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TITLE: PROPOSED TECHNIQUES FOR G.HS

ABSTRACT

Several techniques for G.hs are proposed based on the premise: Automatic detection and disclosure of line conditions and equipment configurations (splitters, provisioning, etc.) is equally important as the modulation capabilities exchange during the handshake period for modems that contain one or more xDSL and/or voiceband modulations. The main proposal is a "line probing"-like procedure, termed "Channel Audit" occurring simultaneously with a traditional modulation based capabilities negotiation. Quick analysis of the Channel Audit would be used near the end of the capabilities exchange to influence which type of xDSL techniques could be support on the loop.

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1. Introduction

ITU-T SG15 Q4 is proposing a new Recommendation G.hs that would be used as a startup procedure (similar to V.8) for all of the various xDSL Recommendations (G.lite, G.dmt, G.hdsl, T1.413, etc.). The Terms of Reference for G.hs have not been completed yet, but some general consensus has already emerged. This document offers several proposed techniques to be used in G.hs. The main premise of the various proposals is: Automatic detection and disclosure of line conditions and equipment configurations (splitters, provisioning, etc.) is equally important as the modulation capabilities exchange during the handshake period for modems that contain one or more xDSL and/or voiceband modulations. The background of that premise is presented in detail in Section 2. Some requirements (for the Terms of Reference) are outlined in Section 3.Explanation of the proposed techniques is given in Section 4.

2. Background

Under the recent legal and technical situation, the possible configuration combinations at each end of a local loop has grown exponentially. The US Telecommunication Act of 1996 opens the vast infrastructure of metallic wires to competitive usage besides the incumbent telephone provider who installed the wires. Thus, multiple providers may have differing responsibilities and equipment deployed for a single wire pair. Further, many various incompatible communication technologies have been developed and introduced to communicate over those wires. These technologies can provide high speed communication in addition to the traditional 0 through 4kHz bandlimited spectrum used for telephony. Finally, a wide range of physical limitations of the various configurations of the wires leads to widely varying expectations of feasible communication capability bandwidth. There is a need for data communication equipment/modems to automatically select and initiate operation under a wide range of unknown channel and equipment conditions.

In a given central office termination, a given local loop may be provisioned for voiceband-only, ISDN, or one of the many new or proposed xDSL (ADSL, VDSL, HDSL, SDSL, etc.) services. Since the 1970's, telephone service users (customers) have enjoyed a wide range of freedom for placing communication customer premise equipment (telephones, answering machines, modems, etc.) on voiceband channels. On the other hand, the customer premise equipment (CPE) for leased data circuits has typically been furnished by the service provider. As the communication market continues to evolve, customers will also expect and demand much freedom in selecting and providing their own CPE for high speed circuits using the band above the traditional voice band. This will place pressure on service providers to be prepared for a wide range of equipment to be unexpectedly connected to a given local loop. Further, the premise wiring condition/configuration inside of the customer premise (e.g. home, office, etc.) and the range of devices already attached to nodes in the wiring are varied and unspecifiable. For a service provider to dispatch a technician or craftsman to analyze premise wiring or make an installation represents a large cost. An efficient and inexpensive (i.e., non-human intervention) method is needed to smoothly provide the initialization of circuits in the current situation of a plethora of communication methods and configuration methods.

Methods of provisioning a given communication channel include installation of various communication terminals capable of a single or multiple communication methods. Also, switching equipment may exist between the communication channel termination and the actual communication device. That switching equipment may attempt to direct a given line to a given type of communication device. Further, provisioning may include the installation of filters including low pass filters, high pass filters and combinations of filters that are sometimes referred to as "splitters". The filters are used to split or separate the frequency spectrum of a given communication channel so that more than one communication method can be used. Recently there has been technology and market motivation to eliminate or reduce the use of those filters. Thus for a given communication channel, the presence and type of filters is often unknown. There is a need for the communication devices to know the existence and configuration of filters before initiating a communication method as it impacts which methods are viable or not.

In the past, the ITU-T has recommended methods for initiating data communication over voice band channels. Specifically, two Recommendations were produced: 1) Recommendation V.8 (09/94) - *Procedures for starting sessions of data transmission over the general switched telephone network*; and 2) Recommendation V.8 bis (08/96) - *Procedures for the identification and selection of common modes of operation between data circuit-terminating equipments (DCEs) and between data terminal equipments (DTEs) over the general switched telephone network*. Both of these Recommendations use a sequence of bits transmitted from each terminal to determine common operating modes in both terminals. These Recommendations only work in the voice band (0-4kHz) and do not test nor disclose any information concerning the operating conditions of the communication channel between the devices.

Voice band line probing techniques are well known in the art. They have been used effectively to optimize a given modulation method. In a set of devices with multiple modulation methods, V.8 or V.8bis has been used to select a particular modulation and once that modulation initiation sequence has started, line probing techniques were used to receive some indication of the condition of the communication channel. If it was later determined that a given communication channel could not effectively support a chosen modulation method, time consuming heuristic fallback techniques were employed to try and find a modulation method that worked. What is needed is a method to observe the line conditions before attempting to select the most appropriate communication method.

3. Proposals for Required Functionality in G.hs

The overall purpose of the proposed techniques is to audit the condition of the communication channel and the capabilities of the communication equipment/systems and then mutually disclose that information through negotiation so as to use the most appropriate digital communication method. To accomplish this grand goal, G.hs should employ several individual techniques as a system. Individual techniques include:

3.1. Modulation Capabilities Exchange

A method to negotiate between modems that embody a multiple of communication methods so as to decide upon a single common method to be used for the subsequent communication method. Recommendation V.8 is good example and basis for this requirement.

3.2. Channel Capabilities Probe and Exchange

A method for determining the general characteristics of the communication channel between a central and remote communication system. Specifically, such impairments as frequency roll-off and noise can be identified and disclosed between the central and remote systems. Knowledge of the communication channel conditions during G.hs allows the modems to make a better informed decision concerning the choice of the subsequent communication method. For example: use ADSL instead of VDSL because the line is severely attenuated above 2 MHz.. The information gained here is not sufficient enough to replace the probing and channel analysis built-in to a given xDSL technique, but it should allow a multi-xDSL capable modem to intelligently select which xDSL to begin negotiating.

3.3. *Splitter Probe*

A method to determine the presence of equipment used to split frequency bands. Although there is ongoing work to define standard splitters with remotely detectable signatures, there exists and will exist many different types and characteristics of splitters. Since the voiceband may be in use during G.hs, the method for detecting splitters should be as non-intrusive on the voiceband as possible. Presence or lack of frequency splitting filters may necessitate the use of different communication methods. For example: use G.lite (splitterless ADSL) instead of ADSL because a splitter is not installed.

3.4. *Voiceband Fallback*

A method to fallback to traditional voiceband communication methods (i.e. V.8) if an initiator determines that high speed band communication is not possible due to equipment or channel conditions. In this case, the PSTN based modem would essentially be working on Leased Lines. A savvy service provider could use a voiceband modulation to automatically receive a remote user's request for an xDSL service and do an online exchange of signup information for converting that line to be xDSL-provisioned in the near future.

3.5. *Simultaneous User Data Channel*

As discussed in other contributions, a method for end-to-end user communication via a user clear channel without having to wait for the completion of the xDSL startup procedures. Until now, communications systems required a lengthy training or startup time before any end-to-end data could be communicated. It is proposed that a user communication path be available simultaneously with negotiation of the channel and communication method. Further, the user data and the negotiation data should be implemented on separate channels so that transmission contention does not occur.

3.6. *Fallback for pre-G.hs xTU*

Although it is recommended for optimum negotiation that both the central and remote modems implement G.hs, a particular point of G.hs should be that if only one side implements G.hs, or if one side only partially implements G.hs, such configuration would be accurately reported to the communication systems and the communication systems can fallback to legacy communication methods if they are supported.

3.7. *Modularity*

In a communication system, the G.hs functionality may not be embodied in the xTUs themselves. G.hs functionality may be implemented in intelligent switches that terminate and segment the local loop. A central office may be using several types of devices/modems that would need to be correctly assigned (perhaps on a "as needed" basis) through explicit negotiation of the capabilities and desires of the central and remote communication systems. (See Fig 1.)

3.8. *External Controllability*

System designers, installers, and providers should be able to set various parameters that are considered by the G.hs modems during the negotiation process to effectively define the meaning of "most appropriate means of communication".

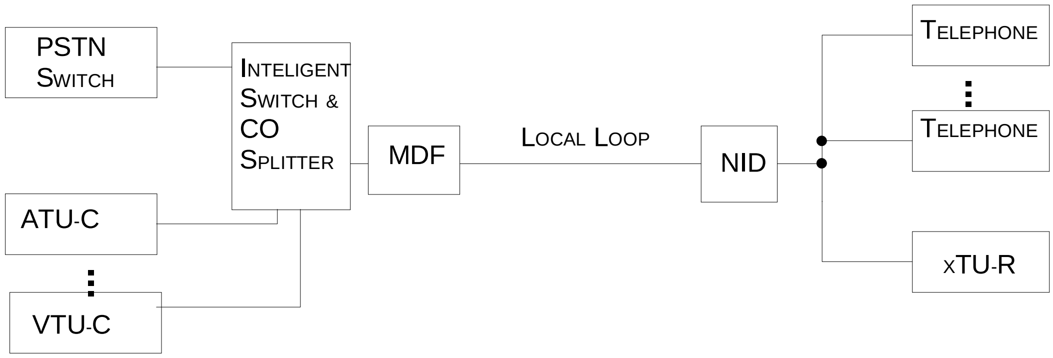
PSTN
SWITCH
INTELIGENT
SWITCH &
CO
SPLITTER
ATU-C
VTU-C
MDF
LOCAL LOOP
NID
TELEPHONE
TELEPHONE
xTU-R

FIG. 1

4. Proposed System

Based upon the above requirements, we propose the following system.

4.1. Description of Frequency Bands

Communication exchange between the xTU-C and xTU-R systems during the handshake would utilize frequency division multiplex (FDM) for the various communication channels as illustrated in Fig. 2.

4.1.1. Voice Band

For voiceband (roughly 0-4 kHz), pseudo-random noise signals would be sent from the xTU-R. The pseudo-random noise signals would serve two purposes: 1) splitter detection and 2) to determine if voice band fallback is feasible. The information content of those pseudo-random noise signals would indicate if the xTU-R supported G.hs and/or V.8. Only of few bits of information are needed, so the sequence can be repeated several times. The spectrum and power level of the signal should be such that it does not detrimentally interfere with voiceband communications and is not readily identifiable by humans.

4.1.2. xDSL Bands

The rest of the communication uses the frequency spectrum above 4 kHz. Typically, the first frequency for allowable transmission power occurs around 25 kHz. Note that on loops that are also provisioned with ISDN in addition to xDSL that frequency may be much higher. Another frequency of particular note is 34.5 kHz as tone bursts at that frequency are used to initiate T1E1 T1.413 ADSL modems (R-ACT-REQ), That frequency should be avoided in the spectrum used by precursor negotiation methods.

Fig. 2 shows approximate bounds on communication channels between the xTU-C and xTU-R during the proposed negotiation method. The communication channels are defined in pairs, one for upstream communication from the xTU-R to the xTU-C, and the other for downstream communication from the xTU-C to the xTU-R. A pair of channels, termed the negotiation channel, is for use by the xTU-C and xTU-R to negotiate their capabilities and decisions. Another pair, termed the User Channel, is a clear channel for use by the DTE equipment connected to the xTU-C and xTU-R. FSK modulation with bit rates of approximately 10k bit/sec is proposed for each of these channels.

The Channel Audit Tones frequencies begin above the negotiation and user channels. There are two sets of tones. The lower set is the basic set of tones with frequencies to around 1 or 2 MHz. These frequencies would be used to test the line conditions for G.lite or ADSL type modems and are referred to as the Basic Channel Audit Tones. The upper set of tones is optional and specifiable. If the xTU-C indicates that it supports xDSL line codes with bandwidths greater than the basic channel audit set (such as VDSL), it would request that the optional tones be sent and specify the cutoff frequency.

4.2. Operation

The operation of the Audit of Channel and Equipment (ACE) is depicted in Fig. 3. The steps of the method, shown in Fig. 3, will now be described in more detail. The xTU-R starts the ACE process by transmitting a pseudo-random noise signal in the voiceband and a pilot tone at the “mark” frequency of the negation upstream FSK channel. Depending on the configuration of the Central Office side, the “xTU-C” monitors for the upstream pilot tone and for the pseudo random noise signal.

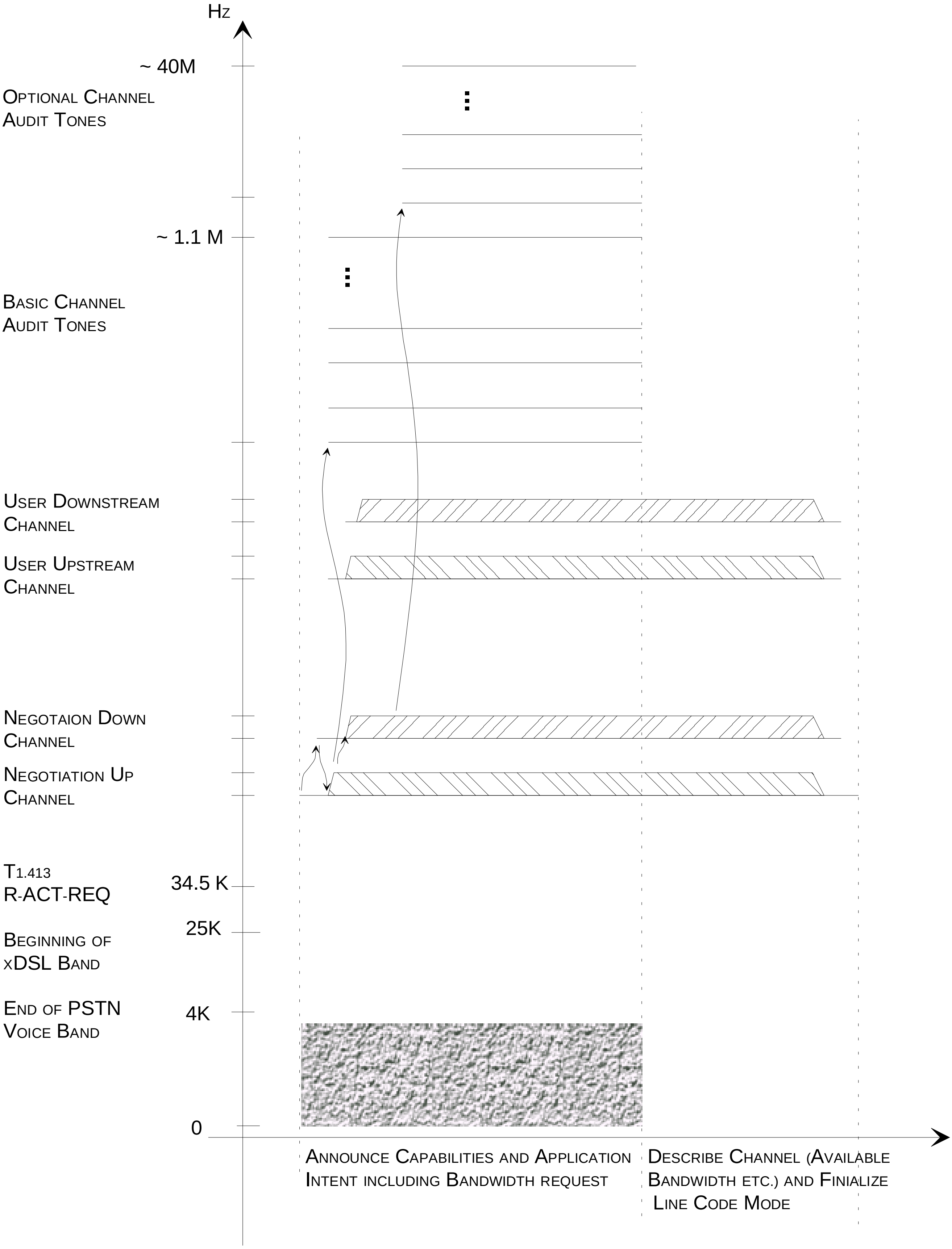
Hz
~ 40M
Optional Channel Audit Tones
~ 1.1 M
Basic Channel Audit Tones
User Downstream Channel
User Upstream Channel
Negotaion Down Channel
Negotiation Up Channel
T1.413 R-ACT-REQ
34.5 K
Beginning of xDSL Band
25K
End of PSTN Voice Band
4K
0
Announce Capabilities and Application Intent including Bandwidth request
Describe Channel (Available Bandwidth etc.) and Finialize Line Code Mode

Fig. 2

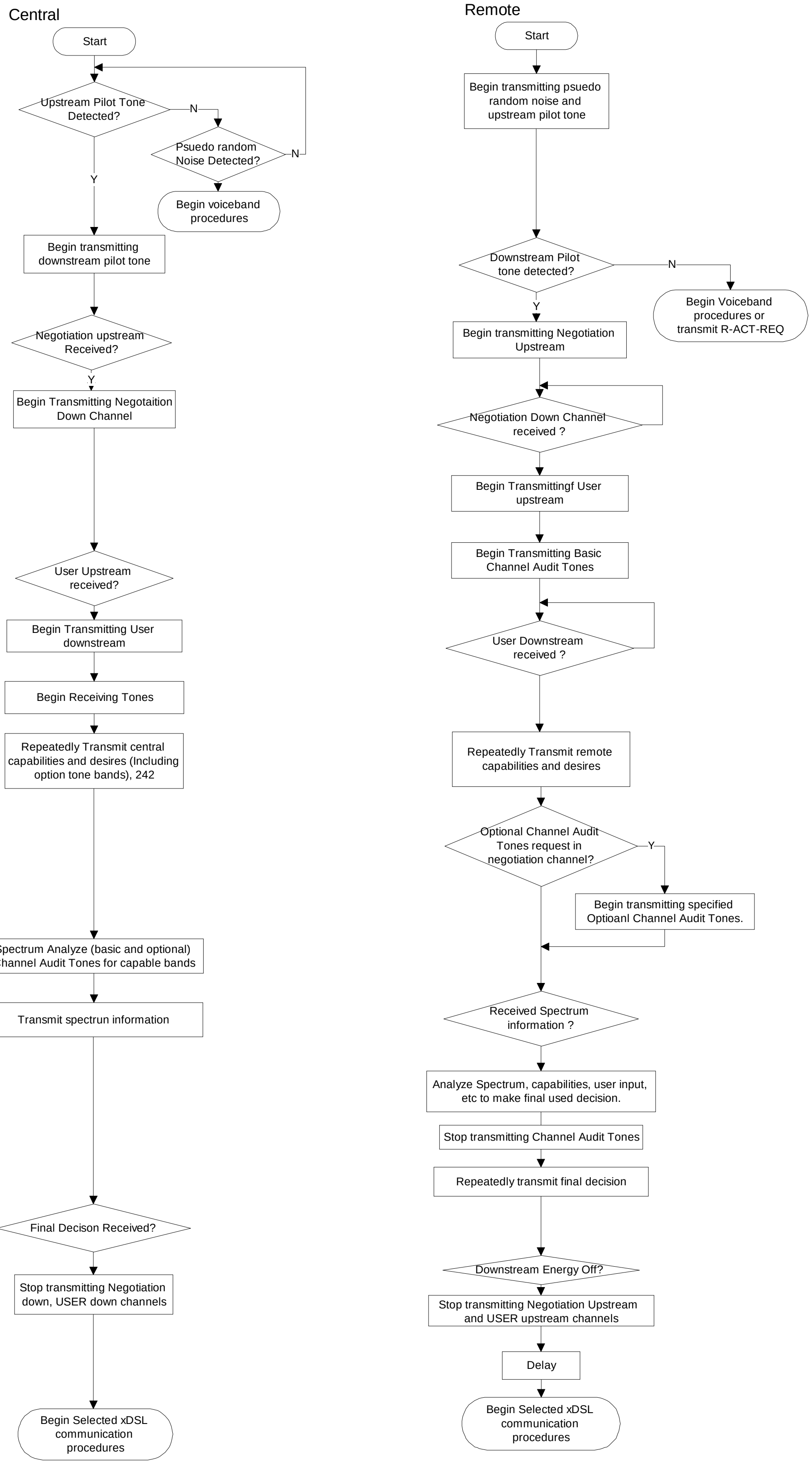
Central
Start
Upstream Pilot Tone Detected?
N
Psuedo random Noise Detected?
N
Begin voiceband procedures
Y
Begin transmitting downstream pilot tone
Negotiation upstream Received?
Y
Begin Transmitting Negotaition Down Channel
User Upstream received?
Begin Transmitting User downstream
Begin Receiving Tones
Repeatedly Transmit central capabilities and desires (Including option tone bands), 242
Spectrum Analyze (basic and optional) Channel Audit Tones for capable bands
Transmit spectrun information
Final Decison Received?
Stop transmitting Negotiation down, USER down channels
Begin Selected xDSL communication procedures
Remote
Start
Begin transmitting psuedo random noise and upstream pilot tone
Downstream Pilot tone detected?
N
Begin Voiceband procedures or transmit R-ACT-REQ
Y
Begin transmitting Negotiation Upstream
Negotiation Down Channel received ?
Begin Transmittingf User upstream
Begin Transmitting Basic Channel Audit Tones
User Downstream received ?
Repeatedly Transmit remote capabilities and desires
Optional Channel Audit Tones request in negotiation channel?
Y
Begin transmitting specified Optioanl Channel Audit Tones.
Received Spectrum information ?
Analyze Spectrum, capabilities, user input, etc to make final used decision.
Stop transmitting Channel Audit Tones
Repeatedly transmit final decision
Downstream Energy Off?
Stop transmitting Negotiation Upstream and USER upstream channels
Delay
Begin Selected xDSL communication procedures

FIG. 3

After the xTU-C detects the upstream pilot tone, it begins transmitting the downstream pilot tone at the “mark” frequency of the negotiation downstream channel. After the xTU-R detects the downstream pilot tone, it begins transmission of the negotiation upstream data channel modulation. Once the xTU-C has detected valid data (for example HDLC flags) from the xTU-R, it begins transmitting the negotiation down stream channel modulation. Once the xTU-R has detected valid negotiation downstream data, it begins transmission of the user upstream data channel and the Basic Channel Audit Tones. Once the xTU-C has detected valid user upstream data, it begins transmitting the user down stream channel. The xTU-C also begins receiving the Basic Channel Audit Tones.

The xTU-R begins repeatedly transmitting its communication method capabilities and it’s preferred communication methods using the negotiation upstream channel. The format of the data is similar to V.8 or V.8bis. At the same time, the xTU-C begins transmitting its communication method capabilities and it’s requests concerning the desired Optional Channel Audit Tones to be transmitted by the xTU-R. Once the xTU-R has received the desired optional tone information, it immediately begins transmitting those upper tones. After the xTU-C has received the Channel Audit Tones long enough to compute the spectrum information, it begins transmitting the spectrum information via the negotiation down stream channel.

Regarding the selection of the direction of Channel Audit transmission, two assumptions were made: performing a duplex Channel Audit would be an overkill since the transmission paths are identical in both directions and the Channel Audit information only needs to be accurate within a few dB. Obviously, if those assumptions are incorrect, a duplex Channel Audit technique could be defined in a very similar manner to the (above) half duplex method.

After the xTU-R has received the spectrum information, it begins to analyze the equipment capabilities, the application desires, and the channel limitations to make a final decision on the communication method. The xTU-R stops transmitting all of the Channel Audit Tones. It then begins to repeatedly transmit the final decision using the negotiation upstream channel. After the xTU-C has received the final decision, it stops transmitting the negotiation down stream data and user down stream data. Once the xTU-R has detected the loss of energy (carrier) from the xTU-C, it stops transmitting the negotiation and user upstream data channels. After a short delay, the negotiated communication method (xDSL) can begin it’s initialization procedures.

4.2.1. Fallback and Error Recovery Modes

If the xTU-C is unable to detect the xTU-R upstream pilot tone (due to equipment configuration), but it did receive the pseudo-random noise signal, it could choose to initiate a voiceband fallback communication mechanism. One possibility would be the transmission of ANSam to begin Recommendation V.8 procedures.

If the xTU-R is unable to detect the xTU-C downstream pilot tone, it can begin T1.413 procedures by transmitting R-ACT-REQ. Alternatively, the xTU-R could begin voiceband procedures or some other procedures defined by the user.

Obviously, error recovery procedures would also need to be defined.

5. Conclusion

We ask that the functionality requirements described in this contribution be included in the G.hs Terms of Reference and that techniques described herein to be considered for inclusion in G.hs.