managing computer **126** can be used to manage the DSL network **100** and to enhance or optimize the performance of the DSL network **100**.

As depicted in FIG. **1**, the DSL network **100** can connect to a customer residence **128** in which a first computer **130** and a second computer **132** are located. FIG. **1** also shows a first telephone **134** and a second telephone **136** that are located in the customer residence **128**. As shown in FIG. **1**, the first computer **130** and the second computer **132** are connected to a remote DSL modem **138**. In the case that the DSL network **100** is an ADSL network the remote DSL modem **138** can be an ADSL terminating unit—remote (ATU-R). The remote DSL modem **138** is connected to a remote POTS splitter **140** that, in turn, is connected to the MDF **122**. Accordingly, either the first central DSL modem **106** or the second central DSL modem **108** can communicate with the remote DSL modem **138** via the POTS splitter **120**, the MDF **122**, and the remote POTS splitter **140** in order to provide network connectivity to the computers **130**, **132**.

FIG. **1** shows that the telephones **134**, **136** are also connected to the remote POTS splitter **140**. Telephone calls made by the telephones **134**, **136** can be routed to the POTS switch **124** at the CO **102** via the remote POTS splitter **140**, the MDF **122**, and the POTS splitter **120**. In the exemplary, non-limiting embodiment of the DSL network **100** shown in FIG. **1**, two computers **130**, **132** and two telephones **134**, **136** are illustrated, but any number of computers and telephones can be located in the customer residence **128** and connected to the CO **102**.

FIG. **1** illustrates that the DSL network **100** can further include a customer business **142** in which a first computer **144** and a second computer **146** are located. A first telephone **148** and a second telephone **150** can also be located in the customer business **142**. As shown in FIG. **1**, the first computer **144** and the second computer **146** are connected to remote DSL modem **152**. In a particular embodiment, the remote DSL modem **152** is connected to a remote POTS splitter **154** that, in turn, is connected to the MDF **122**. Accordingly, either the first central DSL modem **106** or the second central DSL modem **108** can communicate with the remote DSL modem **152** via the POTS splitter **120** within the CO **102**, the MDF **122**, and the remote POTS splitter **154** in order to provide network connectivity to the business computers **144**, **146**.

FIG. **1** shows that the business telephones **148**, **150** are also connected to the remote POTS splitter **154**. Telephone calls made by the telephones **148**, **150** can be routed to the POTS switch **124** located at the CO **102** via the remote POTS splitter **154**, the MDF **122**, and the CO POTS splitter **120**. In an illustrative embodiment, two business computers **144**, **146** and two business telephones **148**, **150** are illustrated, but any number of business computers and business telephones can be located in the customer business **142** and connected to the CO **102**.

In a particular embodiment, data can be transmitted over the DSL network **100** using transmission control protocol/internet protocol (TCP/IP), file transfer protocol (FTP) (e.g., for large files), user datagram protocol (UDP) (e.g., for VoIP and streaming video), or real-time transport protocol (RTP) (e.g., for streaming video files or streaming audio files). As such, the protocol used is an indirect user of the physical layer of the DSL network **100**. In order to provide peak DSL service, and peak protocol throughput, using the DSL network **100**, the physical layer of the DSL network **100** can have its performance enhanced or optimized. In other words, the circuits in the DSL network **100** that are established between the CO **102** and the customer residence **128** can be enhanced or optimized. Optimization is a process of finding and establishing optimal values for provisionable data communications parameters. Once a circuit is optimized, it can provide optimum or near optimum DSL service regardless of the operating conditions.

In an illustrative embodiment, DSL performance is dominated by two major factors: 1) insertion loss caused by the transmission cable connecting the DSL modems; and 2) electronic noise that reduces the signal to noise ratio at the modem receivers. The electronic noise generally includes a relatively predictable amount of random noise and intermittent noise known as impulse noise. Construction and service records can provide information about the transmission channel loop from which the insertion loss can be ascertained. However, both components of the noise on the channel are unknown. Typically, a service provider does not measure the noise on its circuits before a sale is made to a customer, nor does the service provider typically have accurate information about expected or anticipated noise levels on the data communication circuit that will be used by a customer. Loss and noise could be measured prior to circuit provisioning, but the costs associated with such a project could be overly expensive.

In a particular embodiment, the information necessary to enhance or optimize the circuits in the DSL network **100** is available, but only after the circuits have been provisioned, service has been activated, and after the service is in use by one or more customers.

Referring now to FIG. **2**, a method for enhancing or optimizing a DSL network is shown. In a particular embodiment, the method can be used to optimize the DSL network **100** shown in FIG. **1**. During execution of the method, several measurements are taken, recorded, and analyzed for the DSL network **100** to promote statistical confidence. These performance parameters can be used to affect the settings of one or more control parameters. In an illustrative embodiment, the performance parameters that can be measured during the optimization of the DSL network are shown in Table 1. Further, the control parameters are shown in Table 2.

TABLE 1

Exemplary, Non-limiting DSL Performance Parameters.

Performance Parameter	Description
NMR	The Noise Margin Ratio measured upstream and downstream.
Max Bit Rate	The maximum data rate the channel can support (assessed by an DSL modem).
Net Rate (Actual Rate)	The bit rate currently available to the customer.
QLN[n]	The Quiet Line Noise measured during a brief period, e.g., less than two minutes for each DSL DMT.
Hlog[n]	The insertion loss of the DSL channel measured for each DSL DMT.
CV[t]	A times series of counts of Code Violations (CV) wherein each CV represents a data packet that could not be corrected by the channel's provisioned forward-error-control parameters;
ES[t]	A time series of counts of Errored Seconds (ES) wherein each ES is a one second interval during which one to M CVs are observed and wherein M is a value set in DSL standards.
SES[t]	A time series of counts of Severely Errored Seconds (SES) wherein each SES is a one second interval during which greater than M CVs are observed.
SYMu[t]	A count during a fifteen minute interval of the number of user data packets sent and received over the DSL channel.
SYMd[t]	A count during a fifteen minute interval of the number of overhead data packets sent and received over the DSL channel.
Power	The transmission power of the data signal.
PSD[n]	The power spectral density of the data signal.
Freq range	The tone indices of the DSL DMT.
MSE[n]	The noise over the channel when the DSL modem is operating.
SNR[n]	The signal to noise ratio for each tone.
B[n]	The total bits for each tone.
G[n]	The gain for each tone.
Dual Path On?	Fast, Interleaved on/off
Forward Error Correction	The information added to the data transmitted over the DSL channel in order to account for any bits that are corrupted during transmission. The FEC parameters can include: N, which is the Reed Solomon codeword length; P, which is the Parity bytes/codeword (4 bits); D, which is the Interleave depth (6 bits); and S, which is the DMT symbols/codeword.
Trellis On?	An indication of whether Trellis coding is on or off.
ATTNDR	The attainable rate for the DSL channel.
Code violations	One or more code violations for the DSL channel, e.g., cyclic redundancy check (CRC), errored second (ES), forward error correction (FEC), etc.
Attenuation	The difference between the total maximum transmitted power at one end of the DSL channel and the total power received at the remote end of the DSL channel, e.g., loop attenuation as specified in International Telecommunications Union (ITU) Standard G.992.3
Margin	The margin available to accommodate increases losses on the DSL channel, e.g., due to temperature changes, physical aging of equipment, physical aging of copper lines, etc.

TABLE 2

Exemplary, Non-limiting Control Parameters.

Control Parameter	Description
Power	The transmission power of the data signal.
PSD	The power spectral density of the data signal.
ADDNMR	The additional noise margin and signal noise ratio.
MAXSNRM	The maximum noise margin and signal noise ratio.
TARSNRM	The target noise margin and signal ratio.
Dual Paths	The ability to use two data transmission paths.
Forward Error Correction (FEC) controls	The controls used to account for any bits that are corrupted during transmission. The FEC controls can include: N, which is the Reed Solomon codeword length; P, which is the Parity bytes/codeword; D, which is the Interleave depth (6 bits); and S, which is the DMT symbols/codeword.
Data rate	The upstream and downstream data transmission rate.

At block **200**, an DSL circuit, i.e., a connection between one of the DSL modems **106**, **108** (FIG. **1**) at the CO **102** and a user computer is brought on-line in an over-engineered state, i.e., in optimal conditions. This provides that the DSL service to the customer computer is established. At block **202**, the performance parameters are measured in real-time at each DSL modem, e.g., the DSL modem at the CO and the DSL modem at the residence, and stored. In a particular embodiment, QLN is measured during a brief period, e.g., less than two minutes. Moreover, in a particular embodiment, CV[t], ES[t], SES[t], SYMu[t] and SYMd[t] are measured in real-time during an observation time period T_{obs}. In an illustrative embodiment, T_{obs} is approximately fifteen minutes. Further, in a particular embodiment the performance parameters can include dynamic spectrum management (DSM) data. Additionally, in a particular embodiment, the performance parameters can be measured and stored multiple times over a predetermined time period, e.g., every 8 hours for twenty four hours, in order to promote statistical confidence.

In a particular embodiment, to optimize the portion of the DSL circuit transmitting data to a user computer, each of these measurements may be measured by an DSL modem at a user residence. Also, in a particular embodiment, the measurements may be taken by a DSL modem at the CO **102** (FIG. **1**) in order to optimize the portion of the DSL circuit transmitting data from the user computer to the DSL modem at the CO **102** (FIG. **1**). Moreover, once measured, the values can be communicated by the DSL modem at the residence **128** (FIG. **1**) or one of the DSL modems **106**, **108** (FIG. **1**) at the CO **102** (FIG. **1**) to a secure website or a secure computer via a secure network connection.

Proceeding to block **204**, the performance parameters measured in step **202** are analyzed in order to make a number of determinations. In an illustrative embodiment, the maximum attainable bit rate is determined, e.g., by a reported value from the ATU-C or the ATU-R. Moreover, the loop length can be estimated based in part on the HLOG[n] values for the

upstream portion of the DSL channel. In a particular embodiment, excessive power levels can be detected. Further, any cross talk, any white noise, and any non-linear echoes can be detected based on patterns observed in the empirical data collected per tone. For example, cross talk can be determined in part based on the QLN[n] values measured above. In a particular embodiment, the source of white noise or cross talk can be determined based on the "finger prints" of the different sources of the white noise. The "finger prints" of the sources of the white noise can be empirically determined and can include carrier tones or frequencies associated with the sources of the white noise or cross talk. The sources of the white noise or cross talk can include, for example, amplitude modulation (AM) radio interference, HAM radio interference, ionosphere interference that can depend on a time of day, and T-carrier interference.

In a particular embodiment, the presence and location of bridged taps, the presence of bad splices, the presence of bad grounds, and the presence of bad bonds can be determined based in part on the values of the performance parameters measured above. Additionally, an inadequately filtered inside wire at a customer location, the presence of a maintenance test unit, and the presence of an alarm system on an DSL line can be determined based in part on the values performance parameters measured above.

At block **206**, one or more of the control parameters, shown in Table 2, are automatically adjusted to account for any observed deficiencies based on the collected values of the performance parameters. For example, in a particular embodiment, the data rates can be adjusted to maximize service performance. Power and noise margin settings can be adjusted. PSD masks are adjusted to limit cross talk on the DSL channel. Further, the forward error correction (FEC) controls and interleaved settings can be adjusted to optimize TCP/IP performance and minimize signal latency in the presence of impulse noise. Proceeding to block **208**, the existences of any physical problems that may require the attention of service person are indicated, e.g., to the customer or a service person. The physical problems can include one or more bridged taps, one or bad wire bonds, one or more bad grounds, one or more bad splices, one or more line filtering problems, and may require the attention of a service person in order to correct the problem.

Moving to block **210**, layer **2** and layer **3** activity on the DSL circuit is monitored in real-time. (Layer **2** and layer **3** are based on the OSI seven-layer model of networking.) At step **212**, a decision is made in order to determine when usage of the DSL circuit is at a minimum. If the usage is not at a minimum, the logic returns to block **210** and the activity on the DSL circuit continues to be monitored. On the other hand, when the usage is at a minimum, the logic proceeds to block **214** and communication is established between the ATU-C and the ATU-R. At block **216**, the line provisioning parameters are modified based on the data collected and analyzed above. In a particular embodiment, the line provision parameters are modified based on the adjusted control parameters. Moving to block **218**, a re-training cycle is forced between the ATU-R and the ATU-C. Then, the ATU-R and the ATU-C are monitored in real-time, at block **220**. Proceeding to step **222**, a determination is made in order to ascertain whether service over the DSL circuit is restored. If service is not restored, the logic returns to block **218** and another re-training cycle is forced between the ATU-C and the ATU-R and continues as previously described. If service is restored, the logic continues to step **224**.

At step **224**, a decision is made in order to determine whether operation of the DSL circuit is within a normal operating range. If the operation is not within the normal operating range, the logic returns to block **218** and continues as previously described. Conversely, if the operation of the ADLS circuit is within the normal operating range, the logic moves to block **226** where the ATU-R and the ATU-C are monitored. Specifically, in a particular embodiment, performance data for the ATU-R and the ATU-C is monitored. At step **228**, a determination is made in order to determine if the operation of the DSL circuit is stable. If not, the logic returns to step **200** and the DSL circuit is re-optimized using the steps previously described. If the operation of the DSL circuit is stable, the logic ends at state **230**.

In a particular embodiment, the method can be repeated iteratively for each new DSL line until each new DSL line reaches an acceptable state of performance. Moreover, each line can be managed using a state machine translation table that incorporates the performance parameters and control parameters shown in Table 1 and Table 2.

With the configuration of structure described above, the system and method for optimizing DSL data service provides a method to improve and preferably to ensure optimal performance of individual circuits of an DSL network based on numerous parameters measured in real-time. In an illustrative embodiment, each DSL circuit can be optimized many times over the life of the DSL circuit. For example, each DSL circuit can be optimized on a predetermined schedule, e.g., once a week, twice a week, once a month, twice a month, once every two months, once every six months, once a year, etc. Also, the DSL circuit can be monitored and when the operation of the DSL circuit becomes unstable, settings associated with the DSL circuit can be adjusted or modified to bring the operation of DSL circuit into a stable state. Further, the DSL circuit can be optimized when requested by the customer, if the customer believes his or her DSL service is not functioning properly.

In a particular embodiment, the entire process can be encapsulated in a software program that can be executed by a computer connected to the DSL network, e.g., the central office computer **126**. The central office computer **126** can interface with the ATU-Cs and the ATU-Rs, or their respective agents, in order to obtain performance data, extract provisioning data, implant provisioning data, and control the circuit provisioning in order to provide optimum performance of each DSL circuit.

The above-disclosed subject matter is to be considered illustrative, and not restrictive, and the appended claims are intended to cover all such modifications, enhancements, and other embodiments, which fall within the true spirit and scope of the present invention. Thus, to the maximum extent allowed by law, the scope of the present invention is to be determined by the broadest permissible interpretation of the following claims and their equivalents, and shall not be restricted or limited by the foregoing detailed description.

What is claimed is:

1. A method for modifying a control parameter associated with an asymmetric digital subscriber line (DSL) service, the method comprising:

receiving at least one real-time performance parameter from a first termination unit coupled to a DSL circuit, the real-time performance parameter measured over a predetermined period of time at the termination unit after the termination unit is provisioned and after the DSL circuit is placed in-service; and

modifying a value of at least one control parameter associated with the DSL circuit at least partially based on the at least one real-time performance parameter measured

over the predetermined period of time so that statistical confidence of the real-time performance parameter is established.

2. The method of claim **1**, further comprising:

monitoring activity over the DSL circuit in real-time.

3. The method of claim **2**, further comprising:

determining when usage of the DSL circuit is below a threshold; and

modifying at least one provisionable service parameter corresponding to the at least one control parameter.

4. The method of claim **3**, further comprising;

initiating a first re-provisioning cycle between the first termination unit and a second termination unit coupled to the DSL circuit using the at least one provisionable service parameter.

5. The method of claim **4**, wherein:

the first termination device is an DSL modem; and

the second termination device is an DSL modem.

6. The method of claim **5**, further comprising:

determining whether operation of the DSL circuit is within an acceptable operating range; and

modifying the at least one provisionable service parameter after determining that the operation of the DSL circuit is not within the acceptable operating range.

7. The method of claim **6**, further comprising:

monitoring performance data of the termination unit; and

determining whether operation of the DSL circuit is stable at least partially based on the monitored performance data.

8. The method of claim **1**, wherein the at least one real-time performance parameter is a noise parameter.

9. The method of claim **8**, wherein the noise parameter is at least one of the following:

a Noise Margin Ratio measured upstream and downstream in the DSL circuit;

a Quiet Line Noise value measured during a predetermined time period for each DMT within the DSL circuit;

a noise value within the DSL circuit measured while the DSL circuit is in-service; and

an insertion loss of the DSL circuit.

10. The method of claim **9**, wherein the Quiet Line Noise is measured during a period of less than two minutes.

11. The method of claim **1**, wherein the at least one real-time performance parameter is an error parameter.

12. The method of claim **11**, wherein the at least one error parameter is at least one of the following:

a time series of counts of Code Violations (CV), wherein each CV represents a data packet that could not be corrected by one or more forward-error control parameters associated with the DSL circuit;

a time series of counts of Errored Seconds (ES), wherein each ES is a one second interval during which one to M CVs are observed and wherein M is a predetermined value; and

a time series of counts of Severely Errored Seconds (SES), wherein each SES is a one second interval during which greater than M CVs are observed.

13. The method of claim **1**, wherein the at least one real-time performance parameter is a data transmission parameter.

14. The method of claim **13**, wherein the at least one data transmission parameter is at least one of the following:

an assessment by the first termination unit or second termination unit of a maximum data rate the DSL circuit can support;

a bit rate currently available to the customer;

a total number of bits available for each tone in the DSL circuit;

an attainable data transmission rate for the DSL circuit;

a gain for each tone in the DSL circuit;

a first count during a predetermined time interval of the number of user data packets sent and received over the DSL circuit; and

a second count during a predetermined time interval of the number of overhead data packets sent and received over the DSL circuit.

15. The method of claim **14**, wherein the first count and the second count are measured over a period of approximately fifteen minutes.

16. The method of claim **1**, wherein the at least one real-time performance parameter is a signal power parameter.

17. The method of claim **16**, wherein the signal power parameter is at least one of the following:

a transmission power value of a data signal;

a power spectral density value of the data signal; and

an attenuation value that is the difference between a total maximum transmitted power at one end of the DSL circuit and a total power received at a remote end of the DSL circuit.

18. The method of claim **1**, wherein the at least one real-time performance parameter is a margin available to accommodate signal losses.

19. The method of claim **1**, wherein the at least one real-time performance parameter is a forward error correction parameter.

20. The method of claim **1**, wherein the at least one real-time performance parameter is a dual path parameter, wherein the dual path parameter indicates whether an interleaving setting is activated.

21. The method of claim **1**, wherein the at least one real-time performance parameter is a Trellis parameter, wherein the Trellis parameter indicates whether Trellis coding is activated.

22. The method of claim **1**, wherein the at least one real-time performance parameter is a frequency range parameter that includes tone indices of the DSL circuit.

23. The method of claim **1**, wherein the at least one real-time performance parameter includes dynamic spectrum management data.

24. The method of claim **1**, wherein the DSL network is an asymmetric DSL (ADSL) network, an ADSL 2 network, an ADSL 2+ network, a very high data transfer rate DSL (VDSL) network, or a VDSL 2 network.

25. A digital subscriber line (DSL) network, comprising:

a first modem at a central office;

a second modem at a remote site;

at least one DSL channel established between the first modem and the second modem; and

a computer communicating with the first modem and the second modem, the computer comprising a program for modifying a provisionable service parameter associated with the DSL channel based on at least one measured in-service performance parameter received from at least one of the first modem or the second modem; wherein the at least one measured in-service performance parameter is measured over a predetermined time period to provide statistical confidence in the in-service performance parameter.

26. The network of claim **25**, wherein the computer program comprises:

instructions to determine a value of at least one control parameter at least partially based on the at least one measured in-service performance parameter.

27. The network of claim **26**, wherein the computer program further comprises:

instructions to monitor activity over the DSL channel while the DSL channel is in-service.

28. The network of claim **27**, wherein the computer program further comprises:

instructions to determine when usage of the DSL channel is at or below a threshold.

29. The network of claim **28**, wherein the computer program further comprises:

instructions to establish communications with at least one of the first modem and the second modem when usage of the DSL channel is below the threshold.

30. The network of claim **29**, wherein the computer program further comprises:

instructions to modify the provisionable service parameter at least partially based on the measured in-service performance parameter.

31. The network of claim **30**, wherein the computer program further comprises:

instructions to initiate a first re-training cycle between the first modem and the second modem, the first re-training cycle to apply the modified provisionable service parameter to the DSL channel.

32. The network of claim **31**, wherein the computer program further comprises:

instructions to monitor the first modem and the second modem while the first modem and second modem are in-service.

33. The network of claim **32**, wherein the computer program further comprises:

instructions to initiate a second re-training cycle between the first modem and the second modem after determining that service over the DSL channel is not restored.

34. The network of claim **33**, wherein the computer program further comprises:

instructions to determine whether the DSL channel is operating within a predetermined operating range.

35. The network of claim **34**, wherein the computer program further comprises:

instructions to modify the at least one provisionable service parameter after determining that the DSL channel is operating outside the predetermined operating range.

36. The network of claim **35**, wherein the computer program further comprises:

instructions to monitor performance data of the first modem and the second modem.

37. The network of claim **36**, wherein the computer program further comprises:

instructions to determine whether operation of the DSL channel is stable at least partially based on the monitored performance data.

38. A method for modifying a data network, comprising:

provisioning a data circuit within the data network with a first set of provisioning parameters;

acquiring a first set of in-service performance data from at least one terminating unit coupled to the data circuit; wherein the first set of in-service performance data is acquired over a predetermined period of time to establish statistical confidence of the first set of the in-service performance data;

determining a second set of provisioning parameters at least partially based on the first set of performance data; and

re-provisioning the data circuit with the second set of provisioning parameters.

39. The method of claim **37**, further comprising:

monitoring the data circuit while the data circuit is in-service.

40. The method of claim **39**, further comprising:

determining whether operation of the data circuit is in a stable state.

41. The method of claim **40**, further comprising:

acquiring a second set of in-service performance data from the at least one terminating unit coupled to the data circuit; wherein the second set of in-service performance data is acquired over a second predetermined period of time.

42. The method of claim **41**, further comprising:

determining a third set of provisioning parameters at least partially based on the second set of performance data.

43. The method of claim **42**, further comprising:

re-provisioning the data circuit with the third set of provisioning parameters.

44. The method of claim **43**, wherein the first set of provisioning parameters, the second set of provisioning parameters, and the third set of provisioning parameters comprise:

at least one power control parameter;

at least one noise control parameter;

at least one data control parameter; and

at least one forward error correction control parameter.

45. The method of claim **44**, wherein the at least one power control parameter is at least one of the following:

a transmission power of a data signal; and

a power spectral density of the data signal.

46. The method of claim **44**, wherein the at least one noise control parameter is at least one of the following:

an additional noise margin and signal noise ratio;

a maximum noise margin and signal noise ratio; and

a target noise margin and signal ratio.

47. The method of claim **44**, wherein the at least one data control parameter comprises:

a dual path that indicates whether an interleaving setting is activate.

48. The method of claim **44**, wherein the at least one forward error correction control parameter includes at least one of the following:

a Reed Solomon codeword length;

a parity value;

an interleave depth; and

one or more data symbols.

49. The method of claim **43**, wherein the first set of in-service performance data and the second set of in-service performance data comprise:

at least one noise parameter;

at least one error parameter;

at least one data transmission parameter; and

at least one signal power parameter.

50. The method of claim **49**, wherein the at least one noise parameter is at least one of the following:

a Noise Margin Ratio measured upstream and downstream in the data circuit;

a Quiet Line Noise measured during a predetermined time period for the data circuit;

a noise within the data circuit measured while the data circuit is in-service; and

an insertion loss of the data circuit.

51. The method of claim **49**, wherein the at least one error parameter is at least one of the following:

a time series of counts of Code Violations (CV), wherein each CV represents a data packet that could not be corrected by one or more forward-error-control parameters associated with the data circuit;

a time series of counts of Errored Seconds (ES), wherein each ES is a one second interval during which one to M CVs are observed and wherein M is a predetermined value; and

a time sales of counts of Severely Errored Seconds (SES), wherein each SES is a one second interval during which greater than M CVs are observed.

52. The method of claim **49**, wherein the at least one data transmission parameter is at least one of the following:

an assessment by the at least one terminating unit of the maximum data rate the data circuit can support;

an actual bit rate currently available to the customer;

a total number of bits available for each tone in the data circuit;

an attainable data transmission rate for the data circuit;

a gain for each tone in the data circuit;

a count during a predetermined time interval of the number of user data packets sent and received over the data circuit; and

a count during a predetermined time interval of the number of overhead data packets sent and received over the data circuit.

53. The method of claim **49**, wherein the at least one signal power parameter is at least one of the following:

a transmission power value of a data signal;

a power spectral density value of the data signal; and

an attenuation value is the difference between the total maximum transmitted power at one end of the data circuit and a total power received at a remote end of the data circuit.

54. The method of claim **43**, wherein the at least one real-time performance parameter is a margin available to accommodate signal losses.

55. The method of claim **43**, wherein the at least one real-time performance parameter is a forward error correction parameter.

56. The method of claim **43**, wherein the at least one real-time performance parameter is a dual path parameter that indicates whether an interleaving setting is activated.

57. The method of claim **43**, wherein the at least one real-time performance parameter is a Trellis parameter that indicates whether Trellis coding is on or off.

58. The method of claim **43**, wherein the at least one real-time performance parameter is a frequency range parameter that includes tone indices of the data circuit.

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