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Currivan et al.

(54) RANGING AND REGISTERING CABLE MODEMS UNDER ATTENUATED TRANSMISSION CONDITIONS

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(60) Provisional application No. 60/367,564, filed on Mar. 26, 2002. Provisional application No. 60/151,680, filed on Aug. 31, 1999. Provisional application No. 60/416,889, filed on Oct. 8, 2002.

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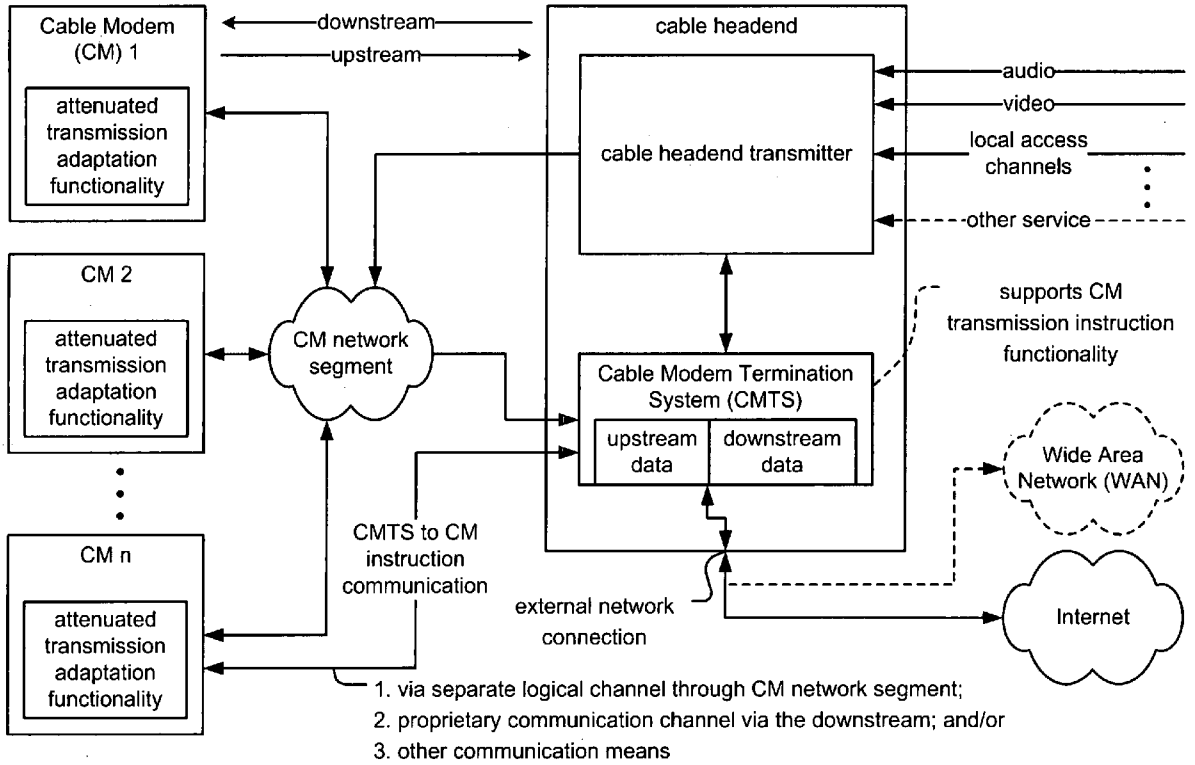
(52) **U.S. Cl.** **725/111**; 725/114; 725/144; 725/118

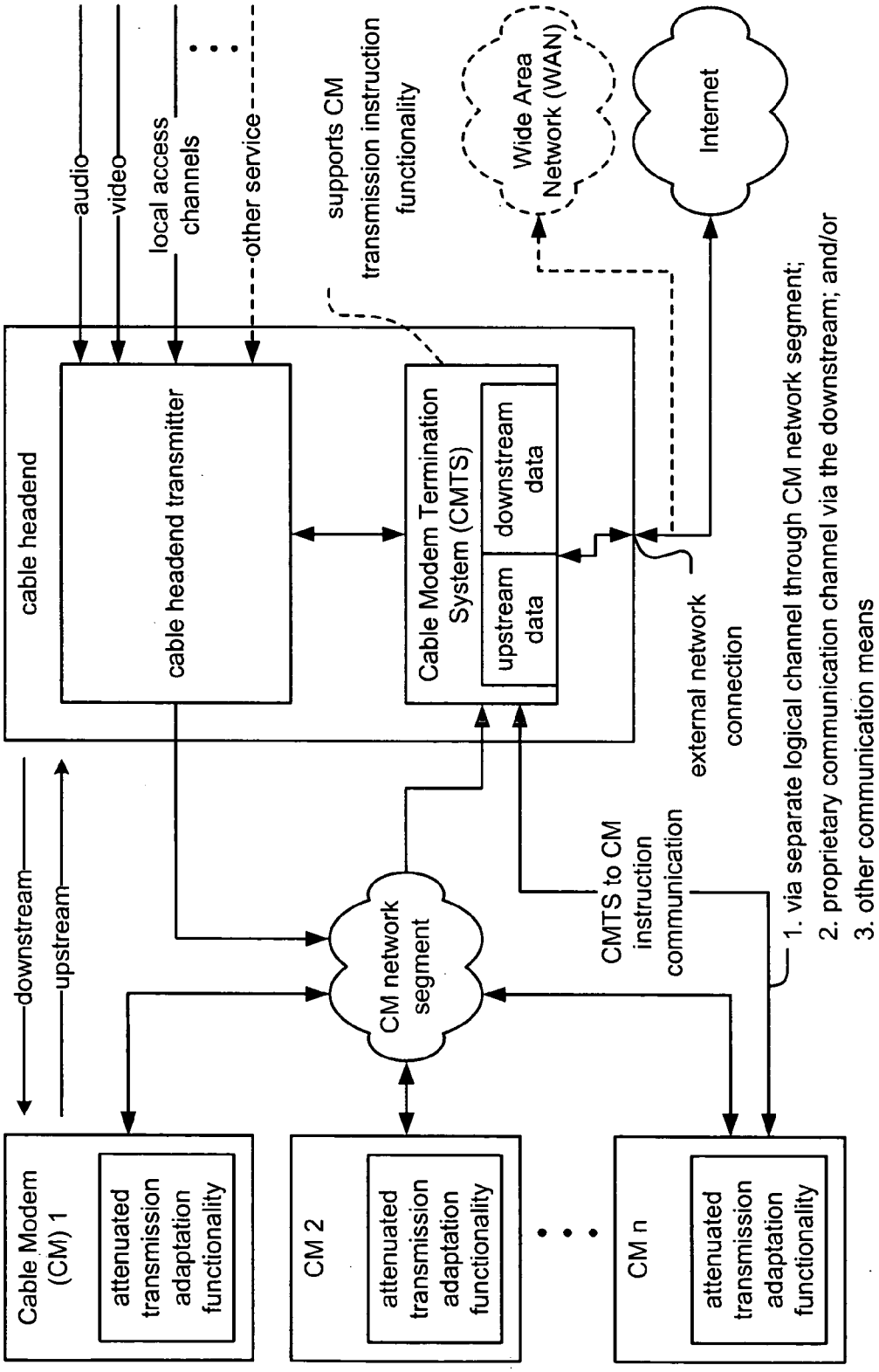
(57) **ABSTRACT**

A cable modem communication system includes a plurality of Cable Modems (CMs), a CM network segment, and a Cable Modem Termination System (CMTS). The CMTS segregates the plurality of CMs into a first group of CMs with which standard registering and ranging operations are performed and a second group of CMs with which attenuated transmission registering and ranging operations are performed. Each CM of the first group of CMs operable to perform registering and ranging operations by transmitting a ranging burst of a first format. Each CM of the second group of CMs operable to perform registering and ranging operations by transmitting a ranging burst of a second format that differs from the ranging burst of the first format. The CMTS may include a rake receiver that receives and demodulates a plurality of multi-path copies of the ranging burst of the second format.



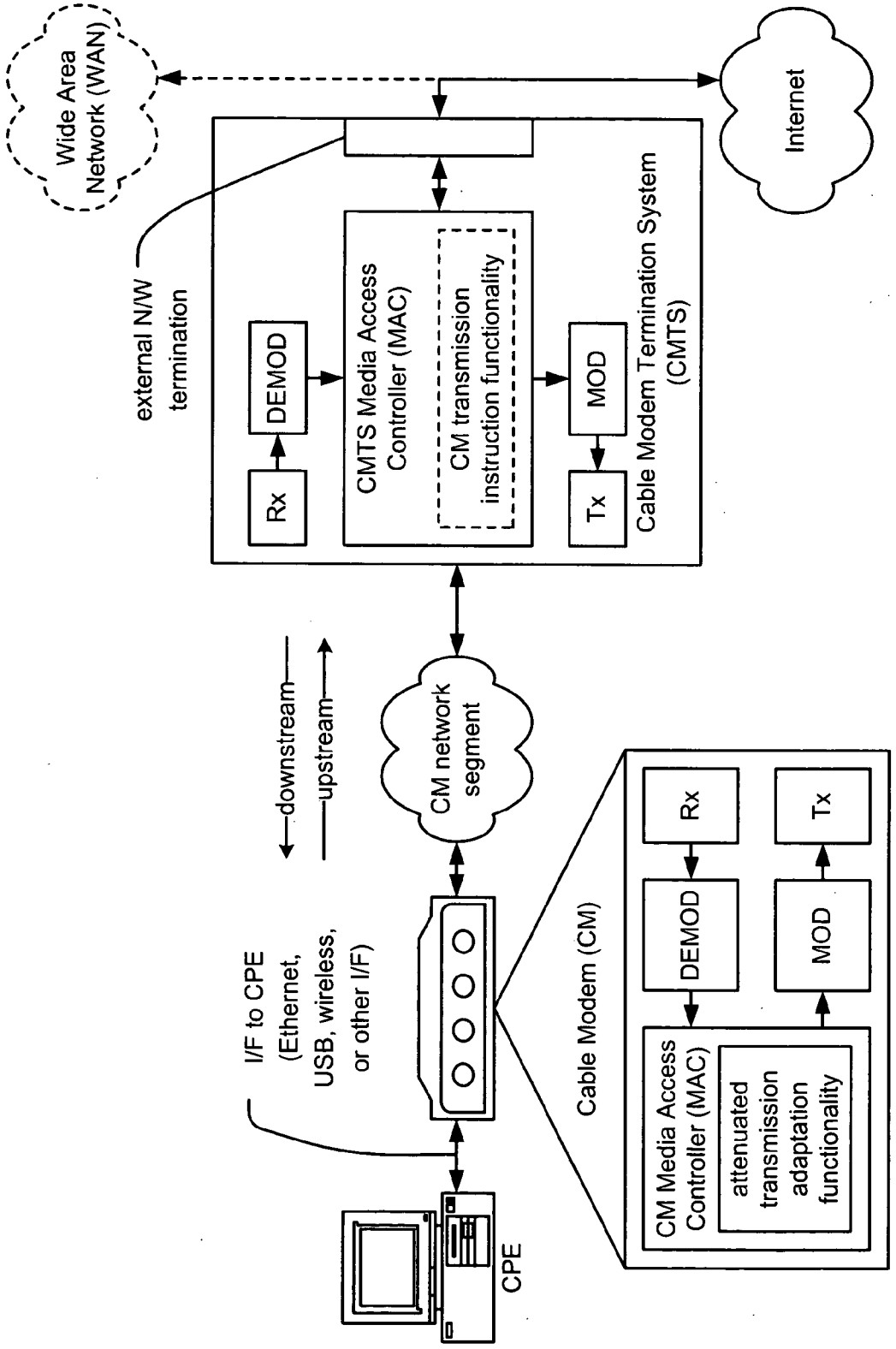
cable modem communication system 100

Comcast, Ex. 1028



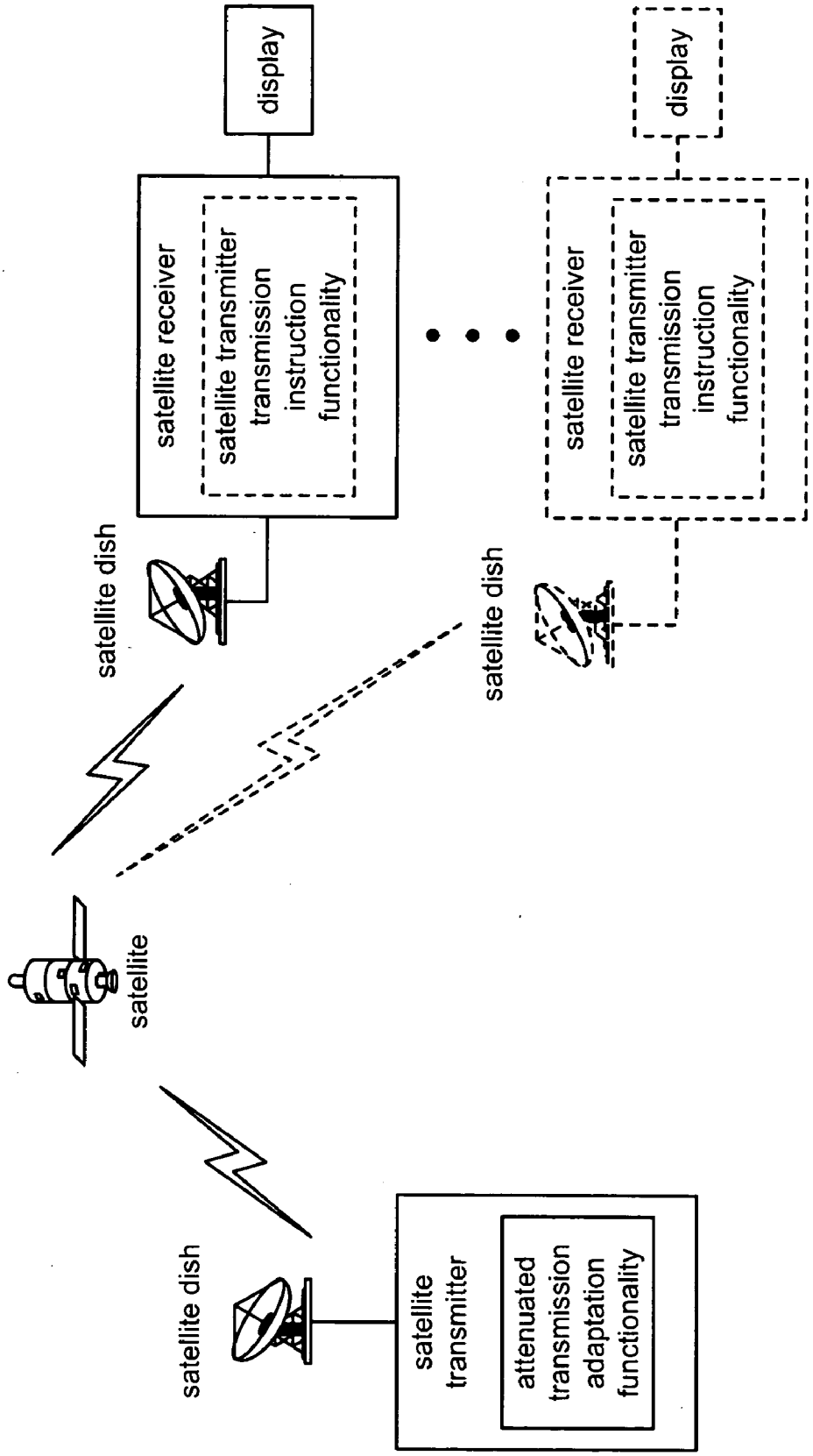
cable modem communication system 100

Fig. 1



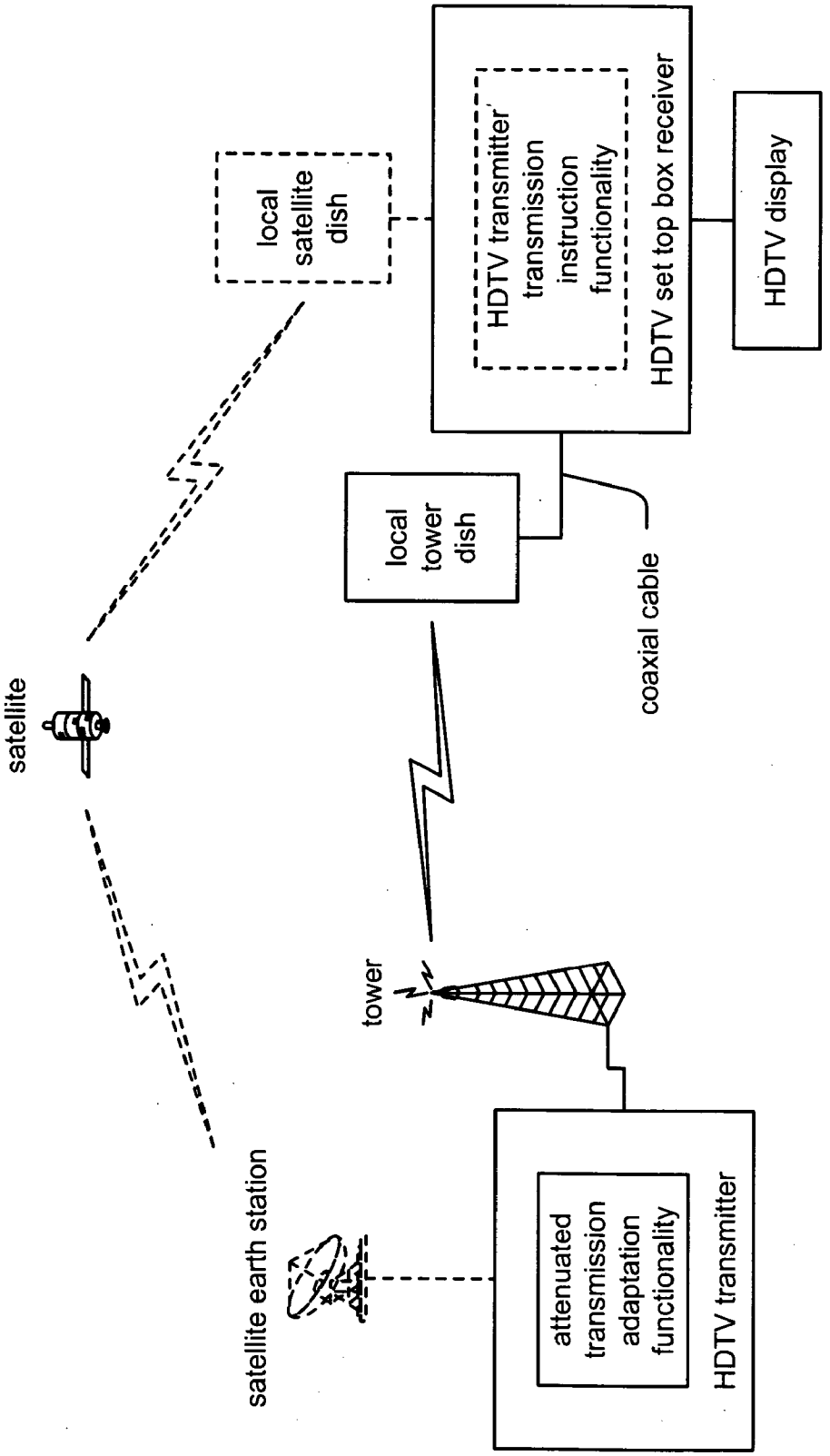
cable modem communication system 200

Fig. 2



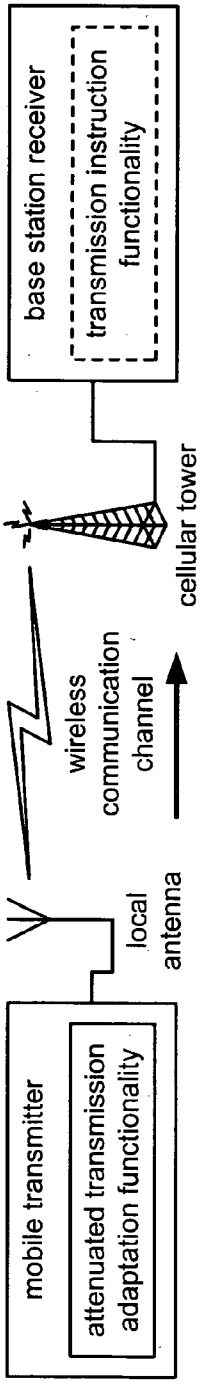
satellite communication system

Fig. 3



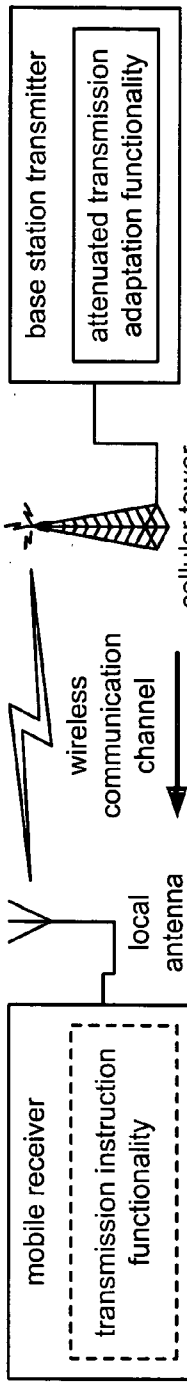
High Definition Television (HDTV) communication system

Fig. 4



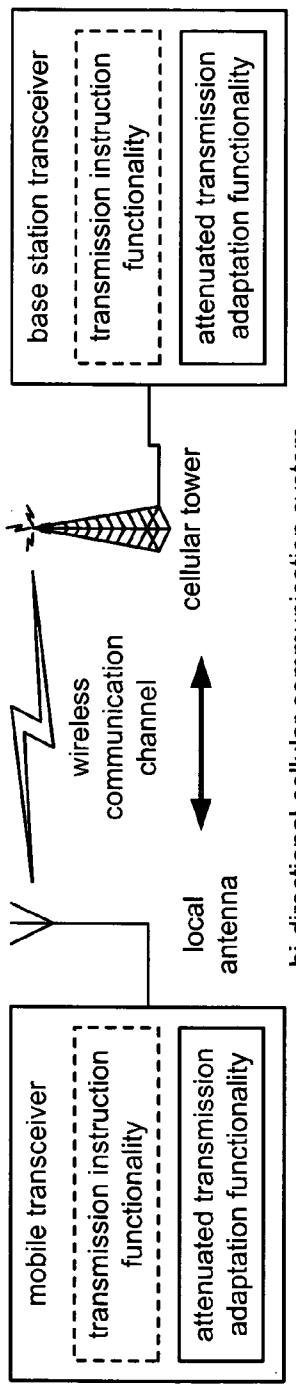
uni-directional cellular communication system

Fig. 5A



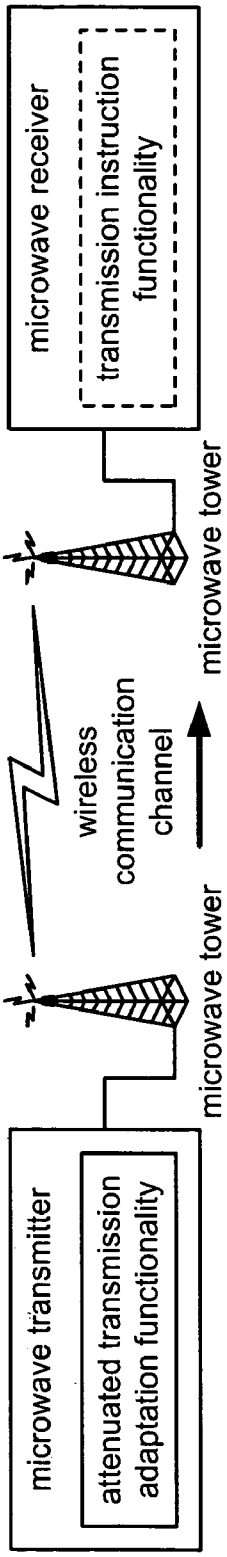
uni-directional cellular communication system

Fig. 5B



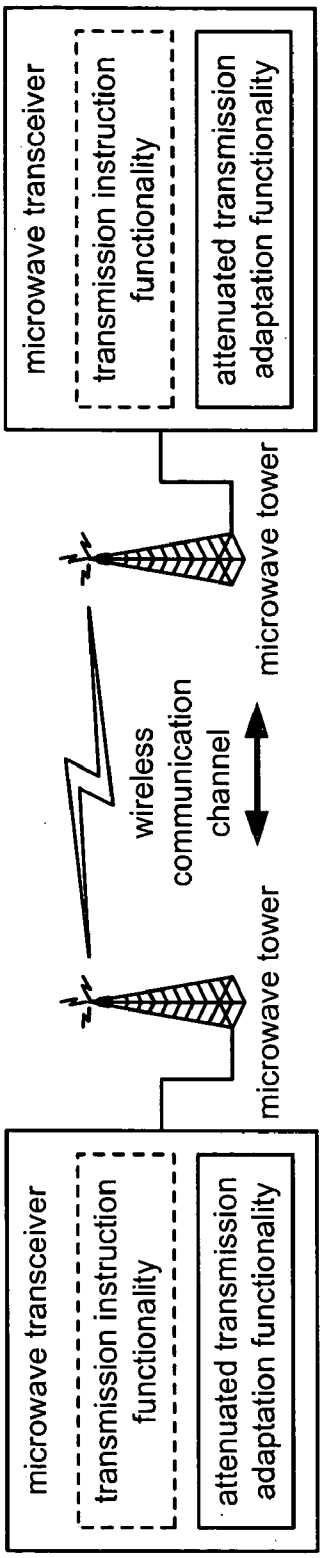
bi-directional cellular communication system

Fig. 5C



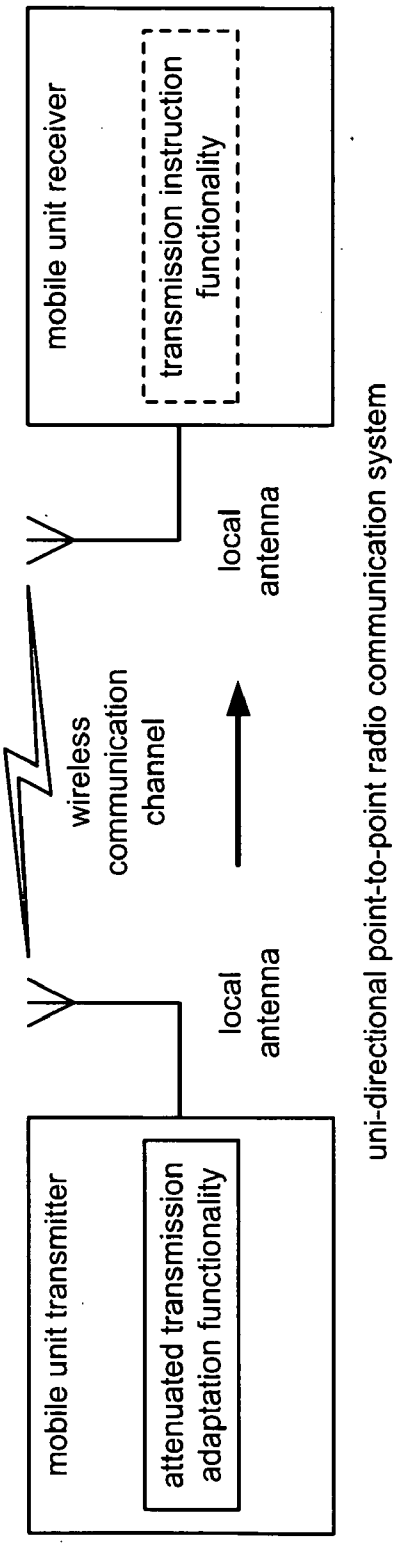
uni-directional microwave communication system

Fig. 6A



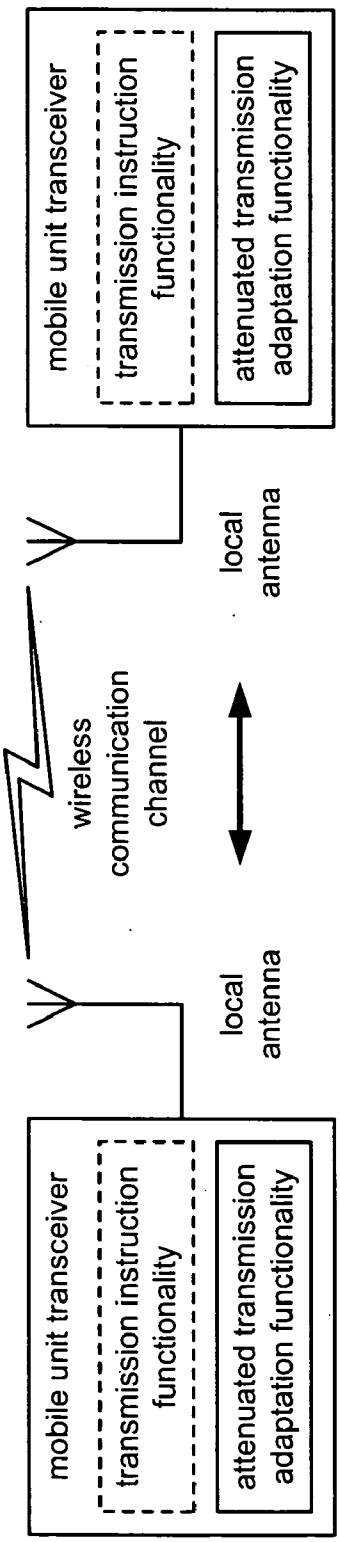
bi-directional microwave communication system

Fig. 6B



uni-directional point-to-point radio communication system

Fig. 7A



bi-directional point-to-point radio communication system

Fig. 7B

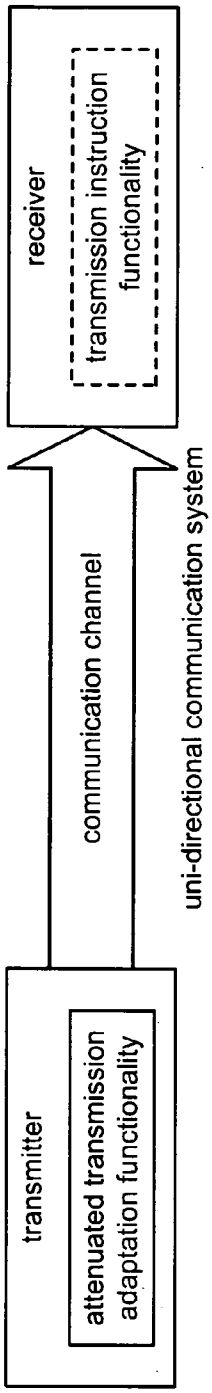


Fig. 8A

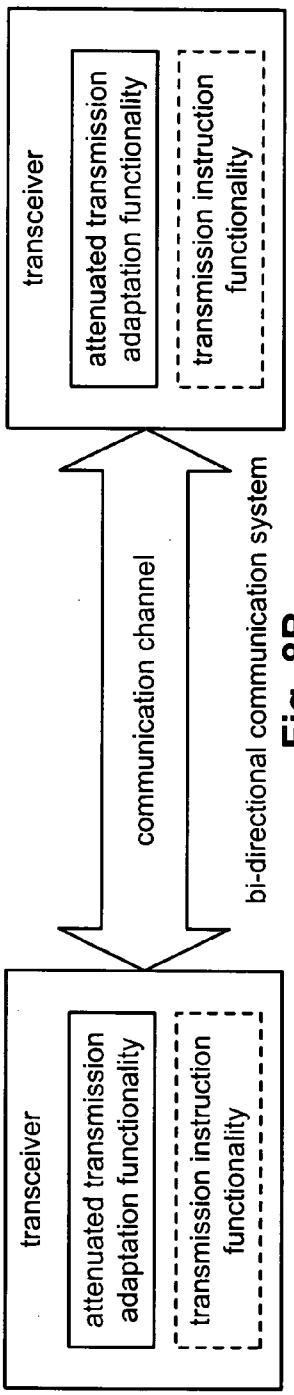


Fig. 8B

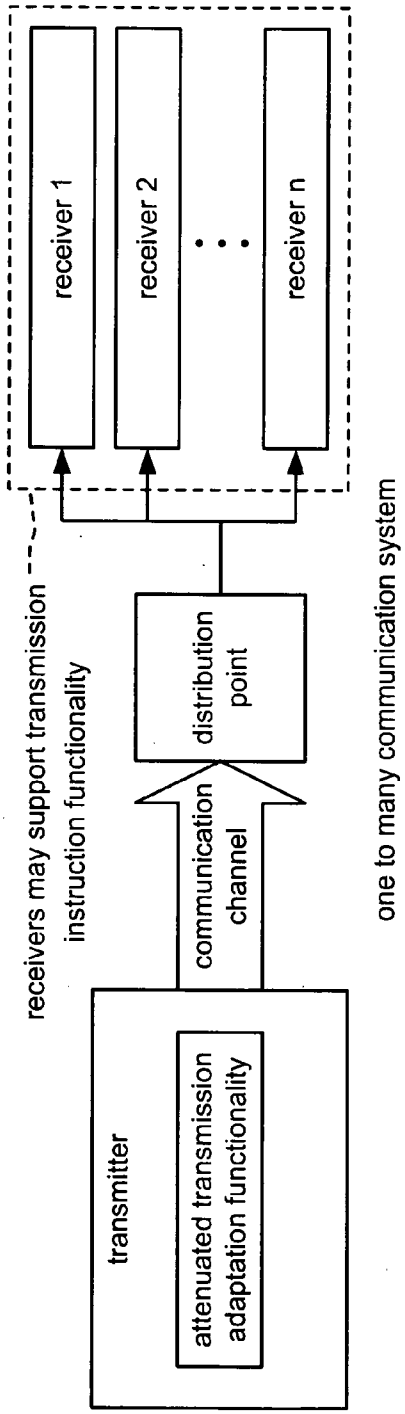
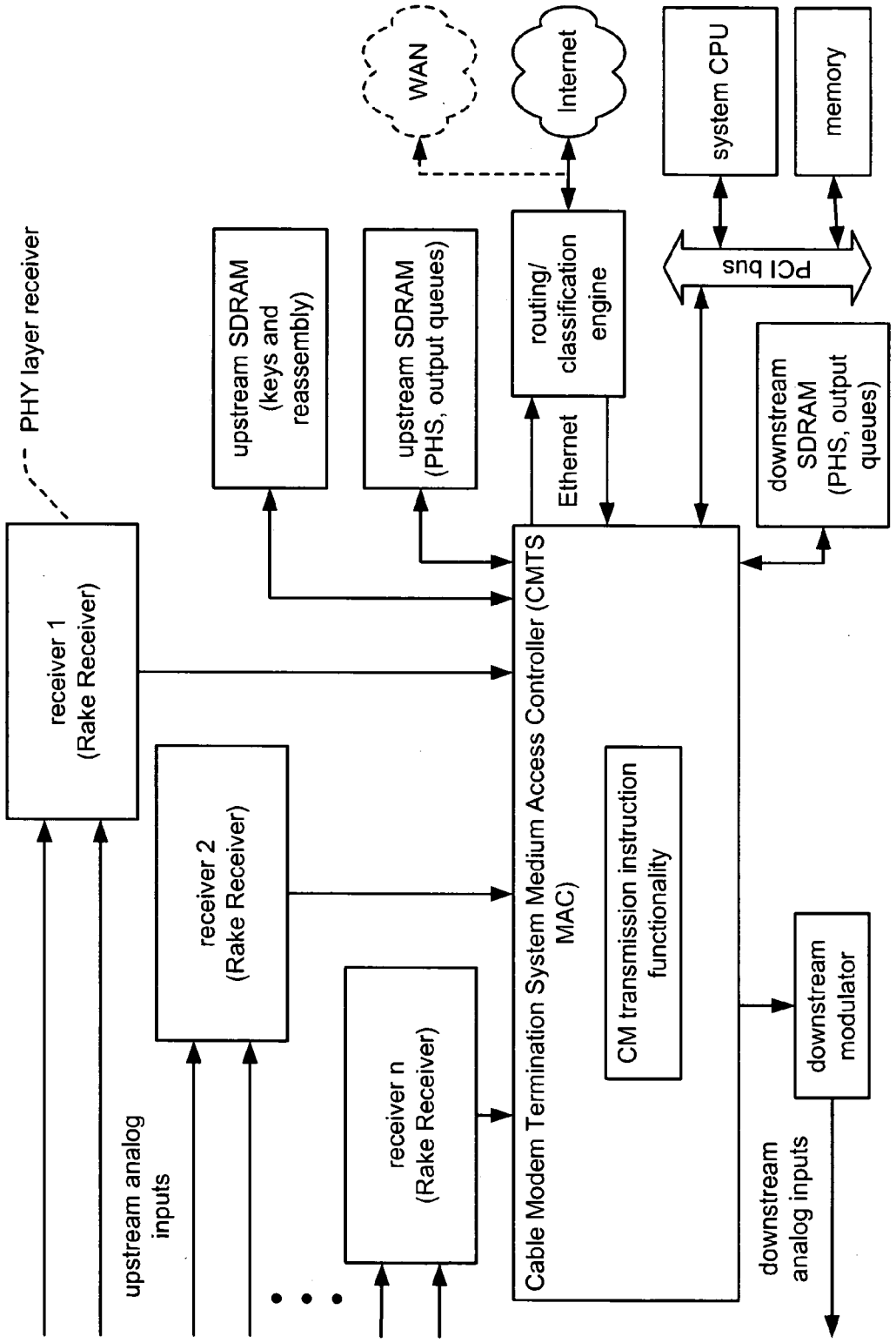
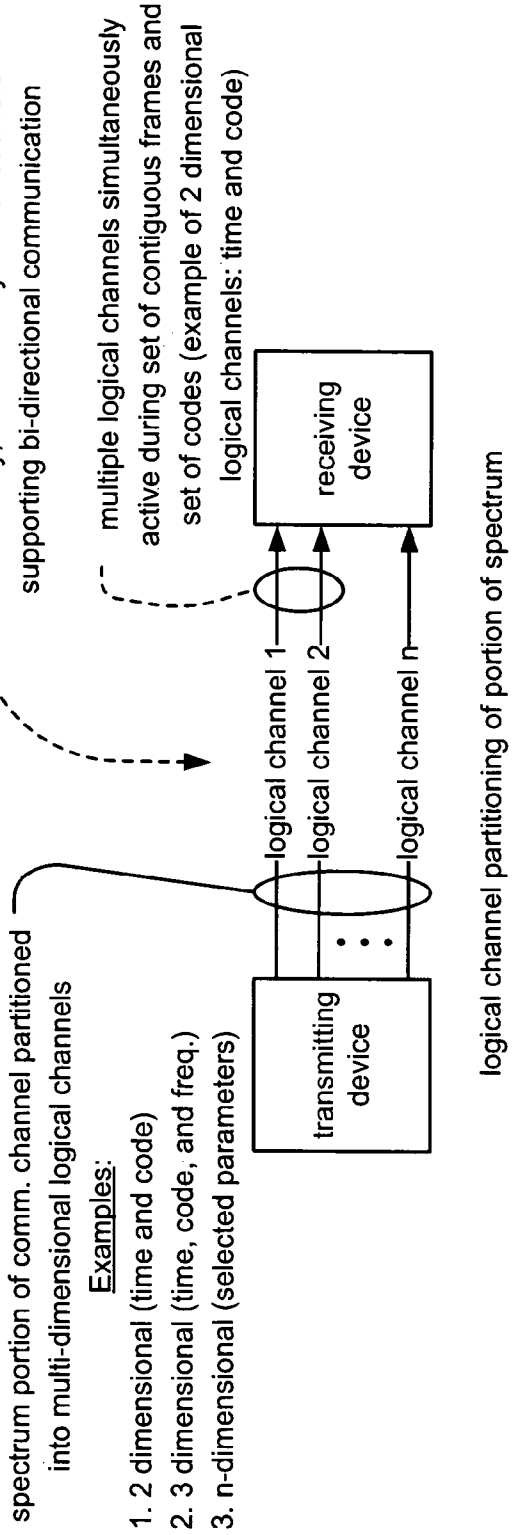


Fig. 8C



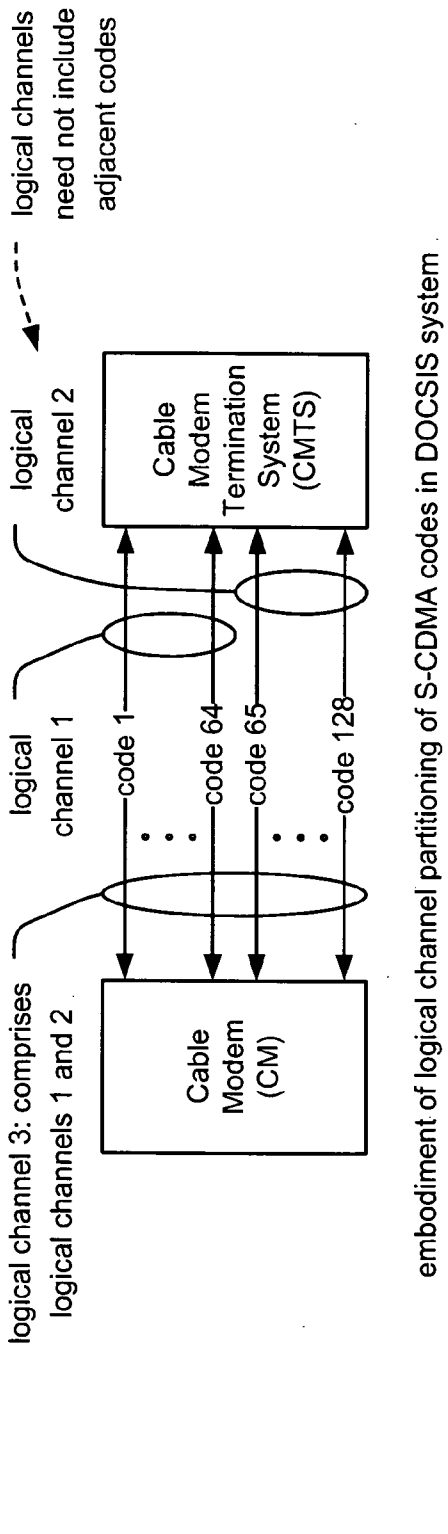
Cable Modem Termination System (CMTS) system

Fig. 9



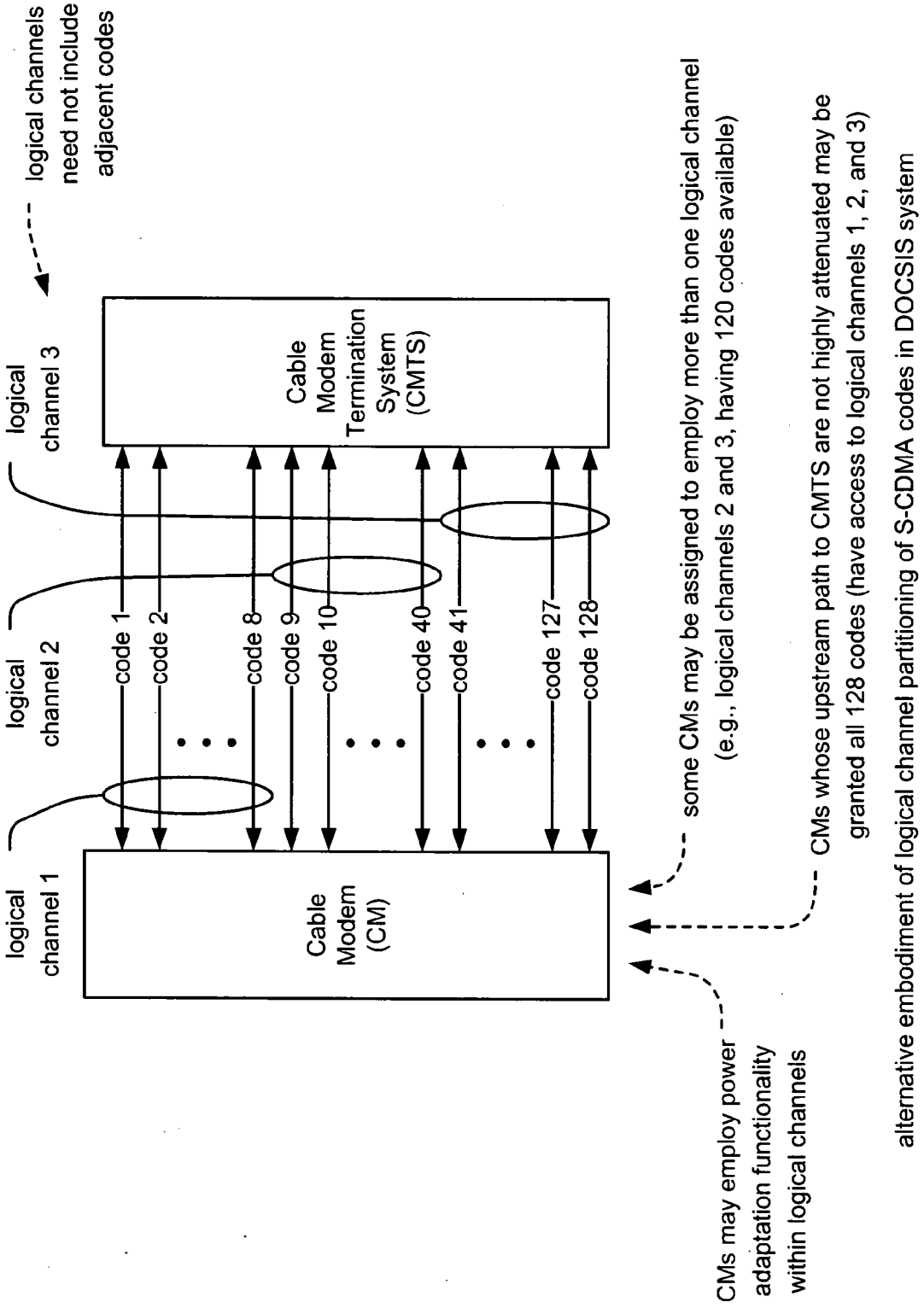
logical channel partitioning of portion of spectrum

Fig. 10A



embodiment of logical channel partitioning of S-CDMA codes in DOCSIS system

Fig. 10B



alternative embodiment of logical channel partitioning of S-CDMA codes in DOCSIS system

Fig. 11

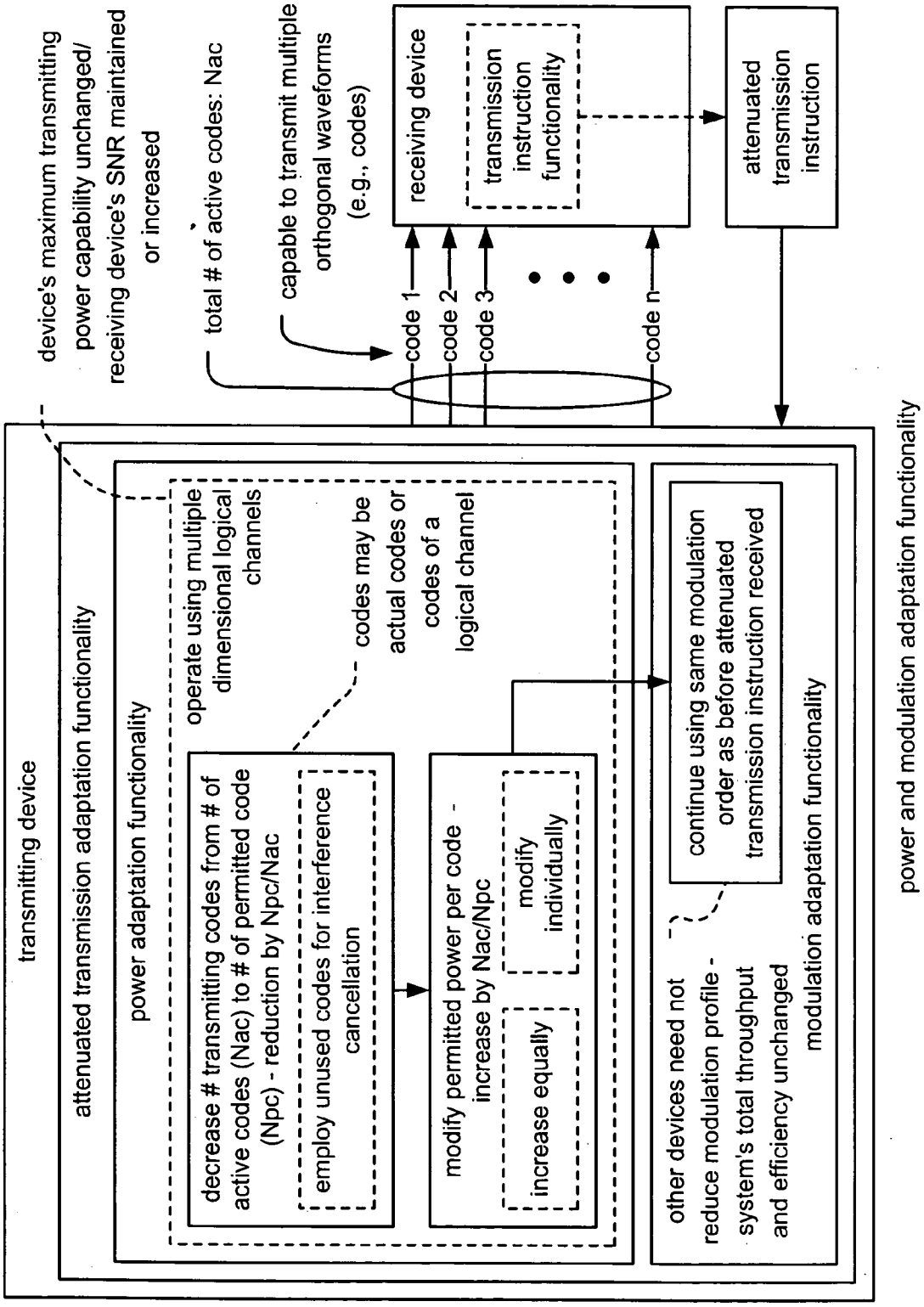

transmitting device
attenuated transmission adaptation functionality
power adaptation functionality
operate using multiple dimensional logical channels
codes may be actual codes or codes of a logical channel
decrease # transmitting codes from # of active codes (Nac) to # of permitted code (Npc) - reduction by Npc/Nac
employ unused codes for interference cancellation
modify permitted power per code - increase by Nac/Npc
increase equally
modify individually
other devices need not reduce modulation profile - system's total throughput and efficiency unchanged
continue using same modulation order as before attenuated transmission instruction received
modulation adaptation functionality
device's maximum transmitting power capability unchanged/ receiving device's SNR maintained or increased
total # of active codes: Nac
capable to transmit multiple orthogonal waveforms (e.g., codes)
code 1
code 2
code 3
code n
receiving device
transmission instruction functionality
attenuated transmission instruction
power and modulation adaptation functionality

Fig. 12

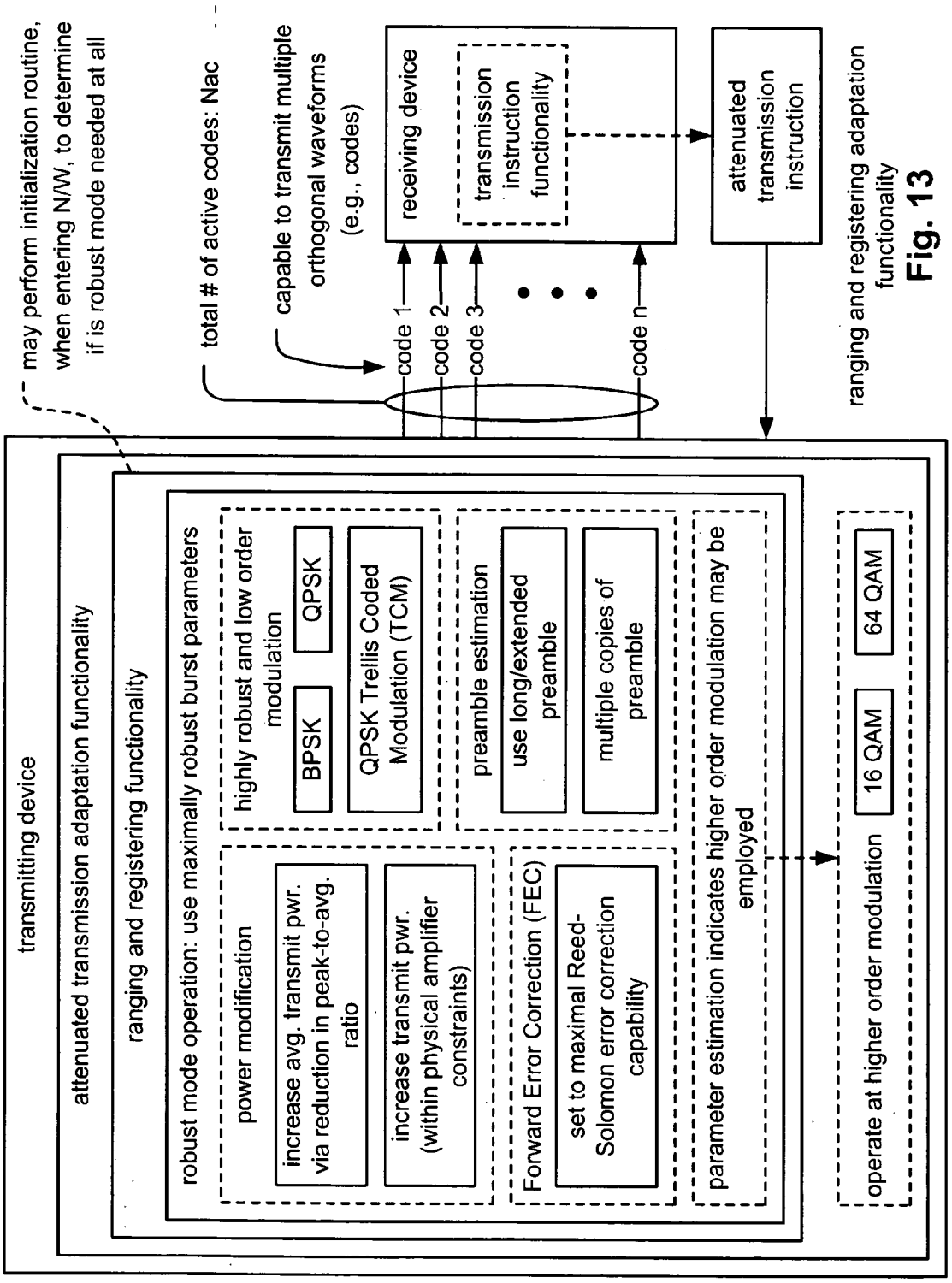
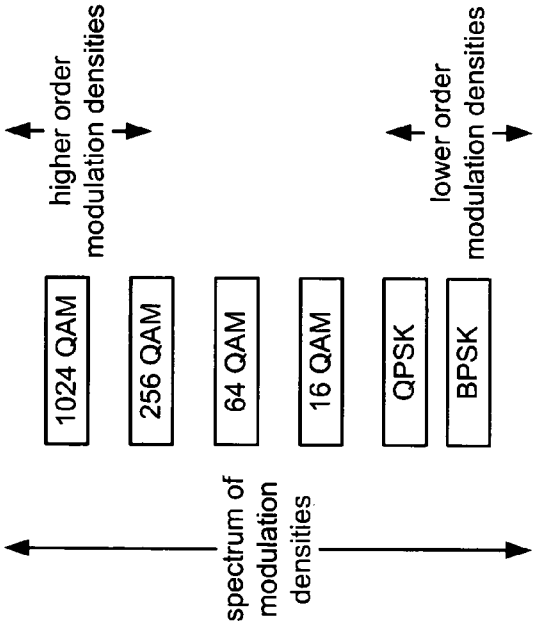
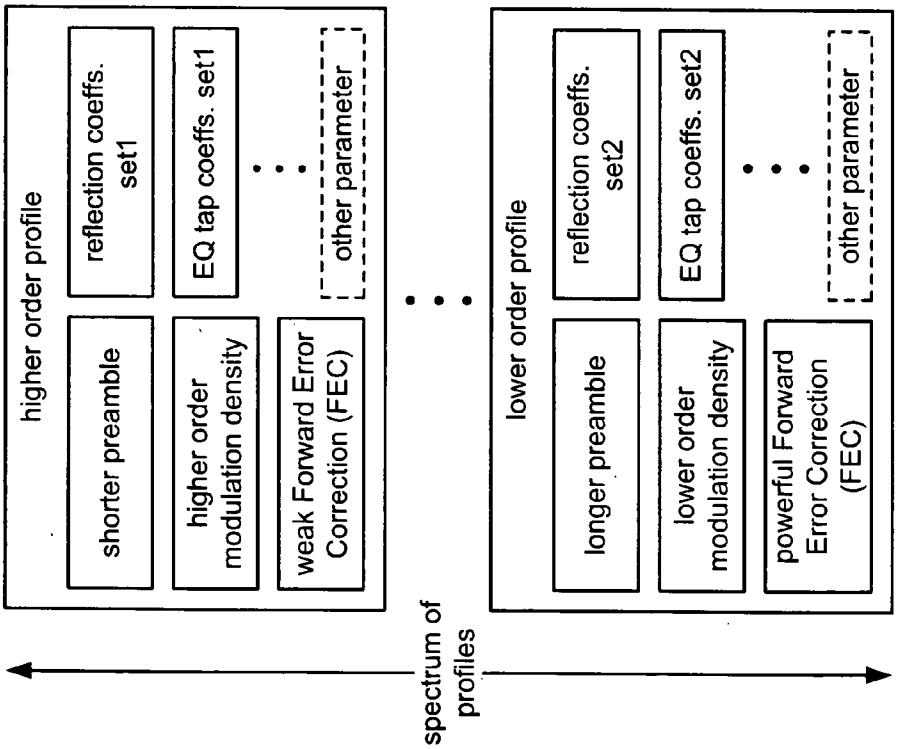

transmitting device
attenuated transmission adaptation functionality
ranging and registering functionality
robust mode operation: use maximally robust burst parameters
power modification
increase avg. transmit pwr. via reduction in peak-to-avg. ratio
increase transmit pwr. (within physical amplifier constraints)
highly robust and low order modulation
BPSK
QPSK
QPSK Trellis Coded Modulation (TCM)
Forward Error Correction (FEC)
set to maximal Reed-Solomon error correction capability
preamble estimation
use long/extended preamble
multiple copies of preamble
parameter estimation indicates higher order modulation may be employed
operate at higher order modulation
16 QAM
64 QAM
may perform initialization routine, when entering N/W, to determine if is robust mode needed at all
total # of active codes: Nac
capable to transmit multiple orthogonal waveforms (e.g., codes)
code 1
code 2
code 3
code n
receiving device
transmission instruction functionality
attenuated transmission instruction
ranging and registering adaptation functionality

Fig. 13



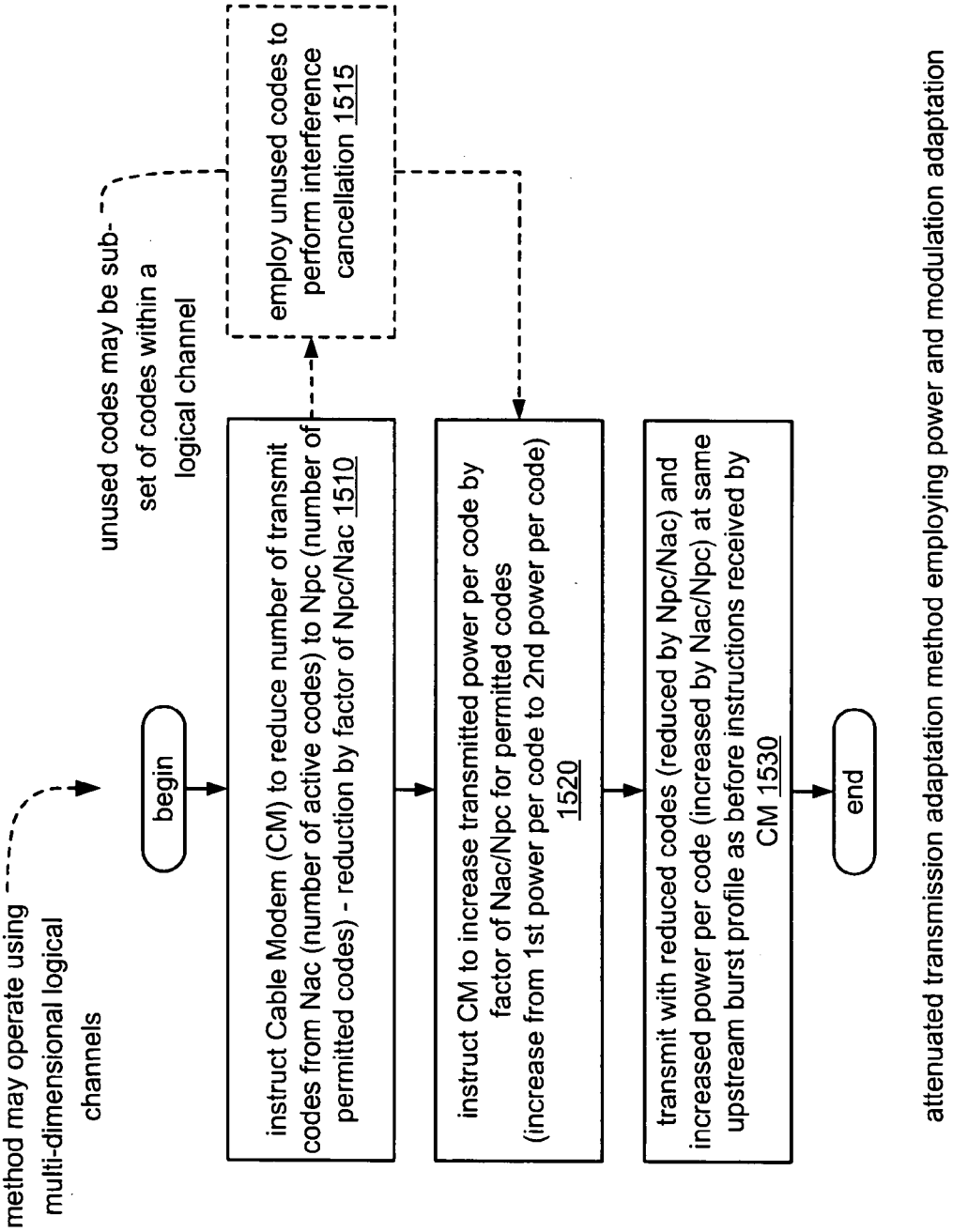
example modulation densities

Fig. 14B



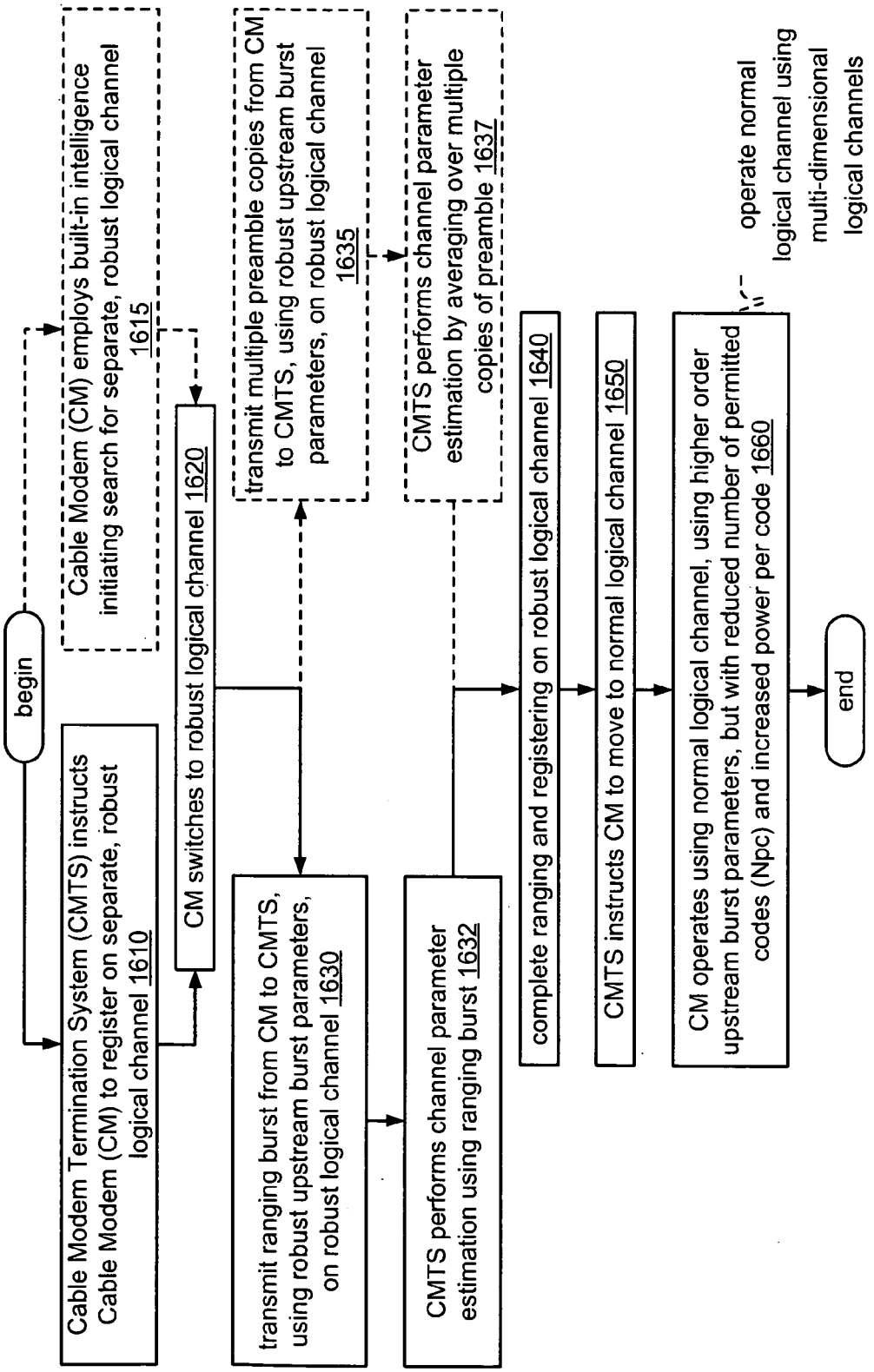
example upstream burst profiles

Fig. 14A



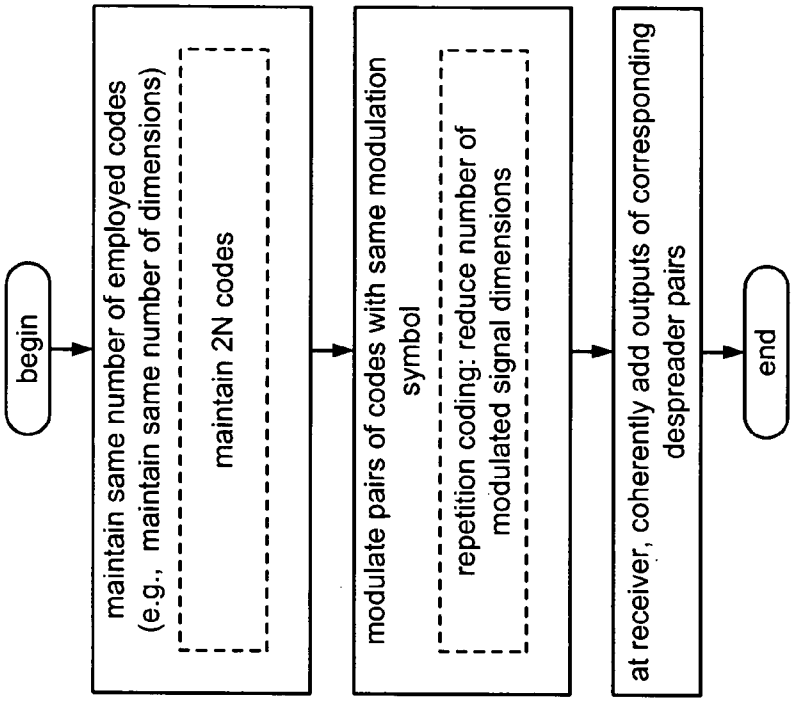
attenuated transmission adaptation method employing power and modulation adaptation

Fig. 15



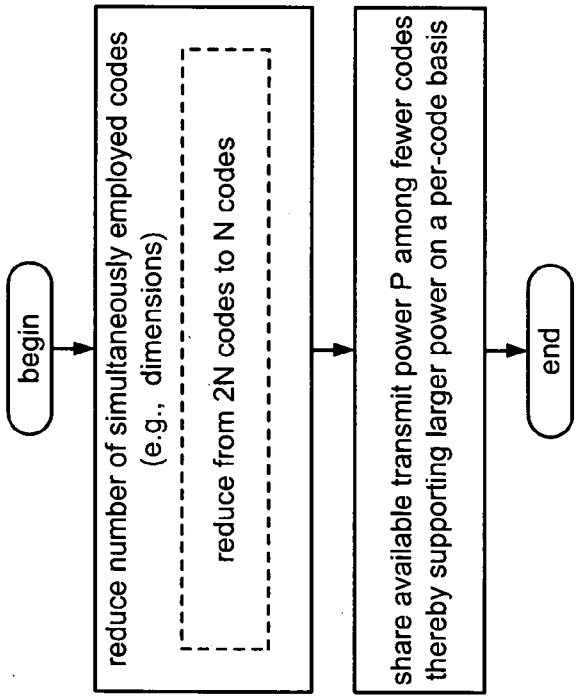
attenuated transmission adaptation method employing ranging and registering adaptation

Fig. 16



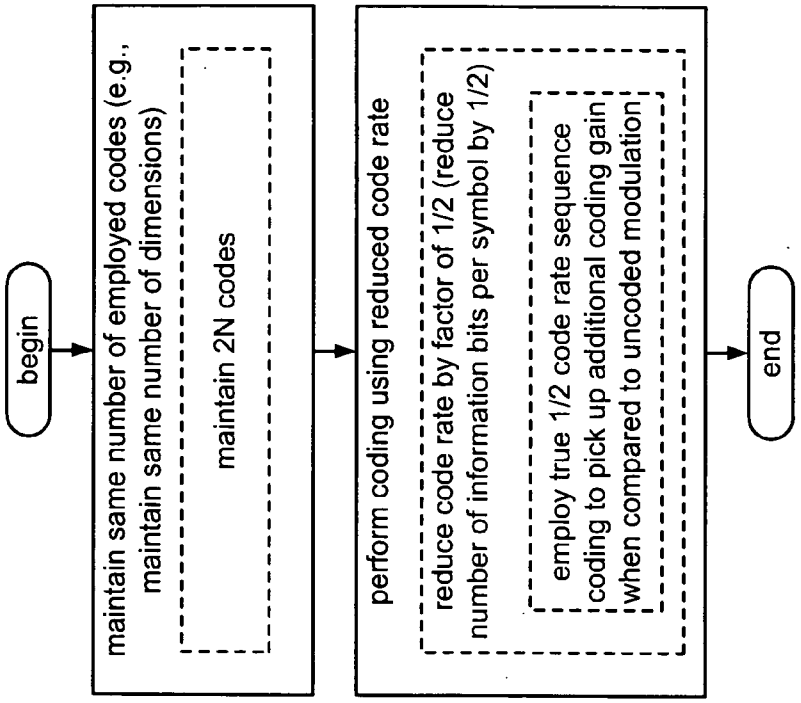
attenuated transmission adaptation method

Fig. 17B



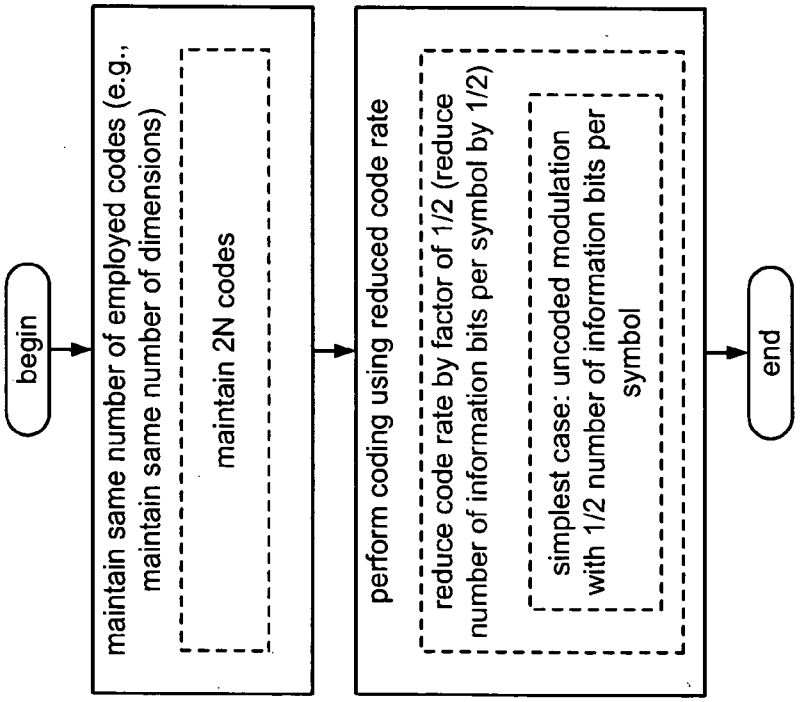
attenuated transmission adaptation method

Fig. 17A



attenuated transmission adaptation method

Fig. 18B



attenuated transmission adaptation method

Fig. 18A

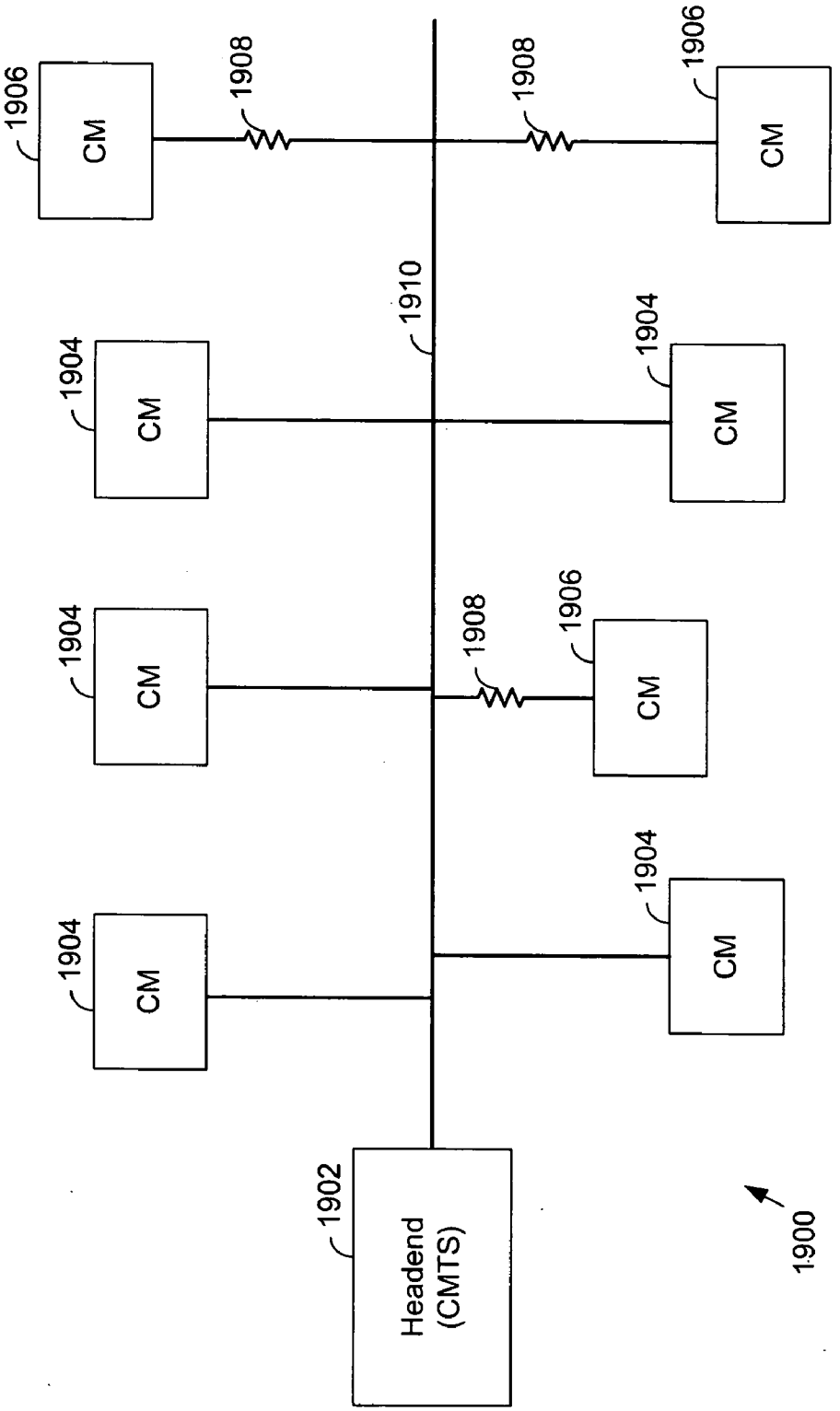
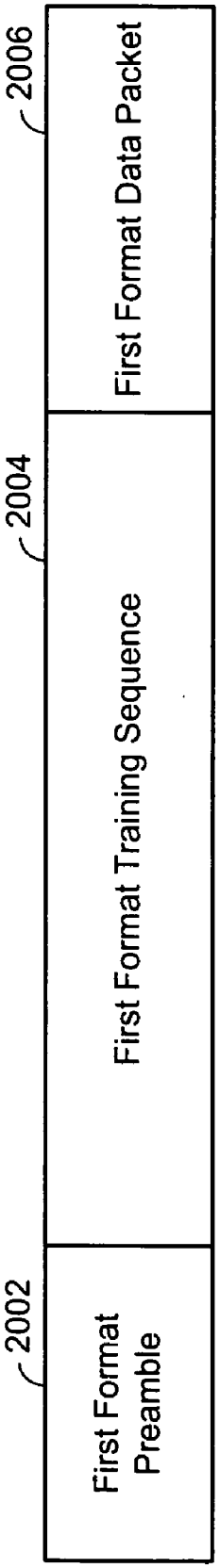
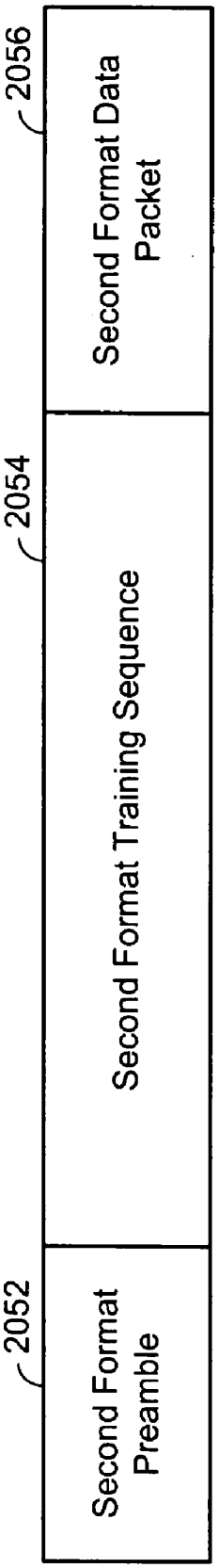

1906
CM
1908
1908
1906
CM
1910
1904
CM
1904
CM
1904
CM
1908
1906
CM
1904
CM
1902
Headend
(CMTS)
1900

Fig. 19



2000

Fig. 20A



2050

Fig. 20B

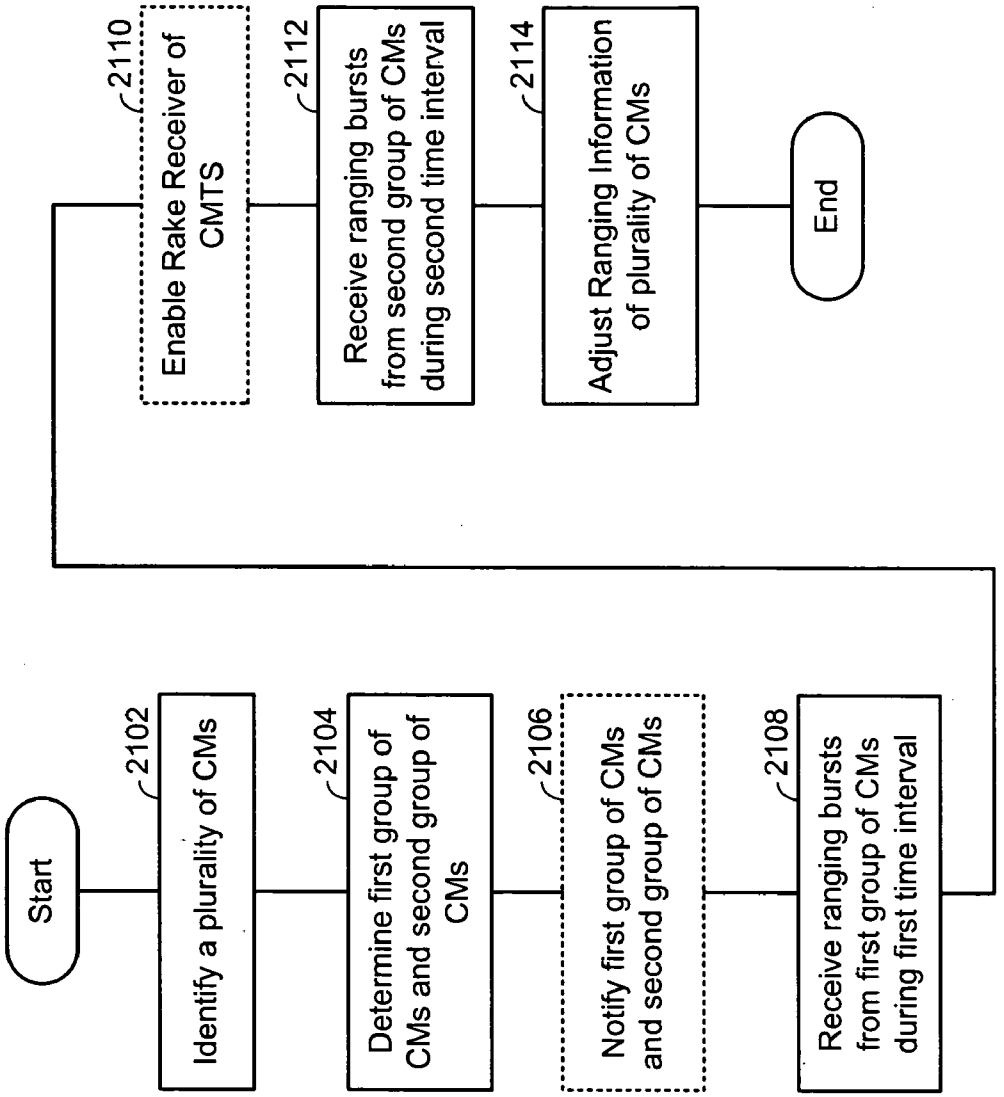

Start
2102
Identify a plurality of CMs
2104
Determine first group of CMs and second group of CMs
2106
Notify first group of CMs and second group of CMs
2108
Receive ranging bursts from first group of CMs during first time interval
2110
Enable Rake Receiver of CMTS
2112
Receive ranging bursts from second group of CMs during second time interval
2114
Adjust Ranging Information of plurality of CMs
End

Fig. 21

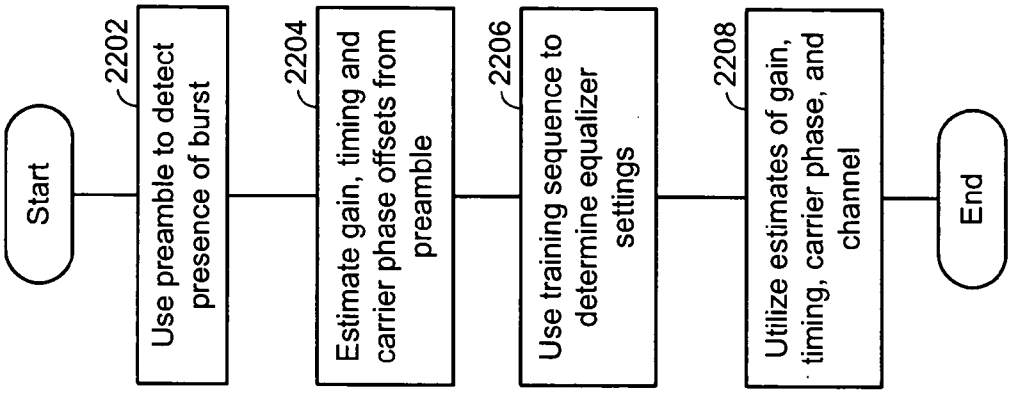

Start
2202
Use preamble to detect presence of burst
2204
Estimate gain, timing and carrier phase offsets from preamble
2206
Use training sequence to determine equalizer settings
2208
Utilize estimates of gain, timing, carrier phase, and channel
End

Fig. 22

RANGING AND REGISTERING CABLE MODEMS UNDER ATTENUATED TRANSMISSION CONDITIONS

CROSS REFERENCES TO RELATED PATENTS/PATENT APPLICATIONS

[0001] The present U.S. Utility Patent Application is a continuation-in-part of U.S. application Ser. No. 10/427,593, filed May 1, 2003, copending, which:

[0002] 1. is a continuation-in-part of U.S. Utility application Ser. No. 10/142,189, entitled "Cancellation of interference in a communication system with application to S-CDMA," (Attorney Docket No. BP 2285), filed May 8, 2002 (May 8, 2002), pending, which claims priority pursuant to 35 U.S.C. § 119(e) to U.S. Provisional Application Ser. No. 60/367,564, entitled "Cancellation of interference in a communication system with application to S-CDMA," (Attorney Docket No. BP 2285), filed Mar. 26, 2002 (Mar. 26, 2002);

[0003] 2. is a continuation-in-part of U.S. Utility application Ser. No. 09/652,721, entitled "Subdimensional single carrier modulation," (Attorney Docket No. BP 1140), filed Aug. 31, 2000 (Aug. 31, 2000), pending, which claims priority pursuant to 35 U.S.C. § 119(e) to U.S. Provisional Patent Application: U.S. Provisional Application Ser. No. 60/151,680, entitled "Subdimensional single carrier modulation," (Attorney Docket No. BP 1140), filed Aug. 31, 1999 (Aug. 31, 1999); and

[0004] 3. Claims priority pursuant to 35 U.S.C. § 119(e) to U.S. Provisional Application Ser. No. 60/416,889, entitled "Signal processing under attenuated transmission conditions," (Attorney Docket No. BP 2630), filed Oct. 8, 2002.

[0005] The present U.S. Utility Patent Application incorporates each of these applications by reference herein in their entirety and makes them part of the present U.S. Utility Patent Application for all purposes.

BACKGROUND OF THE INVENTION

[0006] 1. Technical Field of the Invention

[0007] The invention relates generally to communication systems; and, more particularly, it relates to communication systems that operate under attenuated transmission conditions.

[0008] 2. Description of Related Art

[0009] The problems presented by attenuation of transmitted signals within communication systems have existed for quite some time. In many different types of communication systems, there may be an undesirable attenuation of a signal when being transmitted from a transmitter to a receiver through the infrastructure of the communication system. That is to say, a transmitter may experience a large attenuation of its transmitted signals when they travel to the receiver via the communication system.

[0010] In one type of communication system, a cable modem communication system, this path may be viewed as being an upstream or reverse path between a Cable Modem (CM) and a Cable Modem Termination System (CMTS), and/or the forward path of communication from the CMTS to any one or more CMs within the cable modem communication system.

[0011] In addition, within many communication system networks, there are a multitude of transmitter-to-receiver paths between the various devices, and there is a large variety of degrees of attenuation among all of those various paths. Some paths may have large attenuation, and some may not have so large an attenuation; there is a continuum of possible degrees of attenuation throughout the various paths within the communication system.

[0012] Referring back to the cable modem communication system (which is sometimes referred to as a cable plant), the Data Over Cable Service Interface Specification (DOCSIS) will typically govern the transmission and receipt of signals throughout the cable modem communication system. In this situation, some cable modems (CMs) may have greater attenuation than others over the transmission paths from their respective CM output to the cable headend (e.g., the CMTS contained therein). As a further example, in an apartment complex, there may be long runs of cable, including one or more splitters, connecting the various apartment units. Thus, the cabling itself from the CM may itself even introduce a large attenuation even before that particular CM cabling, within the apartment building, is attached to the rest of the cable plant.

[0013] Operational problems are typically worse when a customer performs a "self-install" of a CM. CMs that are self-installed are oftentimes not properly coupled to the cable network plant, e.g., the terminating connectors used to couple to the cable plant are improperly installed, shielding is improperly maintained, inferior coupling devices are used, etc. These problems result in increased upstream plant ingress and impulse noise as well as increased attenuation of upstream signals.

[0014] These same effects may also be present within wireless communication systems. For example, within a wireless transmission path, where path length differences between the various devices within the system may vary greatly, with some transmitter-receivers being located relatively close and perhaps within a line-of-sight of a wireless termination system, while other transmitter-receivers may be located at a great distance from the wireless termination system and perhaps have an obscured line-of-sight and/or destructively interfering multipath.

[0015] While there are some prior art approaches to deal with the problems presented by undesirable attenuation of signals as they are transmitted through the communication system, these prior art approaches fail to address this large attenuation within the transmission path without also degrading the efficient operation for the full set of transmitters operating into a given receiver. For example, in the cable modem communication system context, these prior art approaches will themselves oftentimes introduce degradation of some, if not all, of the CMs as they transmit signals to the CMTS. In addition, these prior art approaches will typically significantly increase the complexity of the communication system's components. This increase in the complexity of the communication system's components, provided by the prior art approaches, is typically found in increases to the complexity of the Media Access Control

(MAC) (sometimes referred to as the Medium Access Control) and Physical (PHY) layer components of the communication system.

[0016] One prior art means for satisfying the problem of one (or several) of the many transmitter-receiver links suffering excessive attenuation (or path loss) is to employ a receiver having certain flexibility in its operating characteristics. Such a flexible receiver would be capable of operating at a multitude of SNRs (Signal to Noise Ratios) in the network environment. The flexible receiver quickly adjusts from high SNR reception to low SNR reception and/or vice-versa, and it would utilize a MAC layer which efficiently manipulates and allocates access to the network while factoring in the variation throughput which necessarily accompanies the variety of SNRs across the various links within the communication system. These system level concepts have been proposed for this problem already in the prior art, especially in the wireless environment, under the moniker of multi-channel multipoint distribution service (MMDS) Adaptive Modulation approach. However, a major drawback of many such Adaptive Modulation approaches is the typically immense complexity associated therewith, especially, but not solely, when resolving the MAC layer issues.

[0017] In addition, within many communication systems, there is a requirement that all transmitters be constrained to use the same modulation parameters. This may be because the receiver is limited to receiving signals using that common set of modulation parameters or characteristics. As mentioned above, the prior art approach of providing such rapidly changing receiver flexibility at the PHY layer and at the MAC layer is not without a significant increase in complexity. These parameters may include the modulation order (QPSK (Quadrature Phase Shift Keying), 16 QAM (Quadrature Amplitude Modulation), 64 QAM, etc.), the FEC (Forward Error Correction) parameters (RS (Reed Solomon) codeword length N and number of correctable bytes T), and other parameters as well.

[0018] In a communication system lacking such an extremely sophisticated and flexible PHY and MAC layer, if one of the transmitters is disadvantaged and unable to communicate using the particular modulation order at hand, such as 64 QAM, then this would cause a reduction of the modulation order on the entire channel to a lower order prescribed modulation that all of the transmitters can accommodate. For example, this could involve reducing the modulation order from 64 QAM to 32 QAM, in one instance, or to an even lower modulation order as dictated by the highly attenuated and problematic transmitter-receiver path. Therefore, in doing so, all of the transmitters need to be reduced to the lower order modulation; it would require reducing all of the transmitters to 32 QAM in this example. This would undesirably reduce the raw throughput of the communication channel (bits per second) by a ratio of 5/6. Clearly, there are situations where the reduction of modulation order may be even more significant and the throughput of the communication channel would be even more affected.

[0019] Another problem that often arises in such communication systems is an upper limit on the power that a particular transmitter is capable of using, or is permitted to use, to transmit its information. Such an upper power limit may be imposed by the capabilities of economically implemented transmit amplifiers which are allocated to have a certain maximum transmit power given a spurious fidelity requirement that must be met. In addition, the regulatory agencies (e.g., the Federal Communications Commission (FCC)) may also impose a limit on transmit power to prevent interference with other services operating within other frequency spectra. In addition, in some systems, there is a nonlinear element in the communication channel, which limits the power that can be passed through the communication channel. In the case of a cable modem communication system, one potential source of nonlinearity may be an upstream laser which will clips signals above a certain maximum power level.

[0020] One prior art approach that seeks to deal with these deficiencies is to increase the transmitted power of a transmitter up to a certain point so as to overcome the high attenuation of its transmitter-receiver transmission path. However, because of the inherent limitations of the device, the transmitter cannot increase its power beyond an upper limit point, as described above. Again, this upper transmitted power limit could be due to standards, wherein the limitations are attempting to allow coexistence with other communications networks or broadcasts, such as wireless systems. Alternatively, the upper transmitted power limit may be caused by agreed-upon practical or cost-effective limits (as in DOCSIS), or they could be a combination of these factors. This power limitation, regardless of which source introduces it, inherently presents a limit by which this prior art approach can employ the increasing of transmitted power to address this problem.

[0021] Yet another problem that arises in such communication system is a problem associated with the multipoint-to-point connectivity within communication systems. A transmitter may need to enter the network (e.g., range and register) before it can communicate in a normal manner within the communication system. The attenuated transmission conditions may simply make prior art approaches to perform this ranging and registering impossible, given the oftentimes relatively low SNR on the communication channel of interest on which the ranging and registering is to be performed.

[0022] Also along these lines of a communication system having a communication channel that is extremely attenuated, in many multipoint-to-point communication systems, a headend receiver (e.g., a CMTS of a cable headend in a cable modem communication system) must adjust the transmission parameters of the transmitters (e.g., the CMs in a cable modem communication system) based on transmissions (such as ranging bursts) from the transmitters to the receiver. That is, the transmitter must send a ranging burst to the receiver, and the receiver must make measurements on the ranging burst and determine adjustments, if any, to one or more of the transmitter's operational parameters. These transmitter operational parameters may include timing offset, frequency offset, power, equalizer coefficients, among other parameters. However, in an attenuated channel, the ranging burst itself is likely to have a significantly reduced SNR upon arrival at the receiver. This will again make the ranging and registering of the transmitter challenging. Even if the ranging and registering of the transmitter may be performed, it is likely to be made with significant error given the significantly reduced SNR of the ranging burst upon arrival at the receiver.

[0023] Therefore, there does not presently exist, in the art, a means by which a transmitter can overcome a severe attenuation in its transmission path to the receiver and thereby maintain reliable operation at the receiver. As such, no prior art solution is able to address the even more complicated situation that arises within multipoint-to-point communication systems having numerous reflections, additional paths, etc. contained throughout the communication system.

[0024] In addition, the prior art does not presently provide a solution by which a transmitter can overcome a severe attenuation in its path to the receiver and still maintain a desired SNR at the receiver. The prior art also presents no solution by which a transmitter can increase the SNR at the receiver without increasing its transmitted signal power beyond the certain/predetermined limit as described above.

[0025] There also does not presently exist, in the art, a means by which a transmitter can reduce its own throughput while retaining its assigned modulation parameters, and hence not require the other transmitters on the communication channel to reduce their throughput as well.

BRIEF SUMMARY OF THE INVENTION

[0026] A cable modem communication system that supports attenuated transmission adaptation during registering and ranging operations overcomes the above-cited shortcomings of the prior systems, among other shortcomings. The cable modem communication system includes a plurality of Cable Modems (CMs), a CM network segment, and a Cable Modem Termination System (CMTS). The CMTS communicatively couples to the plurality of CMs via a CM network segment. The CMTS is operable to segregate the plurality of CMs into at least two CM groups comprising a first group of CMs with which standard registering and ranging operations are performed and a second group of CMs with which attenuated transmission registering and ranging operations are performed. Each CM of the first group of CMs operable to perform registering and ranging operations by transmitting a ranging burst of a first format. Each CM of the second group of CMs operable to perform registering and ranging operations by transmitting a ranging burst of a second format that differs from the ranging burst of the first format. The CMTS may include a rake receiver that receives and demodulates a plurality of multi-path copies of the ranging burst of the second format.

[0027] With a first embodiment, the ranging burst of the first format includes a first format preamble, a first format training sequence, and a first format data packet comprising a plurality of digitally modulated symbols. Further, with this first embodiment, the ranging burst of the second format includes a second format preamble, a second format training sequence, and a second format data packet comprising a plurality of digitally modulated symbols that have been spread by at least one spreading code.

[0028] With a second embodiment, the ranging burst of the first format includes a first format preamble, a first format training sequence, and a first format data packet. Further, with this second embodiment, the ranging burst of the second format includes a second format preamble, a second format training sequence, and a second format data packet that has been encoded using an outer code.

[0029] With a third embodiment, the ranging burst of the first format includes a first format preamble, a first format training sequence, and a single copy of first format data packet. Further, with this third embodiment, the ranging burst of the second format includes a second format preamble, a second format training sequence, and multiple copies of a second format data packet.

[0030] With a fourth embodiment, the ranging burst of the first format includes a first format preamble, a first format training sequence, and a first format data packet comprising a plurality of digitally modulated symbols of a first modulation order. Further, with this fourth embodiment, the ranging burst of the second format includes a second format preamble, a second format training sequence, and a second format data packet comprising a plurality of digitally modulated symbols of a second modulation order, the second modulation order lower than the first modulation order. With the fourth embodiment, the first modulation order may be of an order higher than Binary Phase Shift Keying (BPSK) while the second modulation order may be BPSK.

[0031] With a fifth embodiment, the ranging burst of the first format includes a first format preamble, a first format training sequence, and a first format data packet having a first code rate. Further, with this fifth embodiment, the ranging burst of the second format includes a second format preamble, a second format training sequence, and a second format data packet having a second code rate that is lower than the first code rate.

[0032] With a sixth embodiment, the ranging burst of the first format includes a first format preamble, a first format training sequence, and a first format data packet encoded using first coding characteristics. Further, with this sixth embodiment, the ranging burst of the second format includes a second format preamble, a second format training sequence, and a second format data packet encoded using second coding characteristics that are more robust than the first coding characteristics.

[0033] With any of these embodiments, the ranging burst of the first format may be transmitted at a first power level and the ranging burst of the second format may be transmitted at a second power level that differs from (e.g., may be greater than) the first power level. Further, with any of these embodiments, the ranging burst of the first format may have a first duration while the ranging burst of the second format may have a second duration, wherein the second duration is greater than the first duration.

[0034] With any of these embodiments, the first group of CMs may be operable to transmit the ranging bursts of the first format to the CMTS during a first contention interval while the second group of CMs may be operable to transmit the ranging bursts of the second format to the CMTS during a second contention interval. Further, the plurality of CMs and the CMTS are interoperable to determine which CMs form the first group and which CMs form the second group. In one particular instance, a CM is within the first group of CMs when professionally installed while a CM is within the second group of CMs when subscriber installed. In a second instance, a CM is assigned to the first or second group of CMs based upon ranging results, e.g., ranging success or the lack thereof, or received ranging burst parameters such as SNR.

[0035] In addition, other aspects, advantages, and novel features of the invention will become apparent from the

following detailed description of the invention when considered in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0036] **FIG. 1** is a system diagram illustrating an embodiment of a cable modem communication system that is built according to the invention.

[0037] **FIG. 2** is a system diagram illustrating another embodiment of a cable modem communication system that is built according to the invention.

[0038] **FIG. 3** is a system diagram illustrating an embodiment of a satellite communication system that is built according to the invention.

[0039] **FIG. 4** is a system diagram illustrating an embodiment of a High Definition Television (HDTV) communication system that is built according to the invention.

[0040] **FIG. 5A** and **FIG. 5B** are system diagrams illustrating embodiment of uni-directional cellular communication systems that are built according to the invention.

[0041] **FIG. 5C** is a system diagram illustrating embodiment of a bi-directional cellular communication system that is built according to the invention.

[0042] **FIG. 6A** is a system diagram illustrating embodiment of a uni-directional microwave communication system that is built according to the invention.

[0043] **FIG. 6B** is a system diagram illustrating embodiment of a bi-directional microwave communication system that is built according to the invention.

[0044] **FIG. 7A** is a system diagram illustrating embodiment of a uni-directional point-to-point radio communication system that is built according to the invention.

[0045] **FIG. 7B** is a system diagram illustrating embodiment of a bi-directional point-to-point radio communication system that is built according to the invention.

[0046] **FIG. 8A** is a system diagram illustrating embodiment of a uni-directional communication system that is built according to the invention.

[0047] **FIG. 8B** is a system diagram illustrating embodiment of a bi-directional communication system that is built according to the invention.

[0048] **FIG. 8C** is a system diagram illustrating embodiment of a one to many communication system that is built according to the invention.

[0049] **FIG. 9** is a system diagram illustrating an embodiment of a Cable Modem Termination System (CMTS) system that is built according to the invention.

[0050] **FIG. 10A** is a diagram illustrating logical channel partitioning of a portion of spectrum that is performed according to the invention.

[0051] **FIG. 10B** is a diagram illustrating an embodiment of logical channel partitioning of Synchronous Code Division Multiple Access (S-CDMA) codes in a Data Over Cable Service Interface Specification (DOCSIS) system that is performed according to the invention.

[0052] **FIG. 11** is a diagram illustrating an alternative embodiment of logical channel partitioning of S-CDMA codes in a DOCSIS system that is performed according to the invention.

[0053] **FIG. 12** is a functional block diagram illustrating an embodiment of power and modulation adaptation functionality that is arranged according to the invention

[0054] **FIG. 13** is a functional block diagram illustrating an embodiment of ranging and registering functionality that is arranged according to the invention

[0055] **FIG. 14A** is a diagram illustrating example upstream burst profiles that may be employed according to the invention.

[0056] **FIG. 14B** is a diagram illustrating example modulation densities that may be employed according to the invention.

[0057] **FIG. 15** is an operational flow diagram illustrating an embodiment of an attenuated transmission adaptation method, employing power and modulation adaptation that is performed according to the invention.

[0058] **FIG. 16** is an operational flow diagram illustrating an embodiment of an attenuated transmission adaptation method, employing ranging and registering adaptation that is performed according to the invention.

[0059] **FIG. 17A**, **FIG. 17B**, **FIG. 18A**, and **FIG. 18B** are operational flow diagrams illustrating embodiments of attenuated transmission adaptation methods that are performed according to the invention.

[0060] **FIG. 19** is a system diagram of a cable modem communication system with which registering and ranging operations of the present invention are employed.

[0061] **FIG. 20A** is a block diagram illustrating a ranging burst of a first format according to the present invention.

[0062] **FIG. 20B** is a block diagram illustrating a ranging burst of a second format according to the present invention.

[0063] **FIG. 21** is a flow chart illustrating operation according to the present invention in registering and ranging Cable Modems (CMs).

[0064] **FIG. 22** is a flow chart illustrating operation according to the present invention in receiving a ranging burst.

DETAILED DESCRIPTION OF THE INVENTION

[0065] Various aspects of the invention address the many deficiencies of the prior art when dealing with a large attenuation in the path from a transmitter to a receiver. The invention is able to provide, among other benefits, a solution that allows optimal use of bandwidth within a communication system. In the presence of insufficient SNR, a transmitter may reduce its throughput or bits per second (and thus attempt reliable communications) in either of two ways: by reducing its constellation order, for example, from 64 QAM to QPSK, or by reducing the bandwidth—or number of signaling dimensions per time interval—that it employs.

[0066] Reducing constellation order (bits per symbol) decreases the SNR required at the receiver for reliable

communications. However, by doing so, it also reduces the throughput efficiency (bits per second per Hertz (Hz)) of the overall communications channel. This may be problematic, in that, the PHY operational parameters are typically shared among ALL of the transmitters on the same channel. Therefore, this choice, by itself, will provide some improved performance, yet it is not particularly attractive. The other option of reducing the number of signaling dimensions per time interval—for the transmitters with insufficient SNR in "normal" operation—remains. Reducing the number of signaling dimensions allocated per time interval for selected transmitters solves the insufficient SNR problem but at the expense of reduced channel throughput.

[**0067**] However, when dealing with the real limitation of maximum possible transmit power of a device (the limitation may be caused by a variety of reasons, some of which are described above), it is found that reducing the number of signaling dimensions combined with keeping the transmit power at a maximum (in one embodiment), does in fact increase the SNR per dimension (or per symbol) at the receiver. In addition, other embodiments of the invention envision reducing the number of signaling dimensions combined with intelligently modifying the transmit power in an effort to increase the SNR per dimension (or per symbol) at the receiver.

[**0068**] Therefore, the appropriate reduction in the number of allocated signaling dimensions for a disadvantaged transmitter, while modifying the allowed transmit power (setting it to a maximum in one embodiment), provides that the SNR per dimension at the receiver can be brought up to the level achieved by the more typical transmitters within the communication system whose transmitter-receiver links are not disadvantaged by severe attenuation.

[**0069**] Therefore, this combination technique provides a solution for many of the deficiencies described above, namely, by ensuring that a similar SNR is working into the receiver for all of the transmitters of the system, and that similar PHY layer operational parameters may be employed for all of the transmitters. Hence, the invention provides, among other benefits, a means by which a transmitter can maintain the desired SNR at the receiver while not decreasing the overall throughput or throughput efficiency of the entire communication channel. By maintaining the SNR at the receiver, the difficulties of the flexible PHY receiver are eliminated, and the difficulties of the associated MAC layer are greatly reduced as well. Other details, benefits, and aspects of the invention are also described in more detail below.

[**0070**] **FIGS. 1**, **2**, **3**, **4**, **5**A, **5**B, **5**C, **6**A, **6**B, **7**A, **7**B, **8**A, **8**B, **8**C, and **9** illustrate a number of communication system context embodiments where various aspects of the invention may be implemented.

[**0071**] **FIG. 1** is a system diagram illustrating an embodiment of a cable modem communication (CM) system **100** that is built according to the invention. The CM communication system **100** includes a number of CMs that may be used by different users (shown as a CM **1**, a CM **2**, . . . , and a CM n) and a cable headend that includes a Cable Modem Termination System (CMTS) and a cable headend transmitter. The CMTS is a component that exchanges digital signals with CMs on a cable network.

[**0072**] Each of the CMs (shown CM **1**, CM **2**, . . . , and CM n) is operable to communicatively couple to a Cable Modem (CM) network segment. A number of elements may be included within the CM network segment. For example, routers, splitters, couplers, relays, and amplifiers may be contained within the CM network segment without departing from the scope and spirit of the invention.

[**0073**] The CM network segment allows communicative coupling between a CMs and a cable headend that includes the cable modem headend transmitter and the CMTS. The CMTS may be located at a local office of a cable television company or at another location within a CM communication system. The cable headend transmitter is able to provide a number of services including those of audio, video, local access channels, as well as any other service known in the art of cable systems. Each of these services may be provided to the one or more CMs (shown as a CM **1**, CM **2**, . . . , and CM n).

[**0074**] In addition, through the CMTS, the CMs are able to transmit and receive data from the Internet and/or any other network to which the CMTS is communicatively coupled via an external network connection. The operation of a CMTS, at the cable-provider's head-end, may be viewed as providing analogous functions that are provided by a digital subscriber line access multiplexor (DSLAM) within a digital subscriber line (DSL) system. The CMTS takes the traffic coming in from a group of customers on a single channel and routes it to an Internet Service Provider (ISP) for connection to the Internet, as shown via the external network connection that communicatively couples to the Internet access. At the head-end, the cable providers will have, or lease space for a third-party ISP to have, servers for accounting and logging, dynamic host configuration protocol (DHCP) for assigning and administering the Internet protocol (IP) addresses of all the cable system's users (specifically, the CM **1**, CM **2**, . . . , and CM n), and typically control servers for a protocol called Data Over Cable Service Interface Specification (DOCSIS), the major standard used by U.S. cable systems in providing Internet access to users. The servers may also be controlled for a protocol called European Data Over Cable Service Interface Specification (EuroDOCSIS), the major standard used by European cable systems in providing Internet access to users, without departing from the scope and spirit of the invention. In addition, a Japanese DOCSIS specification is also currently under development, and the invention is operable within the Japanese DOCSIS specification as well.

[**0075**] The downstream information flows to any one or more of the connected CMs (shown as the CM **1**, CM **2**, . . . , and CM n). The individual network connection, within the CM network segment, decides whether a particular block of data is intended for that particular CM or not. On the upstream side, information is sent from the CMs (shown as the CM **1**, CM **2**, . . . , and CM n) to the CMTS; on this upstream transmission, the CMs (shown as the CM **1**, CM **2**, . . . , and CM n) to which the data is not intended do not see that data at all.

[**0076**] As an example of the capabilities provided by a CMTS, the CMTS will enable as many as 1,000 users to connect to the Internet through a single 6 MHz channel. Since a single channel is capable of 30-40 Mbps (mega-bits per second) of total throughput, this means that users may see far better performance than is available with standard dial-up modems that may be used to access external net-

works such as the Internet. Some embodiments implementing the invention are described below and in the various Figures that show the data handling and control within one or both of a CM and a CMTS within a CM system that operates by employing CDMA (Code Division Multiple Access) and/or S-CDMA (Synchronous Code Division Multiple Access).

[**0077**] The CMs (shown as the CM **1**, CM **2**, . . . , and CM n) and the CMTS communicate synchronization information to one another to ensure proper alignment of transmission from the CMs to the CMTS. This is where the synchronization of the S-CDMA communication systems is extremely important. When a number of the CMs all transmit their signals at a same time such that these signals are received at the CMTS on the same frequency and at the same time, they must all be able to be properly de-spread and decoded for proper signal processing.

[**0078**] Each of the CMs (shown as the CM **1**, CM **2**, . . . , and CM n) is located a respective transmit distance from the CMTS. In order to achieve optimum spreading diversity and orthogonality for the CMs (shown as the CM **1**, CM **2**, . . . , and CM n) when transmitting to the CMTS, each of the CM transmissions must be synchronized so that it arrives, from the perspective of the CMTS, synchronous with other CM transmissions. In order to achieve this goal, for a particular transmission cycle, each of the CMs typically transmits to the CMTS at a respective transmission time, which will likely differ from the transmission times of other CMs. These differing transmission times will be based upon the relative transmission distance between the CM and the CMTS. These operations may be supported by the determination of the round trip delays (RTPs) between the CMTS and each supported CM. With these RTPs determined, the CMs may then determine at what point to transmit their S-CDMA data so that all CM transmissions will arrive synchronously at the CMTS.

[**0079**] The invention employs attenuated transmission adaptation functionality within one or more of the CMs (shown as the CM **1**, CM **2**, . . . , and CM n). Some or all of the CMs include attenuated transmission adaptation functionality. In some of these CMs, this functionality is not active while in other CMs, this functionality is active. Logical channels may be used to separate the CMs into classes: (1) those that have the attenuated transmission adaptation functionality active; and (2) those that do not the attenuated transmission adaptation functionality active. In some embodiments, the CMTS is able to support CM transmission instruction functionality such that the CMTS will direct the CM to perform certain adaptation of the manner in which the CM transmits information upstream to the CMTS; this situation may be viewed as being an embodiment where the CMTS has access to information (such the Signal to Noise Ratio (SNR) of the communication link from the CM to the CMTS, the cable modem communication system's operating conditions, and/or other information) that it is able intelligently to make such decisions regarding the manner in which the CM transmits information upstream to the CMTS. The communication of instructions to and from the CMs and the CMTS may be performed using a variety of means including: 1. via a separate logical channel through the CM network segment, 2. via a proprietary communication channel via the downstream transmission direction from the CMTS to the CMs, and/or 3. via any other communication means.

[**0080**] **FIG. 2** is a system diagram illustrating another embodiment of a cable modem communication system **200** that is built according to the invention. From certain perspectives, the **FIG. 2** may be viewed as a communication system allowing bi-directional communication between a customer premise equipment (CPE) and a network. In some embodiments, the CPE is a personal computer or some other device allowing a user to access an external network. The CM and the CPE may be communicatively coupled via a number of possible means, including an Ethernet interface, a USB (Universal Serial Bus) interface, a wireless interface, and/or some other interface. The external network may be the Internet itself, or, alternatively a wide area network (WAN). For example, the CM communication system **200** is operable to allow Internet protocol (IP) traffic to achieve transparent bi-directional transfer between a CMTS-network side interface (CMTS-NSI: viewed as being between the CMTS and the Internet) and a CM to CPE interface (CMCI: viewed as being between the Cable Modem (CM) and the CPE).

[**0081**] The Internet, and/or the WAN, is/are communicatively coupled to the CMTS via the CMTS-NSI. The CMTS is operable to support the external network termination, for one or both of the WAN and the Internet. The CMTS includes a modulator and a demodulator to support transmitter and receiver functionality to and from a CM network segment. A CMTS Media Access Controller (MAC) in interposed between the modulator and a demodulator of the CMTS that is operable to support CM transmission instruction functionality in some embodiments. In addition, the CM includes a modulator and a demodulator to support transmitter and receiver functionality to and from a CM network segment. A CM Media Access Controller (MAC) in interposed between the modulator and a demodulator of the CM that is operable to support attenuated transmission adaptation functionality.

[**0082**] A number of elements may be included within the CM network segment. For example, routers, splitters, couplers, relays, and amplifiers may be contained within the CM network segment without departing from the scope and spirit of the invention. The CM network segment allows communicative coupling between a CM user and the CMTS.

[**0083**] The **FIG. 1** and the **FIG. 2** show just two embodiments where the various aspects of the invention may be implemented. Several other embodiments are described as well.

[**0084**] **FIG. 3** is a system diagram illustrating an embodiment of a satellite communication system that is built according to the invention. A satellite transmitter is communicatively coupled to a satellite dish that is operable to communicate with a satellite. The satellite transmitter may also be communicatively coupled to a wired network. This wired network may include any number of networks including the Internet, proprietary networks, and/or other wired networks. The satellite transmitter employs the satellite dish to communicate to the satellite via a wireless communication channel. The satellite is able to communicate with one or more satellite receivers, shown as satellite receivers (each having a satellite dish). Each of the satellite receivers may also be communicatively coupled to a display.

[0085] Here, the communication to and from the satellite may cooperatively be viewed as being a wireless communication channel, or each of the communication to and from the satellite may be viewed as being two distinct wireless communication channels.

[0086] For example, the wireless communication "channel" may be viewed as not including multiple wireless hops in one embodiment. In other embodiments, the satellite receives a signal received from the satellite transmitter (via its satellite dish), amplifies it, and relays it to satellite receiver (via its satellite dish); the satellite receiver may also be implemented using terrestrial receivers such as satellite receivers, satellite based telephones, and/or satellite based Internet receivers, among other receiver types. In the case where the satellite receives a signal received from the satellite transmitter (via its satellite dish), amplifies it, and relays it, the satellite may be viewed as being a "transponder." In addition, other satellites may exist that perform both receiver and transmitter operations in cooperation with the satellite. In this case, each leg of an up-down transmission via the wireless communication channel would be considered separately.

[0087] In whichever embodiment, the satellite communicates with the satellite receiver. The satellite receiver may be viewed as being a mobile unit in certain embodiments (employing a local antenna); alternatively, the satellite receiver may be viewed as being a satellite earth station that may be communicatively coupled to a wired network in a similar manner in which the satellite transmitter may also be communicatively coupled to a wired network.

[0088] The satellite transmitter is operable to support attenuated transmission adaptation functionality according to the invention. Each of the satellite receivers is operable, in certain embodiments, to support satellite transmission instruction functionality such that a satellite receiver is capable to instruct the satellite transmitter regarding how the satellite transmitter is to change its transmission operating parameters.

[0089] The **FIG. 3** shows yet another of the many embodiments where attenuated transmission adaptation functionality is supported at a transmitter end of a communication system and transmission instruction functionality may sometimes be supported at the receiver end of the communication channel.

[0090] **FIG. 4** is a system diagram illustrating an embodiment of a High Definition Television (HDTV) communication system that is built according to the invention. An HDTV transmitter is communicatively coupled to a tower. The HDTV transmitter, using its tower, transmits a signal to a local tower dish via a wireless communication channel. The local tower dish communicatively couples to an HDTV set top box receiver via a coaxial cable. The HDTV set top box receiver includes the functionality to receive the wireless transmitted signal that has been received by the local tower dish; this may include any transformation and/or down-converting as well to accommodate any up-converting that may have been performed before and during transmission of the signal from the HDTV transmitter and its tower.

[0091] The HDTV set top box receiver is also communicatively coupled to an HDTV display that is able to display the demodulated and decoded wireless transmitted signals received by the HDTV set top box receiver and its local tower dish. The HDTV transmitter (via its tower) transmits a signal directly to the local tower dish via the wireless communication channel in this embodiment. In alternative embodiments, the HDTV transmitter may first receive a signal from a satellite, using a satellite earth station that is communicatively coupled to the HDTV transmitter, and then transmit this received signal to the to the local tower dish via the wireless communication channel. In this situation, the HDTV transmitter operates as a relaying element to transfer a signal originally provided by the satellite that is destined for the HDTV set top box receiver. For example, another satellite earth station may first transmit a signal to the satellite from another location, and the satellite may relay this signal to the satellite earth station that is communicatively coupled to the HDTV transmitter. The HDTV transmitter performs receiver functionality and then transmits its received signal to the local tower dish.

[0092] In even other embodiments, the HDTV transmitter employs its satellite earth station to communicate to the satellite via a wireless communication channel. The satellite is able to communicate with a local satellite dish; the local satellite dish communicatively couples to the HDTV set top box receiver via a coaxial cable. This path of transmission shows yet another communication path where the HDTV set top box receiver may communicate with the HDTV transmitter.

[0093] In whichever embodiment and whichever signal path the HDTV transmitter employs to communicate with the HDTV set top box receiver, the HDTV set top box receiver is operable to receive communication transmissions from the HDTV transmitter.

[0094] The HDTV transmitter is operable to support attenuated transmission adaptation functionality according to the invention. The HDTV set top box receiver is operable, in certain embodiments, to support HDTV transmitter transmission instruction functionality such that the HDTV set top box receiver is capable to instruct the HDTV transmitter regarding how the HDTV transmitter is to change its transmission operating parameters.

[0095] The **FIG. 4** shows yet another of the many embodiments where attenuated transmission adaptation functionality is supported at a transmitter end of a communication system and transmission instruction functionality may sometimes be supported at the receiver end of the communication channel.

[0096] **FIG. 5A** and **FIG. 5B** are system diagrams illustrating embodiment of uni-directional cellular communication systems that are built according to the invention.

[0097] Referring to the **FIG. 5A**, a mobile transmitter includes a local antenna communicatively coupled thereto. The mobile transmitter may be any number of types of transmitters including a one way cellular telephone, a wireless pager unit, a mobile computer having transmit functionality, or any other type of mobile transmitter. The mobile transmitter transmits a signal, using its local antenna, to a cellular tower via a wireless communication channel. The cellular tower is communicatively coupled to a base station receiver; the receiving tower is operable to receive data transmission from the local antenna of the mobile transmitter that has been communicated via the wireless communi-

cation channel. The cellular tower communicatively couples the received signal to the base station receiver.

[0098] The mobile transmitter is operable to support attenuated transmission adaptation functionality according to the invention. The base station receiver is operable, in certain embodiments, to support transmission instruction functionality such that the base station receiver is capable to instruct the mobile transmitter regarding how the mobile transmitter is to change its transmission operating parameters. The **FIG. 5A** shows a uni-directional cellular communication system where the communication goes from the mobile transmitter to the base station receiver via the wireless communication channel.

[0099] Referring to the **FIG. 5B**, a base station transmitter includes a cellular tower communicatively coupled thereto. The base station transmitter, using its cellular tower, transmits a signal to a mobile receiver via a communication channel. The mobile receiver may be any number of types of receivers including a one-way cellular telephone, a wireless pager unit, a mobile computer having receiver functionality, or any other type of mobile receiver. The mobile receiver is communicatively coupled to a local antenna; the local antenna is operable to receive data transmission from the cellular tower of the base station transmitter that has been communicated via the wireless communication channel. The local antenna communicatively couples the received signal to the mobile receiver.

[0100] The base station transmitter is operable to support attenuated transmission adaptation functionality according to the invention. The mobile receiver is operable, in certain embodiments, to support transmission instruction functionality such that the mobile receiver is capable to instruct the base station transmitter regarding how the base station transmitter is to change its transmission operating parameters. The **FIG. 5B** shows a unidirectional cellular communication system where the communication goes from the base station transmitter to the mobile receiver via the wireless communication channel.

[0101] The **FIG. 5C** shows a bi-directional cellular communication system where the communication can go to and from the base station transceiver and to and from the mobile transceiver via the wireless communication channel.

[0102] Referring to the **FIG. 5C**, a base station transceiver includes a cellular tower communicatively coupled thereto. The base station transceiver, using its cellular tower, transmits a signal to a mobile transceiver via a communication channel. The reverse communication operation may also be performed. The mobile transceiver is able to transmit a signal to the base station transceiver as well. The mobile transceiver may be any number of types of transceiver including a cellular telephone, a wireless pager unit, a mobile computer having transceiver functionality, or any other type of mobile transceiver. The mobile transceiver is communicatively coupled to a local antenna; the local antenna is operable to receive data transmission from the cellular tower of the base station transceiver that has been communicated via the wireless communication channel. The local antenna communicatively couples the received signal to the mobile transceiver.

[0103] The base station transceiver is operable to support attenuated transmission adaptation functionality according to the invention as well as transmission instruction functionality, in certain embodiments, such that the base station transceiver is capable to instruct the mobile transceiver regarding how the mobile transceiver is to change its transmission operating parameters.

[0104] Similarly, the mobile transceiver is operable, in certain embodiments, to support transmission instruction functionality such that the mobile transceiver is capable to instruct the base station transceiver regarding how the base station transceiver is to change its transmission operating parameters.

[0105] The **FIG. 5A**, the **FIG. 5B**, and the **FIG. 5C** show yet more embodiments where attenuated transmission adaptation functionality is supported at the transmitter capable end (or ends) of a communication system and transmission instruction functionality may sometimes be supported at the receiver capable end (or ends) of the communication channel.

[0106] **FIG. 6A** is a system diagram illustrating embodiment of a uni-directional microwave communication system that is built according to the invention. A microwave transmitter is communicatively coupled to a microwave tower. The microwave transmitter, using its microwave tower, transmits a signal to a microwave tower via a wireless communication channel. A microwave receiver is communicatively coupled to the microwave tower. The microwave tower is able to receive transmissions from the microwave tower that have been communicated via the wireless communication channel.

[0107] The microwave transmitter is operable to support attenuated transmission adaptation functionality according to the invention. The microwave receiver is operable, in certain embodiments, to support transmission instruction functionality such that the microwave receiver is capable to instruct the microwave transmitter regarding how the microwave transmitter is to change its transmission operating parameters.

[0108] The **FIG. 6A** shows yet another of the many embodiments where attenuated transmission adaptation functionality is supported at a transmitter end of a communication system and transmission instruction functionality may sometimes be supported at the receiver end of the communication channel.

[0109] **FIG. 6B** is a system diagram illustrating embodiment of a bi-directional microwave communication system that is built according to the invention. Within the **FIG. 6B**, a first microwave transceiver is communicatively coupled to a first microwave tower. The first microwave transceiver, using the first microwave tower (the first microwave transceiver's microwave tower), transmits a signal to a second microwave tower of a second microwave transceiver via a wireless communication channel. The second microwave transceiver is communicatively coupled to the second microwave tower (the second microwave transceiver's microwave tower). The second microwave tower is able to receive transmissions from the first microwave tower that have been communicated via the wireless communication channel. The reverse communication operation may also be performed using the first and second microwave transceivers.

[0110] Each of the microwave transceivers is operable to support attenuated transmission adaptation functionality

according to the invention. In addition, each of the microwave transceivers is operable, in certain embodiments, to support transmission instruction functionality such that one of the microwave transceivers is capable to instruct the other microwave transceiver regarding how that microwave transceiver is to change its transmission operating parameters to the other microwave transceiver.

[0111] The **FIG. 6A** and the **FIG. 6B** show yet more embodiments where attenuated transmission adaptation functionality is supported at the transmitter capable end (or ends) of a communication system and transmission instruction functionality may sometimes be supported at the receiver capable end (or ends) of the communication channel.

[0112] **FIG. 7A** is a system diagram illustrating embodiment of a unidirectional point-to-point radio communication system that is built according to the invention. A mobile unit transmitter includes a local antenna communicatively coupled thereto. The mobile unit transmitter, using its local antenna, transmits a signal to a local antenna of a mobile unit receiver via a wireless communication channel.

[0113] The mobile unit transmitter is operable to support attenuated transmission adaptation functionality according to the invention. In addition, the mobile unit receiver is operable, in certain embodiments, such that the mobile unit receiver is capable to instruct the mobile unit transmitter regarding how the mobile unit transmitter is to change its transmission operating parameters.

[0114] **FIG. 7B** is a system diagram illustrating embodiment of a bi-directional point-to-point radio communication system that is built according to the invention. Within the **FIG. 7B**, a first mobile unit transceiver is communicatively coupled to a first local antenna. The first mobile unit transceiver, using the first local antenna (the first mobile unit transceiver's local antenna), transmits a signal to a second local antenna of a second mobile unit transceiver via a wireless communication channel. The second mobile unit transceiver is communicatively coupled to the second local antenna (the second mobile unit transceiver's local antenna). The second local antenna is able to receive transmissions from the first local antenna that have been communicated via the wireless communication channel. The reverse communication operation may also be performed using the first and second mobile unit transceivers.

[0115] Each of the mobile unit transceivers is operable to support attenuated transmission adaptation functionality according to the invention. In addition, each of the mobile unit transceivers is operable, in certain embodiments, to support transmission instruction functionality such that one of the mobile unit transceivers is capable to instruct the other mobile unit transceiver regarding how that microwave transceiver is to change its transmission operating parameters to the other microwave transceiver.

[0116] The **FIG. 7A** and the **FIG. 7B** show yet more embodiments where attenuated transmission adaptation functionality is supported at the transmitter capable end (or ends) of a communication system and transmission instruction functionality may sometimes be supported at the receiver capable end (or ends) of the communication channel.

[0117] **FIG. 8A** is a system diagram illustrating an embodiment of a uni-directional communication system that is built according to the invention. A transmitter communicates to a receiver via a uni-directional communication channel. The uni-directional communication channel may be a wireline (or wired) communication channel or a wireless communication channel without departing from the scope and spirit of the invention. The wired media by which the uni-directional communication channel may be implemented are varied, including coaxial cable, fiber-optic cabling, and copper cabling, among other types of "wiring." Similarly, the wireless manners in which the uni-directional communication channel may be implemented are varied, including satellite communication, cellular communication, microwave communication, and radio communication, among other types of wireless communication.

[0118] The transmitter is operable to support attenuated transmission adaptation functionality according to the invention. In addition, the receiver is operable, in certain embodiments, such that the receiver is capable to instruct the transmitter regarding how the transmitter is to change its transmission operating parameters.

[0119] **FIG. 8B** is a system diagram illustrating an embodiment of a bi-directional communication system that is built according to the invention. Within the **FIG. 8B**, a first transceiver is communicatively coupled to a second transceiver via a bi-directional communication channel. The bi-directional communication channel may be a wireline (or wired) communication channel or a wireless communication channel without departing from the scope and spirit of the invention. The wired media by which the bi-directional communication channel may be implemented are varied, including coaxial cable, fiber-optic cabling, and copper cabling, among other types of "wiring." Similarly, the wireless manners in which the bi-directional communication channel may be implemented are varied, including satellite communication, cellular communication, microwave communication, and radio communication, among other types of wireless communication.

[0120] Each of the transceivers is operable to support attenuated transmission adaptation functionality according to the invention. In addition, each of the transceivers is operable, in certain embodiments, to support transmission instruction functionality such that one of the transceivers is capable to instruct the other transceiver regarding how that transceiver is to change its transmission operating parameters to the other transceiver.

[0121] **FIG. 8C** is a system diagram illustrating an embodiment of a one to many communication system that is built according to the invention. A transmitter is able to communicate, via broadcast in certain embodiments, with a number of receivers, shown as receivers **1**, **2**, . . . , n via a uni-directional communication channel. The uni-directional communication channel may be a wireline (or wired) communication channel or a wireless communication channel without departing from the scope and spirit of the invention. The wired media by which the bi-directional communication channel may be implemented are varied, including coaxial cable, fiber-optic cabling, and copper cabling, among other types of "wiring." Similarly, the wireless manners in which the bi-directional communication channel may be implemented are varied, including satellite communication, cellular communication, microwave communication, and radio communication, among other types of wireless communication.

[0122] A distribution point is employed within the one to many communication system to provide the appropriate communication to the receivers **1**, **2**, . . . , and n. In certain embodiments, the receivers **1**, **2**, . . . , and n each receive the same communication and individually discern which portion of the total communication is intended for themselves.

[0123] The transmitter is operable to support attenuated transmission adaptation functionality according to the invention. In addition, each of the receivers is operable, in certain embodiments, to support transmission instruction functionality such any one or more of the receivers may be capable to instruct the transmitter regarding how that transmitter is to change its transmission operating parameters for future transmissions to the receivers **1**, **2**, . . . and n.

[0124] The **FIG. 8A**, the **FIG. 8B**, and the **FIG. 8C** show yet more embodiments where attenuated transmission adaptation functionality is supported at the transmitter capable end (or ends) of a communication system and transmission instruction functionality may sometimes be supported at the receiver capable end (or ends) of the communication channel.

[0125] **FIG. 9** is a system diagram illustrating an embodiment of a Cable Modem Termination System (CMTS) system that is built according to the invention. The CMTS system includes a CMTS Medium Access Controller (MAC) that operates with a number of other devices to perform communication from one or more CMs to a WAN. The CMTS MAC is operable to support transmission instruction functionality such that is may direct any one or more Cable Modems (CMs) that are located downstream from the CMTS system.

[0126] The CMTS MAC may be viewed as providing the hardware support for MAC-layer per-packet functions including fragmentation, concatenation, and payload header suppression that all are able to offload the processing required by a system central processing unit (CPU). This will provide for higher overall system performance. In addition, the CMTS MAC is able to provide support for carrier class redundancy via timestamp synchronization across a number of receivers, shown as a receiver **1**, receiver **2**, . . . , and a receiver n. Each receiver is operable to receive upstream analog inputs. In certain embodiments, each of the receivers **1**, **2**, . . . , and n is a dual universal advanced TDMA/CDMA (Time Division Multiple Access/Code Division Multiple Access) PHY-layer burst receiver. That is to say, each of the receivers **1**, **2**, . . . , and n includes at least one TDMA receive channel and at least one CDMA receive channel; in this case, each of the receivers **1**, **2**, . . . , and n may be viewed as being multi-channel receivers. In other embodiments, the receivers **1**, **2**, . . . , and n includes only CDMA receive channels.

[0127] In addition, the CMTS MAC may be operated remotely with a routing/classification engine that is located externally to the CMTS MAC for distributed CMTS applications including mini fiber node applications. Moreover, a Serial Peripheral Interface (SPI) master port may be employed to control the interface to the receivers **1**, **2**, . . . , and n as well as to a downstream modulator.

[0128] The CMTS MAC may be viewed as being a highly integrated CMTS MAC integrated circuit (IC) for use within the various DOCSIS and advanced TDMA/CDMA physical layer (PHY-layer) CMTS products. The CMTS MAC employs sophisticated hardware engines for upstream and downstream paths. The upstream processor design is segmented and uses two banks of Synchronous Dynamic Random Access Memory (SDRAM) to minimize latency on internal buses. The two banks of SDRAM used by the upstream processor are shown as upstream SDRAM (operable to support keys and reassembly) and SDRAM (operable to support output queues). The upstream processor performs Data Encryption Standard (DES) decryption, fragment reassembly, de-concatenation, payload packet expansion, packet acceleration, upstream Management Information Base (MIB) statistic gathering, and priority queuing for the resultant packets. Each output queue can be independently configured to output packets to either a Peripheral Component Interconnect (PCI) or a Gigabit Media Independent Interface (GMII). DOCSIS MAC management messages and bandwidth requests are extracted and queued separately from data packets so that they are readily available to the system controller.

[0129] The downstream processor accepts packets from priority queues and performs Payload Header Suppression (PHS), DOCSIS header creation, DES encryption, Cyclic Redundancy Check (CRC) and Header Check Sequence (of the DOCSIS specification), Moving Pictures Experts Group (MPEG) encapsulation and multiplexing, and timestamp generation on the in-band data. The CMTS MAC includes an out-of-band generator and CDMA PHY-layer (and/or TDMA PHY-layer) interface so that it may communicate with a CM device's out-of-band receiver for control of power management functions. The downstream processor will also use SDRAM (operable to support output queues). The CMTS MAC may be configured and managed externally via a PCI interface and a PCI bus.

[0130] The **FIG. 9** shows yet another embodiment where transmission instruction functionality may sometimes be supported at the receiver capable end of the communication channel, specifically at the CMTS end of a cable modem communication system.

[0131] Further shown in **FIG. 9** are a plurality of receivers of the CMTS. As will be described further with reference to **FIG. 19**, during registering and ranging operations of CMs that operate during attenuated transmission conditions, the receivers may be Rake Receivers. As is generally know in other fields of endeavor, e.g., CDMA cellular communications, a Rake Receiver is operable to demodulate a number of multi-path fading components of a received signal, these components separated in time. Each finger of the Rake Receiver locks onto and demodulates one of the multi-path fading components. From a plurality of demodulated multi-path fading components of the received signal, the Rake Receiver may simply select the demodulated signal corresponding to the strongest, e.g., highest SNR, multi-path fading component. Alternately, the Rake Receiver may demodulate a number of multi-path fading components and combine the resultant demodulated signals to produce a composite signal. While these operations are described with reference to **FIG. 19** in regard to registering and ranging operations, the use of a Rake Receiver may be employed whenever attenuated transmission operations exist or simply when a greater throughput is required for given system conditions.

[0132] **FIG. 10A** is a diagram illustrating logical channel partitioning of a portion of spectrum that is performed according to the invention. The attenuated transmission adaptation functionality and methods described herein may also be implemented using logical channel partitioning of a number of available dimensions of a communication channel. The available dimensions may be time, as in a communication system employing Time Division Multiple Access (TDMA), or alternatively, codes, as in a communication system employing Code Division Multiple Access (CDMA), frequency, as in a communication system employing Frequency Division Multiple Access (FDMA), or a combination thereof.

[0133] For example, a communication channel (e.g., a radio frequency spectrum band, or portion thereof) may be partitioned into a number of logical channels. A given logical channel is active for a certain number of frames (e.g., for a predetermined time duration), then another logical channel is active, and so on, one at a time. This is typically referred to as TDMA with respect to the means of sharing the spectrum among logical channels.

[0134] However, the concept of logical channel partitioning may be extended such that logical channels may be implemented as multi-dimensional logical channels. For example, a logical channel may be implemented to exist in 2 dimensions, such as time and code. This is a 2 dimensional logical channel. In this 2 dimensional approach, the given 2 dimensional logical channel would be active during a given set of contiguous frames (or portions of information), and in a certain set of codes. This would permit several logical channels to be active simultaneously, while being separated in code space. Similarly, the multi-dimensional logical channel concept may be extended to cover higher orders of dimensionality. For example, a logical channel may be implemented to exist in 3 dimensions, such as time, code, and frequency. Clearly, this dimensionality may be extended to an n-dimensional logical channel without departing from the scope and spirit of the invention.

[0135] While the **FIG. 10A** shows a communication system employing uni-directional communication between a transmitting device and a receiving device, the invention envisions performing logical channel partitioning within both directions of a bi-directional communication system as well.

[0136] **FIG. 10B** is a diagram illustrating an embodiment of logical channel partitioning of Synchronous Code Division Multiple Access (S-CDMA) codes in a Data Over Cable Service Interface Specification (DOCSIS) system that is performed according to the invention. The **FIG. 10B** shows how the logical channel partitioning may be employed based on the 128 codes that are currently available according to DOCSIS. For example, a logical channel 1 may be comprised of codes 1 through 64 of DOCSIS, and a logical channel 2 may be comprised of codes 65 through 128 of DOCSIS. A third logical channel, logical channel 3, may be comprised of all 128 codes or of logical channels 1 and 2.

[0137] The selection of which 64 DOCSIS codes will be used to comprise the logical channel 1 and which 64 DOCSIS codes will be used to comprise the logical channel 2 may be performed using a CMTS MAC.

[0138] In some embodiments, when a CM isn't in a highly attenuated path (that is, upstream path to the CMTS), then that CM would be able to receive grants on either the full 128 code logical channel (logical channel 3) or either of the 64 code logical channels (logical channels 1 or 2). The 128 code logical channel (logical channel 3) is again equivalent to the combined two logical channels of 64 codes (logical channels 1 or 2).

[0139] It is also noted that the grouping of codes into logical channels need not be performed such that the codes are adjacent to one another. For example, either of the 64 code logical channels (logical channels 1 or 2) may select the 64 channels from among all of the 128 available codes; for example, logical channel 1 may include codes, 1, 3, 4, 6, 10, and so on, including a total number of codes being 64.

[0140] **FIG. 11** is a diagram illustrating an alternative embodiment of logical channel partitioning of S-CDMA codes in a DOCSIS system that is performed according to the invention. Again, the **FIG. 11** shows an embodiment of how channel partitioning may be performed using the 128 codes of a DOCSIS communication system. If a CM is in an attenuated channel situation (between the CM and the CMTS) where it must only transmit on, for example, Npc=8 codes, then the available channel may be divide into a set of logical channels such that at least one (or a combination thereof) of the logical channels will permit transmission using 8 codes.

[0141] As an example, the 128 DOCSIS codes may be partitioned into logical channels as follows: logical channel 1 with Nc1=8 codes, logical channel 2 with Nc2=32 codes, and logical channel 3 with Nc3=88 codes. It is noted that Nc1+Nc2+Nc3=Nac=128 codes, so that all of the active codes (Nac) may be accounted by all of the logical channels.

[0142] In certain embodiments, a given CM may be assigned to one of these logical channels (e.g., logical channel 1), and transmit the reduced number of codes (e.g., 8 codes). Accordingly, with increased power per code (e.g., 8 times more power per code) may also be employed to overcome the attenuated channel. This power adaptation functionality is described in more detail below.

[0143] As an extension of the concept, a CM may be assigned to more than one of the logical channels that comprise codes. For example, a CM may be assigned to logical channels 2 and 3. In this case it would be assigned Nc2+Nc3=120 codes. This provides even more flexibility in assigning numbers of codes per CM. In addition, for a CM whose upstream path to the CMTS does not experience much attenuation, then a 4th logical channel that includes all of these 3 logical channels may be used thereby making all 128 codes available to that CM.

[0144] It is noted that the invention is adaptable to communication systems that employ modulation techniques having orthogonal waveforms. The invention may also be extended to other communication systems that other communication systems that employ a signal space having orthogonal signals contained therein.

[0145] One particular example of a communication system employing orthogonal waveforms includes a communication system employing Synchronous Code Division Multiple Access (S-CDMA) codes. The orthogonal waveforms have the property that multiple waveforms (e.g., codes in DOCSIS 2.0 S-CDMA) can be transmitted simultaneously by a given transmitting device. The total number

of codes that may be is use anywhere on a communication channel are referred herein as the number of active codes (the number of codes in use anywhere on the channel) and they are denoted Nac.

[0146] As also mentioned above with respect to **FIG. 10**, it is also noted that the grouping of codes into logical channels need not be performed such that the codes are adjacent to one another.

[0147] **FIG. 12** is a functional block diagram illustrating an embodiment of power and modulation adaptation functionality that is arranged according to the invention. This figure shows the power and modulation adaptation functionality being supported within a communication system having a transmitting device and a receiving device. However, the functionality described herein may also be implemented within transceiver type devices that also support both receive and transmit functionality.

[0148] The transmitting device is implemented to support attenuated transmission adaptation functionality. The receiving device may be implemented to support transmission instruction functionality. The receiving device may be the source of instructions provides to the transmitting device, the transmitting device may initiate operations according to the attenuated transmission adaptation functionality contained therein, or a combination thereof may be implemented.

[0149] As shown within the power adaptation functional block, a given transmitting device is instructed to reduce the number of codes it can transmit to Npc, or number of permitted codes. Again, the total number of available codes that can be used anywhere on the system is denoted as Nac (total number of active codes). In general Npc<Nac. This reduction in codes to the number of permitted codes, Npc, reduces the available burst throughput of that individual transmitting device by the factor Npc/Nac. Other transmitting devices on the network are permitted to transmit on the remaining codes; this has the benefit that the overall throughput of the communication channel is not affected by the limitation on this individual transmitting device.

[0150] The unused codes (those codes of Nac that are left over after the reduction has been made to Npc, the number of unused codes being Nac-Npc) may be used to perform interference cancellation according to the invention.

[0151] In addition, the transmitting device is also instructed to increase its permitted power per code by the factor Nac/Npc which is substantially the inverse of the factor by which the number of transmitting codes has been reduced. This may even give the transmitting device a higher Signal to Noise Ratio (SNR) at the receiving device by the same factor Nac/Npc. When the transmitting device is using all Npc of its codes, its transmitted power is the same as if it were if permitted to use Nac codes with the original amount of power per code. That is, the decrease in the number of codes transmitted, and the increase in power per code, will substantially cancel one another, and the maximum power transmit capability of the transmitting device will remain unchanged. This has the benefit that the power limitation of the transmitting device is not exceeded, even though the receive SNR is either maintained or increased.

[0152] As shown within modulation adaptation functional block, when the transmitting device is transmitting with this reduced number of permitted codes, the transmitting device may continue to use the same upstream burst profile as before. For example, if a high order modulation density, such as 64 QAM (Quadrature Amplitude Modulation) was used before the instruction to decrease the number of transmitting codes was received, then the same high order modulation density may also be used afterwards as well. This gives a significant benefit, in that, any other transmitting devices on the network are not required to reduce their upstream burst profiles. It gives even another benefit that the total throughput and throughput efficiency on the communication channel may remain unchanged.

[0153] **FIG. 13** is a functional block diagram illustrating an embodiment of ranging and registering functionality that is arranged according to the invention. A transmitting device is operable to support robust mode operation to do ranging and registering using a group of maximally robust burst parameters and the ranging and registering may be performed across a robust logical channel. The maximally robust burst parameters may be achieved using a variety of means, and some possible means are described below.

[0154] A highly robust and low order modulation may be employed to support the robust mode operation. Some examples of highly robust and low order modulation may include BPSK (Binary Phase Shift Keying) modulation, QPSK (Quadrature Phase Shift Keying) and/or QPSK TCM (QPSK Trellis Coded Modulation).

[0155] In addition, the Forward Error Correction (FEC) of the communication system, that is typically performed in a receiving device, may also be controlled using parameters stored within the transmitting device. For example, the transmitting device may provide information to the receiving device that it is to use the maximal setting of any Reed-Solomon error correction capability contained therein.

[0156] Moreover, even other means may be performed by which the robust mode operation may be supported. For example, preamble estimation may be modified by the receiving device as governed by the transmitting device. The transmitting device is able to send ranging bursts to the receiving device. These ranging burst sent by the transmitting device are designed to permit accurate parameter estimation at the receiving device. For example, the transmitting device may send an extended preamble (sometimes referred to as a long preamble), or multiple copies of the preamble, and the receiving device may average or otherwise combine its estimates over the multiple copies of the preamble. The extended preamble/long preamble is longer than a preamble typically employed within the communication system.

[0157] It is noted that a key element here, to support robust mode operation, is that the ranging may take place using a lower order modulation such as QPSK, at a relatively low SNR such as 10 dB, but the parameter estimates are of high enough quality to support eventual transmission at a higher order modulation, such as 16 QAM or 64 QAM, at a higher SNR such as 25 dB. This higher SNR may be achieved, as described above, by increasing the power per code while using fewer codes. In addition, the robust mode operation may perform the parameter estimation, and that parameter estimation may then indicate that a higher order modulation may subsequently be employed. In so, then the transmitting device will operate at that higher order modulation, such as 16 QAM or 64 QAM, among other higher order modulation types.

[0158] Alternatively, power modification functionality may be employed to provide for the robust mode operation. The transmitting device may increase the transmit power where possible given physical amplifier constraints, or the transmitting device may increase the average transmit power via reduction in peak-to-average ratio, among other power modification that may be performed to support the robust mode operation.

[0159] A means is utilized to communicate to the transmitting device that it needs to enter this robust mode. Such a means may include a separate logical channel, and/or a proprietary communications channel via the downstream. In the context of a cable modem communication system, this communication may be achieved using the CM network segment itself.

[0160] It is also noted that when a transmitting device first attempts to enter the network, it may have to follow a logical decision process to determine if it should go into this robust mode. That is to say, the transmitting device may perform an initialization routine, when entering the network, to determine if robust mode operation is even needed at all.

[0161] **FIG. 14A** is a diagram illustrating example upstream burst profiles that may be employed according to the invention. A spectrum of upstream data burst profiles may be used. Generically speaking, a higher order profile and a lower order profile may be used. The higher order profile may be viewed as having a relatively shorter preamble, a relatively higher modulator density, relatively weak Forward Error Correction (FEC), an equalizer tap coefficient set1, a reflection coefficients set1, and other parameters as required or desired. The higher order profile may be viewed as being operable on a channel whose characteristics can support this higher order level of processing. A relatively accurate channel estimation and channel equalization may need to be performed to accommodate upstream data bursting using the higher order profile.

[0162] The lower order profile may be viewed as having a relatively longer preamble (when compared to the shorter preamble of the higher order profile), a relatively lower modulator density (when compared to the higher order modulator density of the higher order profile), relatively powerful FEC (when compared to the weaker FEC of the higher order profile), an equalizer tap coefficient set2, a reflection coefficients set2, and other parameters as required or desired; the parameters of the lower order profile are much more robust than the parameters of the higher order profile. The lower order profile may be viewed as being operable on a channel whose characteristics are unable to support the higher order level of processing within the higher order profile. A relatively accurate channel estimation and channel equalization may not be available or may be unable to be performed to accommodate upstream data bursting using the higher order profile, the invention then provides operation using the lower order profile.

[0163] This figure shows a spectrum of available upstream data burst profiles that may be used according to the invention to perform and continue upstream data bursting from the CMs to the CMTS. Operation at the lower order profile will provide sufficient protection to ensure that the upstream data burst will get through even when the channel may be corrupted. Each of the upstream data burst profiles includes a modulation density. The modulation density may be viewed as being one parameter within an upstream data burst profile. If desired, and as will be shown and described in various embodiments, various profiles may be employed when performing upstream data bursting according to the invention; or alternatively, only various modulation densities may be employed when performing upstream data bursting according to the invention. Clearly, other operational parameters may be used to differentiate and continue upstream data bursting when desiring to operate at a more (or less) robust operational state.

[0164] **FIG. 14B** is a diagram illustrating example modulation densities that may be employed according to the invention. The spectrum of modulation densities involves higher order modulation densities and lower order modulation densities. For example, the spectrum of modulation densities ranges from 1024 QAM (Quadrature Amplitude Modulation), 256 QAM, 64 QAM, 16 QAM, QPSK (Quadrature Phase Shift Keying), and BPSK (Binary Phase Shift Keying). Other modulation schemes could similarly be employed and arranged in an increasing/decreasing order of density without departing from the scope and spirit of the invention. The higher order modulation densities may be viewed as including the 1024 QAM and 256 QAM, and the lower order modulation densities may be viewed as including the 16 QAM, QPSK, and BPSK. In some embodiments, a higher order modulation density may be viewed as including only 16 QAM, and a lower order modulation density may be viewed as including only QPSK. Other intermediate modulation densities may of course be employed, such as 8 QAM, 32 QAM, 128 QAM, etc., or other values or types of modulation.

[0165] The higher order modulation densities may be used within those communication channels (which may be logical channel and/or multi-dimensional logical channels) that have been adequately ranged and registered to support that level of modulation density, and the low order modulation densities may be used within those channels that have not yet been adequately ranged and registered to support higher levels of modulation density. In addition, the low order modulation densities may be used to perform the actual ranging and registering of a CM onto a new channel (such as a logical channel and/or a multi-dimensional logical channel).

[0166] **FIG. 15** is an operational flow diagram illustrating an embodiment of an attenuated transmission adaptation method, employing power and modulation adaptation, that is performed according to the invention. It is noted that the method described herein may operate using an embodiment of the multi-dimensional logical channels described in more detail above.

[0167] As shown in a block **1510**, a given CM is instructed to reduce the number of codes it can transmit to Npc, or number of permitted codes, from the total number of active codes Nac. In general Npc<Nac. This reduces the available burst throughput of that individual CM by the factor Npc/Nac. Any other CMs on the network will be permitted to transmit on the remaining codes; this has the benefit that the overall throughput of the channel is not affected by the limitation on this individual CM.

[0168] If desired in certain embodiments, these now unused codes, codes of Nac that are not included in Npc, may be employed to perform interference cancellation as

shown in a block **1515**. In an alternative embodiment, these unused codes may a sub-set of codes within a logical channel; the logical channel may also be implemented as a multi-dimensional logical channel without departing from the scope and spirit of the invention.

[**0169**] Continuing on with the method, as shown in a block **1520**, the CM is also instructed to increase its permitted power per code by the factor Nac/Npc for the remaining permitted codes, Npc. This may be viewed as increasing the power per code form a 1st power per code to a 2nd power per code. This gives the CM a higher SNR at the CMTS by the same factor Nac/Npc. When the CM is using all Npc of its codes, the total transmitted power of the CM may be maintained the same as if it were if permitted to use Nac codes with the original amount of power per code. That is, the decrease in the number of codes transmitted, and the increase in power per code, will substantially cancel one another, and the maximum power transmitted by the CM is unchanged. This has the benefit that the power limitation of the CM is not exceeded, even though the receive SNR is increased.

[**0170**] Moreover, as shown in a block **1530**, when transmitting with this reduced number of permitted codes, Npc, the CM continues to use the same upstream burst profile as before. For example, even if a higher order modulation density is employed beforehand, such as 64 QAM, then the same higher order modulation density may be employed after reducing the number to transmitting codes from Nac to Npc. This gives a benefit that any other CMs on the cable modem network are not required to reduce their upstream burst profiles. It gives yet another benefit, in that, the total throughput and throughput efficiency on the communication channel may remain unchanged.

[**0171**] **FIG. 16** is an operational flow diagram illustrating an embodiment of an attenuated transmission adaptation method, employing ranging and registering adaptation, that is performed according to the invention.

[**0172**] A CM is given the means to range and register using the maximally robust burst parameters. Such a robust parameter set may include BPSK modulation, or QPSK trellis coded modulation; maximal setting of Reed-Solomon error correction capability; long preamble/extended preamble; increased transmit power where possible given physical amplifier constraints; increased average transmit power via reduction in peak-to-average ratio; etc.

[**0173**] As shown in a block **1610**, a Cable Modem Termination System (CMTS) instructs a CM that it is to register on a separate, robust logical channel. In this embodiment, a means may be utilized to communicate from the CMTS to the CM that it needs to enter this robust mode operation. Such a means may include a separate logical channel, a proprietary communications channel via the downstream, and/or some other communication means. When a CM first attempts to enter the cable modem network, the CM may have to follow a logical decision process to determine if it should go into this robust mode operation. Alternatively, as shown in a block **1615**, the CM itself employs built-in intelligence that is used to initiate a search for a separate, robust logical channel. In yet another embodiment, a combination thereof may be employed where the CM and the CMTS operate cooperatively to search for the separate, robust logical channel.

[**0174**] In whichever embodiment of the blocks **1610** or **1615** is employed, the method continues, as shown in a block **1620**, such that the CM switches to the separate, robust logical channel.

[**0175**] As shown in a block **1630**, ranging bursts sent by the CM are designed to permit accurate parameter estimation at the CMTS. The CMTS then performs parameter estimation of the communication channel using the ranging burst as shown in a block **1632**. In addition, the CM may send an extended preamble, or multiple copies of the preamble, and the CMTS may average its estimates over the multiple copies of the preamble. Specifically, as shown in a block **1635**, multiple copies of a preamble are transmitted from the CM to the CMTS. Then, as shown in a block **1637**, the CMTS performs parameter estimation of the communication channel by averaging over the multiple copies of the preamble that have been transmitted form the CM to the CMTS.

[**0176**] As shown in a block **1640**, the ranging and registering of the CM is completed on the separate, robust logical channel. After the ranging and registering of the CM is completed, then the CMTS instructs the CM to move to a normal logical channel as shown in a block **1650**. This normal logical channel may include a higher order upstream burst profile. Then, as shown in a block **1660**, the CM operates on the normal logical channel, using higher order upstream burst parameters, but with reduced number of permitted codes (Npc) and increased power per code (as described above in greater detail).

[**0177**] Again, it is noted that the ranging may take place using a lower order modulation such as QPSK, at low SNR such as 10 dB, but the parameter estimates are of high enough quality to support eventual transmission at a higher order modulation such as 64 QAM at a higher SNR such as 25 dB. This higher SNR is achieved, as described above, by increasing the power per code while using fewer codes (again, as described above in greater detail).

[**0178**] While the methods shown within the **FIGS. 15 and 16** are described in the context of a communication system having at least one CM and a CMTS, it is understood that the invention envisions that these methods may be performed within any communication system having a transmitting device (shown in these examples as the CM) and a receiving device (shown in these examples as the CMTS).

[**0179**] A specific example is provided to illustrate some of the more general concepts of the invention. This example operates on the framework of a DOCSIS 2.0 S-CDMA system, where Nac=128 active codes. For 64 QAM, a SNR of 25 dB SNR is required at the receiver (e.g., the CMTS). A given CM can output up to 53 dBmV power in S-CDMA mode when transmitting to the CMTS, and up to 58 dBmV in TDMA mode when transmitting to the CMTS.

[**0180**] In this example, the assumption is made that most CMs are communicating with the required 25 dB SNR using 64 QAM. However, a given CM, referred to as CM **1**, may have a greater attenuation due to a poorly planned cable layout in the apartment complex. When transmitting at its maximum power of 53 dBmV with all 128 codes, CM **1** would only produce 15 dB SNR (instead of the desired 25 dB) at the receiver (e.g., the CMTS). Hence it has a disadvantage of 10 dB that must be overcome.

[0181] The CM **1** will then attempt to enter the cable modem network, and the system will find that CM **1** cannot communicate easily. The system determines this fact by failed ranging attempts and/or by other means. The cable headend (e.g., the CMTS) will then instruct CM **1** to register on a separate robust logical channel, or the CM **1** itself has built-in intelligence that causes it to search for a robust logical channel. CM **1** then switches to the robust logical channel, where the upstream ranging is more robust, perhaps due to the fact that preamble lengths are longer, e.g., QPSK TCM is used, 58 dBmV or slightly more is transmitted on QPSK ranging bursts, maximum Reed-Solomon (RS) Forward Error Correction (FEC) parameters are used, etc.

[0182] CM **1** then succeeds in ranging and registering on the separate, robust logical channel. The cable headend (e.g., the CMTS) then instructs CM **1** to move to the normal logical channel and begin communicating in 64 QAM, but with a reduced number of permitted codes: Npc=128/16=8 codes. This causes the power per code to increase by a factor of 16. This gives CM **1** an advantage of 10 log **16**=12 dB, which more than overcomes the disadvantage of 10 dB. Now CM **1** finds that its SNR at the receiver is 25 to 27 dB, which is more than enough to communicate using a modulation density of 64 QAM. The burst throughput of CM **1** is of course limited by a factor of 16, but the overall throughput and throughput efficiency of the channel is unchanged.

[0183] **FIG. 17A**, **FIG. 17B**, **FIG. 18A**, and **FIG. 18B** are operational flow diagrams illustrating embodiments of attenuated transmission adaptation methods that are performed according to the invention. These various attenuated transmission adaptation methods may be viewed as enabling upstream transmission from CMs operating in an S-CDMA mode (or using a similar orthogonal spreading technique such as spread S-TDMA (Synchronous Time Division Multiple Access)=spread single carrier modulation) with limited transmit power in the presence of very large channel attenuation. A variety of different cases are presented to show some of the many different ways in which the invention may be implemented.

[0184] Referring to the **FIG. 17A**, this embodiment operates by reducing the number of simultaneously employed codes (=dimensions). One specific embodiment involves reducing the number of codes to be used from 2N codes to N codes; clearly, other degrees of reduction of used codes may also be performed without departing from the scope and spirit of the invention. In this embodiment, the available total transmit power P is then shared among fewer codes and hence allows for the use of the transmit power P to be larger on a per-code basis. That is to say, each of the used codes then employs a larger portion of the total transmit power P.

[0185] Referring to the **FIG. 17B**, this embodiment operates by maintaining the same number of employed codes (or the same number of dimensions) as is initially employed; this involves no reduction in the number of used codes. For example, all 2N of the codes may be employed in one specific embodiment. Then, the method involves modulating pairs of codes with the same modulation symbol. This may be viewed as performing repetition coding which may also be viewed as a reduction of the modulated signal dimensions. In the receiver, the output signals of the corresponding despreaders are coherently added together. The SNR (Signal to Noise Ratio) of this attenuated transmission adaptation method may be implemented to provide for precisely the same SNR as that provided by the attenuated transmission adaptation method described with respect to the **FIG. 17A**.

[0186] Referring to the **FIG. 18A**, this embodiment also operates by maintaining the same number of employed codes (or the same number of dimensions) as is initially employed; this involves no reduction in the number of used codes. For example, all 2N of the codes may be employed in one specific embodiment.

[0187] However, in this embodiment, the coding is performed using a reduced code rate. In one particular embodiment, this code rate reduction involves using 2N codes and employing a code rate that is ½ when compared to the code rate to the attenuated transmission adaptation methods described with respect to the **FIG. 17A** and the FIG. **17**B. In a simplest case implementation, this embodiment takes the form of uncoded modulation with ½ the number of information bits per symbol. The performance of this attenuated transmission adaptation method embodiment will generally be better than the attenuated transmission adaptation method described with respect to the **FIG. 17B**.

[0188] Referring to the **FIG. 18B**, this embodiment also operates by maintaining the same number of employed codes (or the same number of dimensions) as is initially employed; this involves no reduction in the number of used codes. For example, all 2N of the codes may be employed in one specific embodiment.

[0189] Again, the coding is performed using a reduced code rate. In one particular embodiment, this code rate reduction involves using 2N codes and employing a code rate that is ½ when compared to the code rate to the attenuated transmission adaptation methods described with respect to the **FIG. 17A** and the **FIG. 17B**. However, in this particular embodiment, which may be provide for the best performance according to the invention, is employed to employ all of the 2N codes and also to employ a true code rate R=½ (rate compared to that of the attenuated transmission adaptation methods described with respect to the **FIG. 17A** and the **FIG. 17B**) sequence coding to pick up any additional coding gain over the attenuated transmission adaptation method described with respect to the **FIG. 18A**. For example, a true ½ code rate sequence coding may be employed to pick up additional coding gain when compared to performing uncoded modulation as described with respect to the **FIG. 18A**.

[0190] In general, the various embodiments described with respect to the **FIG. 17A**, **FIG. 17B**, **FIG. 18A**, and **FIG. 18B** may be summarized as follows: unless a reduction of dimensions permits to evade stronger interference in some dimensions than in others, using all available signal dimensions will present an optimum implementation solution according to the invention.

[0191] Moreover, the invention relies on and extends the concept of reducing the number of dimensions that are transmitted in order to gain an advantage over various types of noise. This reduction in transmitted dimensions, coupled with intelligent processing at the receiver, provides an extremely large processing gain. The various embodiments described herein extend this concept to white noise, or equivalently, to increased plant attenuation. From certain perspectives, white noise can be thought of as a limiting case

of colored noise, where the color is white. In the case of white noise, the processing gain may not be as great as for colored noise. However, the advantage (which may be realized as a 3 dB for a reduction in the number of used codes from 128 down to 64 codes, and which may be realized as up to an 18 dB gain for a reduction down to 2 codes, at the expense of throughput) is still worth obtaining in some communication system applications. This may be viewed as being particular useful when constraints exist on the modulation order; this may be viewed as arising in an application where there is a very limited number of burst profiles that are available for use. In addition, the idea of increasing the transmitted power on the active dimensions, to take advantage of the lack of power transmitted on the inactive dimensions may be viewed in this invention as being applied to combat the deleterious effects introduced by white noise within a communication system.

[0192] **FIG. 19** is a system diagram of a cable modem communication system with which registering and ranging operations of the present invention are employed. The cable modem communication system **1900** includes a plurality of cable modems **1904** and **1906** and a headend (CMTS) **1902**. The CMTS **1902** communicatively couples to the plurality CM's **1904** and **1906** via a cable modem network segment **1910**. The CMTS **1902** is operable to segregate the plurality of CM's **1904** and **1906** into at least two CM groups. A first group of CM's **1904** employ standard registering and ranging operations. However, a second group of CM's **1906** operate under attenuated transmission registering and ranging operations according to the present invention. The CM's **1906** of the second group couple to the CM network segment **1910** through attenuated transmission paths **1908**. These attenuated transmission paths **1908** may be caused by problems in connectors, terminators, or other elements that couple the CMs **1906** to the cable modem network segment **1910**. Thus, in one embodiment, the cable modems **1904** of the first group of cable modems are in the first group because they are professionally installed while the cable modems **1906** of the second group of cable modems are within the second group because they are subscriber installed. In another embodiment, the cable modems **1904** of the first group of cable modems are in the first group when ranging measurements fall within a favorable range while the cable modems **1906** of the second group of cable modems are within the second group when ranging measurements fall within an unfavorable range.

[0193] According to operations of the present invention of the cable modem communication system **1900**, each cable modem **1904** of the first group of cable modems is operable to perform registering and ranging operations by transmitting a ranging burst of a first format to the CMTS **1902**. Further, each cable modem **1906** of the second group of cable modems is operable to perform registering and ranging operations by transmitting a ranging burst of a second format to the CMTS that differs from the ranging burst of the first format.

[0194] **FIG. 20A** is a block diagram illustrating a ranging burst of a first format according to the present invention. The ranging burst **2000** of the first format includes the first format preamble **2002**, a first format training sequence **2004**, and a first format data packet **2006**. **FIG. 20B** is a block diagram illustrating a ranging burst of a second format according to the present invention. The ranging burst **2050** of the second format includes a second format preamble **2052**, a second format training sequence **2054**, and a second format data packet **2056**. According to the present invention, during registering and ranging operations of the cable modems **1904** of the first group of cable modems, the ranging burst **2000** of the first format is employed. Further, during registering and ranging operations of the cable modems **1906** of the second group of cable modems, the ranging burst **2050** of the second format is employed. According to the present invention, the ranging burst **2000** of the first format and the ranging burst **2050** of the second format differ such that the ranging burst **2050** of the second format is more robust than the ranging burst **200***o* of the first format. With such additional robustness, the cable modems **1906** of the second group of cable modems may successfully register and range with the CMTS **1902** even with the attenuated transmission conditions. Because the cable modems **1904** of the first group of cable modems have conventional attenuation properties via the cable modem segment **1910** with regards to the CMTS **1902**, the normal ranging burst **2000** of the first format may be employed.

[0195] According to one embodiment of the present invention, the ranging burst of the first format **2000** includes the first format preamble **2002**, the first format training sequence **2004**, and the first format data packet **2006** which includes a plurality of modulated symbols. Further, with this embodiment, the ranging burst **2050** of the second format includes the second format preamble **2052**, the second format training sequence **2054**, and the second format data packet **2056**. However, the second format data packet **2056** includes a plurality of modulated symbols that have been spread by at least one spreading code.

[0196] According to another aspect to the present invention, the structure of the ranging burst **2050** of the first format differs from the ranging burst **2050** of the second format in a manner. With this embodiment, the second format data packet **2056** is encoded using an outer code. This outer code may be the same as or similar to outer codes described with reference to co-pending application Ser. No. 10/175,330 filed Jun. 20, 2002 entitled "System and Method in Computer Program Products for Mitigating Burst Noise of the Communication System" and having attorney docket number BP1958.

[0197] In another embodiment of the present invention, the second format data packet **2056** differs from the first format data packet **2006** in that the second format data packet **2056** includes multiple copies of a data packet while the first format data packet **2006** includes a single copy of the data packet. Such embodiment may result from redundancy code applied to the second format data packet **2056**. Further, in another embodiment the coding employed for the second format data packet may be different from the first format data packet **2006** in that a coding type such as Reed-Solomon SEC and/or Trellis coding is employed for the second format data packet **2056** but not the first format data packet **2006**.

[0198] According to another embodiment to the present invention, the second format data packet **2056** employs a lower modulation order than does the first format data packet **2006**. For example, the first format data packet **2006** may employ a modulation order higher than binary phase shift keying (BPSK) while the second format data packet

2056 employs BPSK modulation. The higher order modulation employed by the first format data packet **2006** may be QPSK, QAM, or another higher order modulation. With the ranging burst of the second format **2050** using a lower modulation order for the second format data packet **2056**, the ranging burst of the second format **2050** is less susceptible to the attenuation.

[**0199**] According to another embodiment to the present invention, the first format data packet **2006** employs a first code rate. Further with this embodiment, the second format data packet **2056** has a second code rate applied thereto that is lower than the first code rate. Such lower coding rate causes the second format data packet **2056** to be less susceptible to the attenuated transmission conditions than is the first format data packet **2006**.

[**0200**] Further, varying power levels may be employed by the cable modems to overcome the attenuation of the transmission path to the CMTS **1902**. In such case, the cable modems **1906** of the first group of cable modems transmit the ranging burst of the second format at a second power level that exceeds the power level employed by the cable modem **1904** of the first group of cable modems for the ranging burst of the first format **2000**. In another embodiment, the duration of the second format data packet **2056** is greater than the duration of the first format data packet **2006** to cause it to be more robust.

[**0201**] In order to allow the cable modems **1906** of the first group of cable modems to better perform their registering ranging operations, the cable modems **1904** of first group of cable modems are operable to transmit the ranging bursts of the first format to the CMTS **1902** during a first contention interval while the cable modems **1906** of the second group of cable modems are operable to transmit the ranging burst of the second format to the CMTS **1902** during a second contention interval. The second contention interval may differ in duration and frequency from the first contention interval to allow the cable modems **1906** of the second group to be better able to range and register with the CMTS **1902**.

[**0202**] **FIG. 21** is a flow chart illustrating operation according to the present invention in registering and ranging Cable Modems (CMs). As shown in **FIG. 21**, a first operation according to the present invention includes identifying a plurality of cable modems **1904** and **1906** serviced by a CMTS **1902** (step **2102**). The CMTS **1902** and/or the CMs **1904** and **1906** then determine which CMs are in the first group of CMs and which CMs are in the second group of CMs (step **2104**). Operation continues by the CMTS **1902** notifying the CMs **1904** of the first group of CMs and the CMs **1906** of the second group of CMs, if required (step **2106**). In one embodiment of the present invention, the CMs are able to determine whether they are in the first group or the second group based upon whether they are professionally installed (first group) or subscriber installed (second group) via plug and play operations, for example. With the CMs themselves determining which group they reside within, the CMTS need not assign the CMs to particular groups. Based upon their assigned group the CMs may select the time interval in which they will perform ranging and registering operations.

[**0203**] Operation continues with the CMTS **1902** receiving ranging bursts from CMs **1904** of the first group of CMs during a first time interval (step **2108**). Then, the CMTS **1902** may optionally enable its rake receiver for subsequent operations with CMs **1906** of the second group of CMs (step **2110**). The CMTS **1902** then receives ranging bursts from the CMs **1906** of the second group during a second time interval (step **2112**). The CMTS **1902** then adjusts ranging information of the plurality of CMs based upon the received ranging bursts (step **2114**).

[**0204**] **FIG. 22** is a flow chart illustrating operation according to the present invention in receiving a ranging burst. The operations of **FIG. 22** are used with respect to the ranging bursts of the first format **2000** and/or the ranging bursts of the second format **2050** of **FIG. 20**. Operation commences where the CMTS **1902** uses the preamble **2002** or **2052** of the ranging burst **2000** or **2050** to detect the presence of the burst (step **2202**). The CMTS **1902** then estimates the gain, timing and carrier phase offsets from the received preamble of the ranging burst **2000** or **2005** (step **2204**). The CMTS **1902** then uses the training sequence **2004** or **2054** to determine its equalizer settings (step **2206**). Then, the CMTS **1902** utilizes the estimates of gain timing carrier phase and channel via the equalizer settings to receive the first format data packet **2006** or second format data packet **2056** of the ranging bursts **2000** or **2050**, respectively (step **2208**).

[**0205**] In view of the above detailed description of the invention and associated drawings, other modifications and variations will now become apparent. It should also be apparent that such other modifications and variations may be effected without departing from the spirit and scope of the invention.

1. A cable modem communication system that supports attenuated transmission adaptation during registering and ranging operations, the system comprising:

a plurality of Cable Modems (CMs);

a Cable Modem Termination System (CMTS) that communicatively couples to the plurality of CMs via a CM network segment and that is operable to segregate the plurality of CMs into at least two CM groups comprising a first group of CMs with which standard registering and ranging operations are performed and a second group of CMs with which attenuated transmission registering and ranging operations are performed;

each CM of the first group of CMs operable to perform registering and ranging operations by transmitting a ranging burst of a first format; and

each CM of the second group of CMs operable to perform registering and ranging operations by transmitting a ranging burst of a second format that differs from the ranging burst of the first format.

2. The cable modem communication system of claim 1, wherein:

the ranging burst of the first format comprises a first format preamble, a first format training sequence, and a first format data packet comprising a plurality of digitally modulated symbols; and

the ranging burst of the second format comprises a second format preamble, a second format training sequence, and a second format data packet comprising a plurality of digitally modulated symbols that have been spread by at least one spreading code.

3. The cable modem communication system of claim 1, wherein the CMTS includes a rake receiver that receives and demodulates a plurality of multi-path copies of the ranging burst of the second format.

4. The cable modem communication system of claim 1, wherein:

the ranging burst of the first format comprises a first format preamble, a first format training sequence, and a first format data packet; and

the ranging burst of the second format comprises a second format preamble, a second format training sequence, and a second format data packet that has been encoded using an outer code.

5. The cable modem communication system of claim 1, wherein:

the ranging burst of the first format comprises a first format preamble, a first format training sequence, and a single copy of first format data packet; and

the ranging burst of the second format comprises a second format preamble, a second format training sequence, and multiple copies of a second format data packet.

6. The cable modem communication system of claim 1, wherein:

the ranging burst of the first format comprises a first format preamble, a first format training sequence, and a first format data packet comprising a plurality of digitally modulated symbols of a first modulation order; and

the ranging burst of the second format comprises a second format preamble, a second format training sequence, and a second format data packet comprising a plurality of digitally modulated symbols of a second modulation order, the second modulation order lower than the first modulation order.

7. The cable modem communication system of claim 6, wherein:

the first modulation order comprises an order higher than Binary Phase Shift Keying (BPSK); and

the second modulation order comprises BPSK.

8. The cable modem communication system of claim 1, wherein:

the ranging burst of the first format comprises a first format preamble, a first format training sequence, and a first format data packet having a first code rate; and

the ranging burst of the second format comprises a second format preamble, a second format training sequence, and a second format data packet having a second code rate that is lower than the first code rate.

9. The cable modem communication system of claim 1, wherein:

the ranging burst of the first format comprises a first format preamble, a first format training sequence, and a first format data packet encoded using first coding characteristics; and

the ranging burst of the second format comprises a second format preamble, a second format training sequence, and a second format data packet encoded using second coding characteristics that are more robust than the first coding characteristics.

10. The cable modem communication system of claim 1, wherein:

the ranging burst of the first format is transmitted at a first power level; and

the ranging burst of the second format is transmitted at a second power level that is greater than the first power level.

11. The cable modem communication system of claim 1, wherein the ranging burst of the first format has a first duration, the ranging burst of the second format has a second duration, and the second duration is greater than the first duration.

12. The cable modem communication system of claim 1, wherein:

the first group of CMs is operable to transmit the ranging bursts of the first format to the CMTS during a first contention interval; and

the second group of CMs is operable to transmit the ranging bursts of the second format to the CMTS during a second contention interval.

13. The cable modem communication system of claim 1, wherein the plurality of CMs and the CMTS are interoperable to determine which CMs form the first group and which CMs form the second group.

14. The cable modem communication system of claim 1, wherein:

a CM is within the first group of CMs when professionally installed; and

a CM is within the second group of CMs when subscriber installed.

15. The cable modem communication system of claim 1, wherein:

a CM is within the first group of CMs when ranging measurements fall within a favorable range; and

a CM is within the second group of CMs when ranging measurements fall within an unfavorable range.

16. A method for operating a cable modem communication system that includes a plurality of Cable Modems (CMs) that communicatively couple to a Cable Modem Termination System (CMTS) via a CM network segment, the method comprising:

segregating the plurality of CMs into at least two CM groups comprising a first group of CMs with which standard registering and ranging operations are performed and a second group of CMs with which attenuated transmission registering and ranging operations are performed;

each CM of the first group of CMs transmitting a ranging burst of a first format to the CMTS; and

each CM of the second group of CMs transmitting a ranging burst of a second format to the CMTS, the ranging burst of the second format differing from the ranging burst of the first format.

17. The method of claim 16, further comprising:

each CM of the first group of CMs forming the ranging burst of the first format with a first format preamble, a first format training sequence, and a first format data packet having a plurality of digitally modulated symbols; and

each CM of the second group of CMs forming the ranging burst of the second format with a second format preamble, a second format training sequence, and a second format data packet having a plurality of digitally modulated symbols that have been spread by at least one spreading code.

18. The method of claim 16, further comprising the CMTS demodulating a plurality of multi-path copies of the ranging burst of the second format using a rake receiver.

19. The method of claim 16, further comprising:

each CM of the first group of CMs forming the ranging burst of the first format with a first format preamble, a first format training sequence, and a first format data packet; and

each CM of the second group of CMs forming the ranging burst of the second format with a second format preamble, a second format training sequence, and a second format data packet that has been encoded using an outer code.

20. The method of claim 16, further comprising:

each CM of the first group of CMs forming the ranging burst of the first format with a first format preamble, a first format training sequence, and a single copy of first format data packet; and

each CM of the second group of CMs forming the ranging burst of the second format with a second format preamble, a second format training sequence, and multiple copies of a second format data packet.

21. The method of claim 16, further comprising:

each CM of the first group of CMs forming the ranging burst of the first format with a first format preamble, a first format training sequence, and a first format data packet having a plurality of digitally modulated symbols of a first modulation order; and

each CM of the second group of CMs forming the ranging burst of the second format with a second format preamble, a second format training sequence, and a second format data packet having a plurality of digitally modulated symbols of a second modulation order, the second modulation order lower than the first modulation order.

22. The method of claim 21, wherein:

the first modulation order comprises an order higher than Binary Phase Shift Keying (BPSK); and

the second modulation order comprises BPSK.

23. The method of claim 16, further comprising:

each CM of the first group of CMs forming the ranging burst of the first format with a first format preamble, a first format training sequence, and a first format data packet having a first code rate; and

each CM of the second group of CMs forming the ranging burst of the second format with a second format preamble, a second format training sequence, and a second format data packet having a second code rate that is lower than the first code rate.

24. The method of claim 16, further comprising:

each CM of the first group of CMs forming the ranging burst of the first format with a first format preamble, a first format training sequence, and a first format data packet encoded using first coding characteristics; and

each CM of the second group of CMs forming the ranging burst of the second format with a second format preamble, a second format training sequence, and a second format data packet encoded using second coding characteristics that are more robust than the first coding characteristics.

25. The method of claim 16, further comprising:

each CM of the first group of CMs transmitting the ranging burst of the first format at a first power level; and

each CM of the second group of CMs transmitting the ranging burst of the second format at a second power level that is less than the first power level.

26. The method of claim 16, further comprising:

each CM of the first group of CMs transmitting the ranging burst of the first format with a first duration; and

each CM of the second group of CMs transmitting the ranging burst of the second format with a second duration, wherein the second duration is greater than the first duration.

27. The method of claim 16, further comprising:

the first group of CMs transmitting the ranging bursts of the first format to the CMTS during a first contention interval; and

the second group of CMs transmitting the ranging bursts of the second format to the CMTS during a second contention interval.

28. The method of claim 16, further comprising the plurality of CMs and the CMTS communicating to determine which CMs form the first group and which CMs form the second group.

29. The method of claim 16, further comprising:

determining that a CM is within the first group of CMs when professionally installed; and

determining that a CM is within the second group of CMs when subscriber installed.

30. The method of claim 16, further comprising:

determining that a CM is within the first group of CMs when ranging measurements fall within a favorable range; and

determining that a CM is within the second group of CMs when ranging measurements fall within an unfavorable range.

31. A method for operating a cable modem communication system that includes a plurality of Cable Modems (CMs) that communicatively couple to a Cable Modem Termination System (CMTS) via a CM network segment, the method comprising:

identifying a CM of the plurality of CMs for with which attenuated transmission registering and ranging operations are required;

the CM forming a ranging burst having a preamble, a training sequence, and a data packet having a plurality of digitally modulated symbols that are spread by at least one spreading code;

the CM transmitting the ranging burst to the CMTS;

the CMTS receiving the ranging burst from the CMTS; and

the CMTS determining ranging information based upon the ranging burst.

32. The method of claim 31, further comprising the CMTS demodulating a plurality of multi-path copies of the ranging burst using a rake receiver.

33. A method for operating a cable modem communication system that includes a plurality of Cable Modems (CMs) that communicatively couple to a Cable Modem Termination System (CMTS) via a CM network segment, the method comprising:

identifying a CM of the plurality of CMs for with which attenuated transmission registering and ranging operations are required;

the CM forming a ranging burst having a preamble, a training sequence, and a data packet that has been encoded using an outer code;

the CM transmitting the ranging burst to the CMTS;

the CMTS receiving the ranging burst from the CMTS; and

the CMTS determining ranging information based upon the ranging burst.

34. A method for operating a cable modem communication system that includes a plurality of Cable Modems (CMs) that communicatively couple to a Cable Modem Termination System (CMTS) via a CM network segment, the method comprising:

identifying a CM of the plurality of CMs for with which attenuated transmission registering and ranging operations are required;

the CM forming a ranging burst having a preamble, a training sequence, and multiple copies of a data packet;

the CM transmitting the ranging burst to the CMTS;

the CMTS receiving the ranging burst from the CMTS; and

the CMTS determining ranging information based upon the ranging burst.

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