International Telecommunication Union

ITU-T   Technical Paper

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

(3 July 2015)

TPLS.G-HN
Operation of G.hn technology over access and in-premises phone line medium

International Telecommunication Union

Summary

This technical paper describes typical network architectures, parameters, and implementation issues regarding broadband applications that use ITU-T G.9960/G.9961 transceivers (called here *"G.996x transceivers"*). G.996x devices are designed to be capable of operating over different types of physical media, using different bandplans (frequency ranges), and different sets of PHY and MAC parameters. Each of these applications has specific characteristics that may require optimized settings (configuration options) to be used. Additionally, implementations themselves need to consider various aspects of the applications, which are described in detail in this document.

This document is not an ITU-T Recommendation, but rather a tutorial that provides guidance for the user and describes how to configure ITU-T G.996x home networking systems to operate in the context of applications that require operating over various phone lines with potentially high level of crosstalk, such as phone line cables within private apartment buildings, connecting GAM equipment in the basement with GNT equipment in the individual apartments.

This technical paper does not intend to describe ITU-T G.9960/G.9961 as an alternative to Recommendations ITU-T G.9700/G.9701. Unlike the G.9700/G.9701 (also known as ITU-T G.fast), which is intended for high data rate application in the access network, ITU-T G.9960/G.9961 does not support vectoring and hence does not support peak data rates on the various phone lines in the same bundle simultaneously. Data rates will be limited due to crosstalk caused by simultaneous transmission over various phone lines.

As VDSL2, G.fast and G.hn share partially or totally the same bandwidth, the use of G.hn technology over the phone line medium can generate crosstalk that may impact the performances (data rate or Quality of Service) of VDSL2 and G.fast systems.

Change Log

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1   Scope

The scope of this document is the use of G.996x transceivers over phone line infrastructure in the presence of neighbouring domains, and is intended to provide guidance to system vendors and service providers to define, configure, deploy, and network various devices using G.996x transceivers in this type of environment.

This technical paper does not intend to describe G.9960/G.9961 as an alternative to the ITU-T Recommendations G.9700/G.9701. Unlike the G.9700/G.9701 (also known as G.fast), which is intended for high data rate application in the access network, G.9960/G.9961 does not support vectoring and hence does not support data rates comparable to vectored systems on the various phone lines in the same bundle simultaneously. Data rates will be limited due to crosstalk caused by simultaneous transmission over various phone lines. This paper assumes a management system based on G.9962, which is not compatible with standardized broadband access-section management (e.g., G.997.1 and G.997.2). Furthermore, this technical paper does not address topics such as QoS or does not provide a solution for scaling of transmit power as a function of user data rate.

The G.996x family of Recommendations includes G.9960, G.9961, G.9962, G.9963, G.9970, and G.9972 (optional), and is referred to herein as G.996x.

2   References

[ITU G.9960]	Recommendation ITU-T G.9960 (2011), *Unified high-speed wire-line based home networking transceivers – System architecture and physical layer specification*.
[ITU G.9961]	Recommendation ITU-T G.9961 (2010), *Unified high-speed wire-line based home networking transceivers – Data link layer specification*.
[ITU G.9962]	Recommendation ITU-T G.9962 (2014), *Unified high-speed wire-line based home networking transceivers – management specification*.
[BBF TR-069]	CPE WAN Management Protocol, Broadband Forum.

3 Definitions and acronyms

3.1 Definitions

Term	Definition
Device	Any type of system used for an application using a networking transceiver.
End Point	G.hn End Point (EP) as defined in G.9960 Reference Model
G.hn device	A device using a G.996x transceiver.
G.hn domain	A G.996x network comprised of a domain master and its registered nodes.
G.hn network	In the scope of this Technical Paper, a group of interconnected G.hn domains
Coordinated G.hn network	In the scope of this Technical Paper, a group of interconnected G.hn domains that are time-coordinated in order to minimize the crosstalk between each other.
Domain Master	G.hn Domain Master (DM) as defined in G.9960 Reference Model
G.hn transceiver	A node in a G.996x domain that conforms with G.996x family of recommendations
GAM	G.hn Aggregation Multiplexed. In this Technical paper it represents the device that implements DM and GDM functionalities as defined in G.9960 architecture. The GAM usually includes an additional switching function to connect it to a broadband backbone.
GAM manager	In the scope of this Technical paper, entity that implements the Global Master functionality of a G.hn Network as defined in G.9962
GNT	G.hn Network Termination. In this Technical paper it represents the device that implements EP functionalities as defined in G.9960 architecture
Node	A network element or member; specifically, in the context of this Technical Paper, a G.hn transceiver.

3.2 Acronyms

AKM	Authentication and Key Management
BAT	Bit Allocation Table
BB	Broadband
BLER	Block Error Rate
CGN	Coordinated G.hn Network
DLL	Data Link Layer
DM	Domain Master
DOD	Domain Identifier
DS	Downstream
EP	End Point
FAST	Fast Access to Subscriber Terminals
FEXT	Far End Crosstalk
GAM	G.hn Aggregation Multiplexer
GN	G.hn Network
GM	Global Master
GNT	G.hn Network Terminal
GW	Gateway
HN	Home Network
IH	In-Home (regarding location of a domain)
LAN	Local Area Network
LFSR	Linear Feedback Shift Register
MAC	Medium Access Control
MAP	Medium Access Plan
MAP-A	Active Medium Access Plan
MAP-D	Default Medium Access Plan
MDU	Multi-Dwelling Unit
NEXT	Near End Crosstalk

OFDM	Orthogonal Frequency Division Multiplexing
OSI	Open Systems Interconnection (network communications reference model)
PHY	Physical Layer
PON	Passive Optical Network
PSD	Power Spectral Density
QoS	Quality of Service
SC	Security controller
SNR	Signal to Noise Ratio
TDD	Time Division Duplexing
TDMA	Time Division Multiple Access
US	Upstream
VDSL2	Very high bit-rate Digital Subscriber Line

4   Introduction

This Technical Paper describes how to apply coordination techniques that facilitate the establishment of broadband applications over phone line networks in presence of high level of crosstalk (presence of neighbouring domains, in the G.hn terminology) using G.hn transceivers. These coordination techniques are accommodated through the G.hn network architecture.

G.hn Recommendation defines a communication protocol for phone line medium that enables data rates up to 1 Gbps for in-premises networks. Based on a Time Division Multiple Access (TDMA) architecture and using spectrum up to 100 MHz OFDM, G.hn enables operation on various types of environments. This Technical Paper shows how to take advantage of the different mechanisms offered by the technology to allow multiple pairs of G.hn transceivers to operate in a Time Division Duplexing (TDD) context over neighbour phone lines (in-premises or access) while minimizing the loss of performance due to crosstalk from other G.hn systems.

Readers of this Technical paper should take the following points into consideration:
- The ITU-T has defined Recommendations G.9701/G.9700 (G.fast) and Recommendation G.993.2/G.993.5/G.998.4 (Vectored VDSL2) that are intended specifically to establish high-speed transmission over twisted pairs in the access network, including MDUs. Vectoring, defined in G.9701 & G.993.5, that cancels the Self-FEXT, results in optimum system performance for G.fast & VDSL2.

- G.hn is an ITU-T Recommendation targeting in-home networking (point-to-multipoint) applications. G.hn transceivers can be configured to operate in a coordinated manner to enable multi-line point-to-point transmission in Multi-Dwelling Unit (MDU) cable distribution network. However, G.hn does not use vectoring to cancel Self-crosstalk, and so system performance is limited, particularly on quad cables, and on topologies with distributed loop lengths due to the near-far Self-FEXT effect, i.e. FEXT from short lines onto longer lines.

- It should be noted that coexistence between G.hn and VDSL2 in the same cable in the access environment may require frequency separation to avoid interference between them. Frequency separation may lead to performance degradation if the G.hn operates only in the higher part of the spectrum where the crosstalk is stronger.

- Since G.hn and G.fast use the same spectrum, due to high Self-FEXT particularly at higher frequencies, use of these technologies in the same access environment should be avoided.

5   Brief introduction to G.hn

5.1   Generic network architecture

A G.hn domain may be established over any type of wiring (power lines, coaxial cables, phone lines and Plastic Optical Fiber). For distribution of broadband services in Multi-dwelling Units (MDUs) phone line is a convenient option because it is widely available.

Each G.hn domain may include up to 250 G.hn nodes, one of which is designated as domain master (DM), which coordinates operation of all nodes in the domain. All other nodes in the domain are called "end-point nodes" (EP) or simply "nodes". The DM is responsible for assigning a schedule that meets the traffic constraints of the EPs and uses in the most efficient way the available channel resources.

A G.hn network is composed of multiple domains. The Global Master (GM) function provides coordination of resources, priorities, and operational characteristics between neighbour domains of a G.hn network. The GM is a high-level management function that communicates with the management entities of the DMs and that may also convey the relevant inter-domain coordination functions.

Generic architecture of a G.hn network is presented in Figure 5-1.
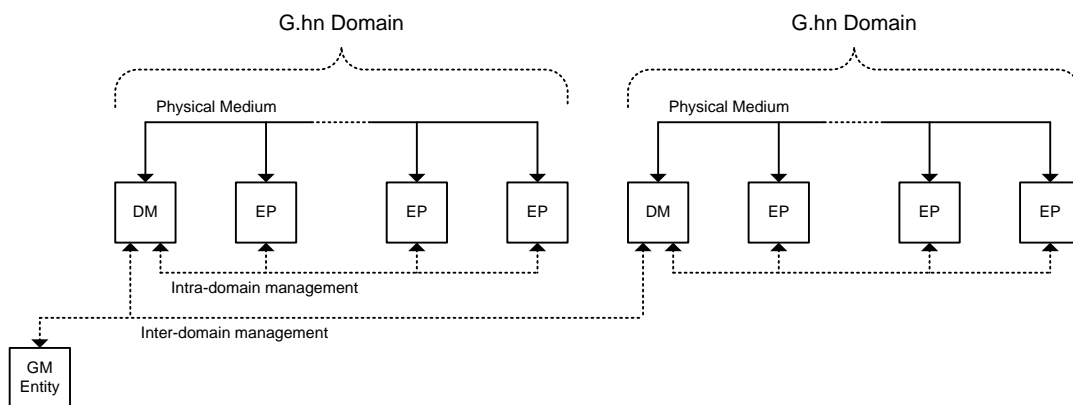
Figure 5-1 - Generic architecture of G.hn network

G.hn domains can support flexible topologies. Depending on the application, G.hn domains may include many nodes (in a point to multipoint configuration) or just two nodes (in a point to point configuration). The only constraint is that one of the nodes needs to be a DM.

6   Use of G.hn in broadband applications over phone lines

6.1   G.hn-based system over phone lines

G.hn over phone line is optimized for the deployment of in-home network over a single phone line. However, G.hn includes techniques of crosstalk avoidance and mitigation between home networks located over different phone lines. Those techniques can be reused in order to use G.hn technology for the delivery of broadband services to individual homes or apartments In most cases, multiple phone lines are installed near each other, often in the same bundle. While operation of G.hn over phone lines has been defined in existing ITU-T G.996x Recommendations, no specific guidance is provided on those Recommendations about what is the optimal configuration required to allow operation in cases in where multiple phone lines are located in close proximity to each other.

When multiple G.hn domains are operating over separate phone lines that are part of the same bundle, each domain may suffer from interference created by any other nearby domain. This Technical Paper shows how to use the different mechanisms offered by the G.hn family of Recommendations to allow multiple point to point systems based on G.hn to operate simultaneously over phone line media as neighbouring domains.

6.2   G.hn domains in presence of crosstalk

The G.hn Recommendation describes a multi-node domain with multiple devices that share a channel. A domain is controlled by a single node called Domain Master (DM). The DM is in charge of coordinating the transmissions of all the nodes in the network (scheduling) to avoid collisions in the channel and guarantee a required level of quality of service (QoS) to the traffic conveyed in the domain. Each node can communicate with any of the other nodes of the domain (multi-point to multi-point communications).

Even though G.hn supports multi-point to multi-point topologies, the architecture of broadband delivery systems over phone lines is often point to point: It is based on a pair of nodes that communicate with each other, with one of the nodes at the customer premises, while the other node is located at the Service Provider network.

This Technical Paper uses specific terminology to describe this type of architecture. In this document, the G.hn device installed at the user side is called a "G.hn Network Terminal" (GNT), while the G.hn device connected to the broadband backbone is called a GAM (G.hn Aggregation Multiplexer). The GAM may include multiple G.hn transceivers, each one connected to a separate phone line, serving a different subscriber.

A common situation is that the phone lines run partially in parallel with each other (for example if they are part of the same bundle (e.g. distribution from a single optical termination) with the potential to interfere with each other. In G.hn, these types of domains are considered a type of neighbouring domains and are characterized by the (potentially) strong crosstalk levels between them.

Typically, this crosstalk is composed of two different contributions:

- **NEXT** (near end crosstalk): interference from a node located in the GAM to another node located in the same GAM (or a neighbour GAM) or from a node located at the GNT to another node located at a neighbour GNT.
- **FEXT** (far end crosstalk): interference from a node located in the GAM to nodes located at the GNTs of other lines, or the other way around (interference from one node located in a GNT to the nodes of other domains located in the GAM)
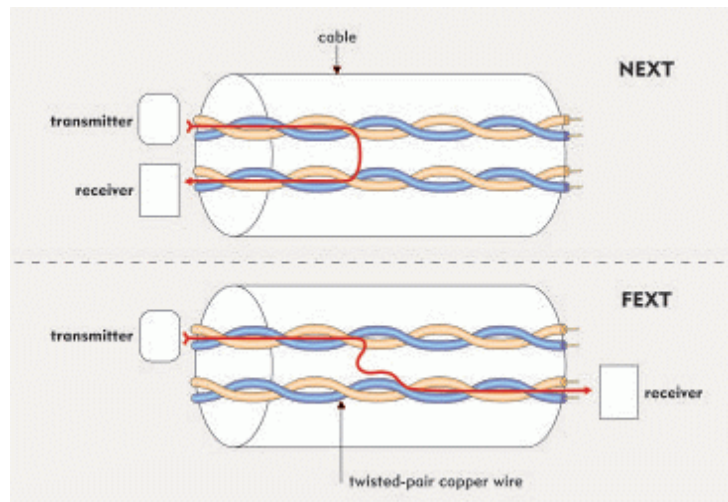
Figure 6-1: FEXT/NEXT interference. Left side represents the GAM. Right side represents the GNT

G.hn nodes can cope with these two sources of crosstalk, by imposing the following constrains to the G.hn domains in the network:

- Each point to point connection between the GAM and each of the GNTs is established by creating a G.hn domain composed of two nodes.
- The combination of the individual G.hn domains forms the Coordinated G.hn Network.
- The nodes located in the GAM are configured as G.hn Domain Master
- Each domain has a different DomainId
- Each domain uses a different preamble seed to achieve near-orthogonal preamble signals. This allows nodes of a domain to decode only the frames belonging to nodes of the same domain.
- DS/US transmissions within the different domains are synchronized by the alignment of the scheduling of each of the domains in the G.hn Network in order to eliminate NEXT.
- Bit-loading and Forward Error Correction are dynamically optimized to operate under the noise created by FEXT

The following clause describes with further details the previous points.

6.3   Coordinated G.hn Network architecture
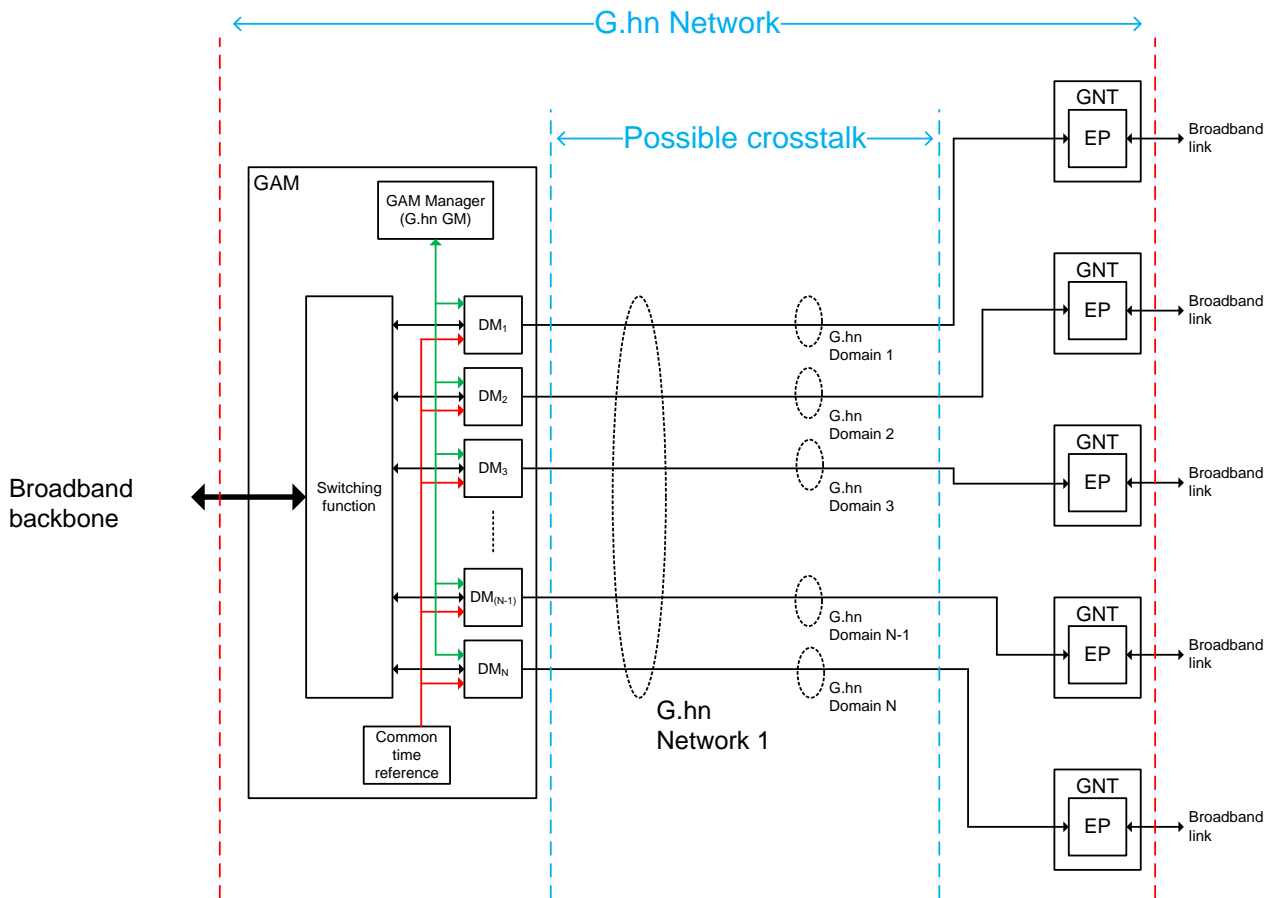
Figure 6-2: Coordinated G.hn Network architecture

NOTE – The terminology used in the previous diagram is defined in clause 3 of this document.

6.3.1   Coordinated G.hn Network

A Coordinated G.hn Network (GN) is defined as multiple G.hn domains that coordinate their transmissions in order to minimize interference between them. Figure 6-2 presents an example of such network.

The Coordinated G.hn Network includes a G.hn Aggregation Multiplexer (GAM) that makes the interface between the backbone broadband link and multiple G.hn Network Terminal devices (GNT).

In some cases, the GAM function is physically split across multiple devices. For example, a GAM with 48 DM entities may be physically built with two physical devices that have 24 DMs each. Both physical devices need to have a common clock to ensure the 48 domains have the proper coordination.

6.3.2 G.hn Domains

Each domain composing a Coordinated G.hn network operates quasi-independently but is managed and/or controlled by a GAM manager that implements the G.hn Global Master (GM) functionality.

Each domain is be composed of two G.hn nodes:
- A DM, which is always located in the GAM. The A-interface (see clause 5.2.1 of [ITU-T G.9960]) of this node is connected to the GAM switching function. The physical interface of the device is connected to the phone line port of the G.hn device.
- An EP, which is always located in the GNT. The A-interface of this node is connected to a broadband link (for example, a Gigabit Ethernet port), usually connected to a LAN. The physical interface of the device is connected to the phone line port of the G.hn device.

6.3.3 Bandplans

All the nodes belonging to a G.hn domain that is part of a Coordinated G.hn Network need to comply with one of the G.hn bandplans defined for telephone baseband medium (50 MHz or 100 MHz) (see [ITU-T G.9961])

6.3.4 GAM Manager (GM)

The GAM Manager ensures the Global Master functionality of the Coordinated G.hn Network (see [ITU-T G.9962]) by controlling the behaviour of the different DM management entities (DME) of each of the G.hn domains composing the network.

The GAM Manager is responsible for guaranteeing the correct configuration of the different DMs in order to bring the overall G.hn coordinated network to a state where the effects of the self-crosstalk are stable.

The functions of the GAM Manager are:

- Configure the appropriate seeds for PROBE frame transmission in each domain (see clause 6.4.2).
- Configure the appropriate seed for Unloaded supported sub-carriers LFSR generator seeds in each domain (see clause 6.4.4)
- Guarantee coherence of scheduling in each of the domains (see clause 6.5.1.2)

The GAM manager may be either a physical entity, a function running on one of the DMs of the GAM or a distributed entity between the DMs of the GAM.

6.3.5 Synchronization of domains

The different domains that compose a Coordinated G.hn network are synchronized by using an external common clock reference. For this, each of the DMs is synchronized to the same external source (see clause 8.6.3 of [ITU-T G.9961]) generated by the GAM.

In order to guarantee that every DM chooses the same MAC Cycle Start time, the parameter NUM_SYNC_PERIODS of the G.hn DM is fixed to 1 and EXT_SYNC_ACCURACY of the G.hn DM is fixed to 2 µs

The MAC cycle length is flexible within the boundaries specified by G.hn family of Recommendations (see CYCLE_MIN and CYCLE_MAX parameters in clause 8.4 of [ITU-T G.9961]), but a value of 40 ms is typically used.

NOTE – This 40 ms value is convenient since many of G.hn systems typically use a MAC cycle linked to the AC power line frequency (50 Hz or 60 Hz). The value of 40 ms for the MAC cycle corresponds to an AC power line frequency of 50 Hz

If the GAM function is split across multiple physical devices, they need to include a mechanism to ensure that the same clock signal is used across all devices.

6.4   PHY layer

6.4.1   Introduction

Several mechanisms are used within a Coordinated G.hn Network in order to minimize the effect of FEXT (Far End Cross Talk). If these mechanisms are not used FEXT could impact each G.hn domains in different way:

- **Detection of frames from neighbour domains**: The DM from a G.hn domain might detect the preamble of an upstream frame coming from the EP of a different domain of the Coordinated G.hn network. In order to prevent this issue, each domain uses a different seed to generate near-orthogonal preambles between frames of different domains(see clause 6.4.2). Through the use of this "orthogonal preambles" mechanism, the DM of each domain will only decode the frames transmitted by the EP of its domain.
- **Instability of SNR measurements**: G.hn uses a channel estimation process (see clause 8.11 of [ITU-T G.9961] to detect the changes in line conditions, measure the characteristics of the line and dynamically adapt the number of bits per sub-carrier to use (bit allocation table - BAT) to ensure that the performance is optimized. This channel estimation process depends on having relatively stable SNR measurement. Since the transmissions from another domain of the Coordinate G.hn network are considered as noise, the SNR results will be different depending on the transmission status of the other lines. To avoid this problem the Coordinated G.hn network needs to ensure that every node transmits during the allocated time slots (see 6.5.1.2). Whenever the node has no data to transmit, Probe frames are sent (see clause 6.4.3).
- **Wrong channel estimation results**: G.hn systems may use Probe frames in order to estimate the channel characteristics. The Coordinated G.hn network needs to ensure that the Probe transmissions from each domain are different in order to avoid the coherent addition of contributions that may lead to a wrong SNR measurement. For this, per domain LFSR seeds are used (see clause 6.4.4).

### 6.4.2   Use of orthogonal preambles

In order to avoid wrong detection of frames, the Coordinated G.hn Network makes use of the orthogonal preamble technique to generate the preambles of the frames, as described in [ITU-T G.9960]. The objective is that the frames from other domains that are interfering a given G.hn domain are not decoded and are treated as noise.

To achieve this, each G.hn domain of a Coordinated G.hn Network uses a different orthogonal preamble. Nodes of a G.hn domain will only decode the frames with the preamble corresponding to its domain. In order to generate the preamble signal, the DM chooses a domain-specific seed taken from the pool of allowed initialization seed values for preambles for the chosen DomainID assigned to that domain (DOD) (see clause 7.2.2.2.3 of [ITU-T G.9961]).

The GAM Manager of the Coordinated G.hn Network guarantees that the seeds used in the Coordinated G.hn Network generate preambles that are orthogonal to each other.

6.4.3 Probe frame transmission

G.hn systems assess the channel characteristics through the process of channel estimation (see clause 8.11 of [ITU-T G.9961]). During this process, a node (node A) may use PROBE frames transmitted by another node (node B) in order to measure the channel characteristics and calculate the Bit Allocation table (BAT) to be used by node B when transmitting to node A as shown in Figure 6-3.
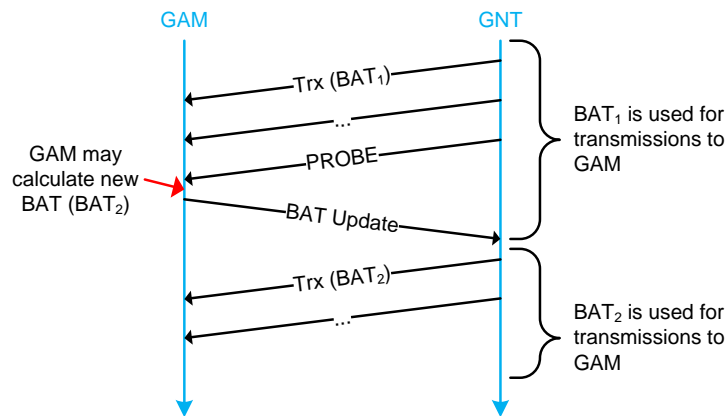

Figure 6-3: Channel estimation process

NOTE – Previous figure is a simplified vision of the process. An in-depth description of the protocol may be found in clause 8.11 of [ITU-T G.9961]

G.hn systems used in an access context, need to ensure that the BAT used during transmissions has been calculated during the same crosstalk conditions than when the BAT was originally calculated; if the SNR during data transmissions is lower than the SNR during BAT estimation, the BLER (block error rate) will be too high.

In order to guarantee this behavior and maintain the channel as stable as possible, the transmissions have to be continuous when a node is not in power down. Therefore, G.hn nodes transmit PHY frames even when there is no data available for transmission.

For this, G.hn transceivers need to use "PROBE PHY frames" (see clause 7.1.3.6 of [ITU-T G.9961]). When a device has a time slot assigned for transmission and it has no data to transmit, it programs a Probe frame transmission so that the adjacent links suffer a stable level of interference (see Figure 6-4). In this way, receivers SNR estimation is more accurate (and independent on the amount of traffic on neighbour lines), thus diminishing errors, latency and jitter.
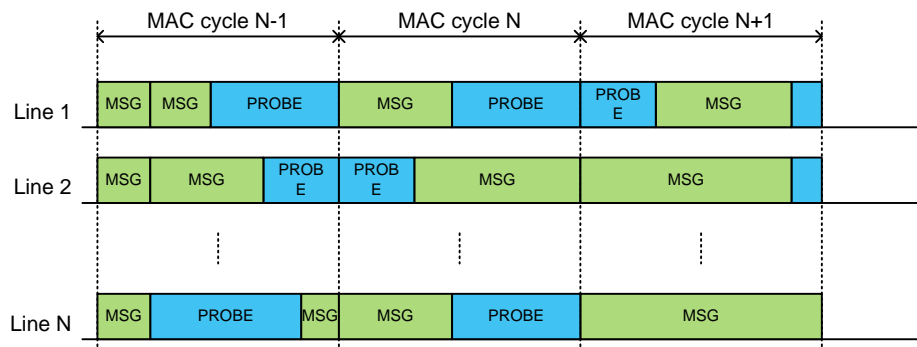
Figure 6-4: Usage of PROBE frames when a node has no data to transmit

NOTE – Figure 6-4 represents a simplified version of the scheduling applied to the domains during several MAC cycles. This simplified version does not include the MAPs that need to be transmitted in every MAC cycle.

6.4.4 Unloaded supported sub-carriers LFSR generator seeds

In a Probe frame, sub-carriers are loaded with bits coming from a linear feedback shift register (LFSR) whose initial seed (for the first sub-carrier of the first symbol of the payload) is as defined in clause 7.1.4.2.6 of [ITU-T G.9960]. If all nodes used the default see, they would generate Probe frames with the same bit sequence modulated in the sub-carriers of the same payload symbols.

This default behavior would have a negative side effect in this application because several nodes might be transmitting synchronized Probe frames with the same contents. In this case, the interference coming from other lines (domains) might add-up coherently producing a higher (or lower if the interference is destructive) level of interference compared with the case of uncorrelated transmissions (normal case when transmitting data when signals add-up non-coherently), preventing an accurate SNR estimation.

For this, each G.hn domain of a Coordinated G.hn Network will use different unloaded supported sub-carriers LFSR generator seed, taken from the pool of allowed seeds assigned to that domain (see clause 7.1.4.2.6 of [ITU-T G.9961]

The GAM manager ensures that the seed used for a particular domain in the network is unique.

6.5 DLL layer

6.5.1 Introduction

Several mechanisms are used within a Coordinated G.hn Network in order to avoid the effect of NEXT (Near End Cross Talk):

- **MAC cycle synchronization**. NEXT interference effect can be mitigated by synchronizing transmissions between the different domains in the Coordinated G.hn Network. However, this is only possible if the position of the MAC cycle start is the same in each of them. Clause 6.5.1.1 describes how to achieve this synchronization in G.hn
- Common **DS/US scheduling**: The DS/US transmissions in the Coordinated G.hn Network need to be synchronized in order to guarantee the isolation between lines. For this, the scheduling in G.hn Networks follows additional rules as explained in clause 6.5.1.2.
- **Selective acknowledgements**: In order to guarantee the homogeneity of the DS/US transmissions, only delayed Acknowledgements are used in the Coordinated G.hn Network, as described in clause 6.5.1.3.

6.5.1.1 MAC cycle synchronization

Since the different domains share a common clock reference (see clause 6.3.5) from the same external source the MAC cycle duration and position is synchronized between the different domains of the Coordinated G.hn Network.

6.5.1.2 DS/US Scheduling

In a Coordinated G.hn Network system the DS/US transmission schedule are the same for all G.hn domains composing the network. For this, the schedule broadcasted in each domain's MAP (see clause 8.2 of [ITU-T G.9961]) are divided in upstream and downstream slots as shown in Figure 6-5.

> NOTE – MAP-D includes all the information required for registration (seeds to be used, value of some given parameters, capabilities of the network). It is sent from time to time (vendor discretionary). MAP-A includes scheduling information of the next MAC cycle. In this way, scheduling information can vary from cycle to cycle.
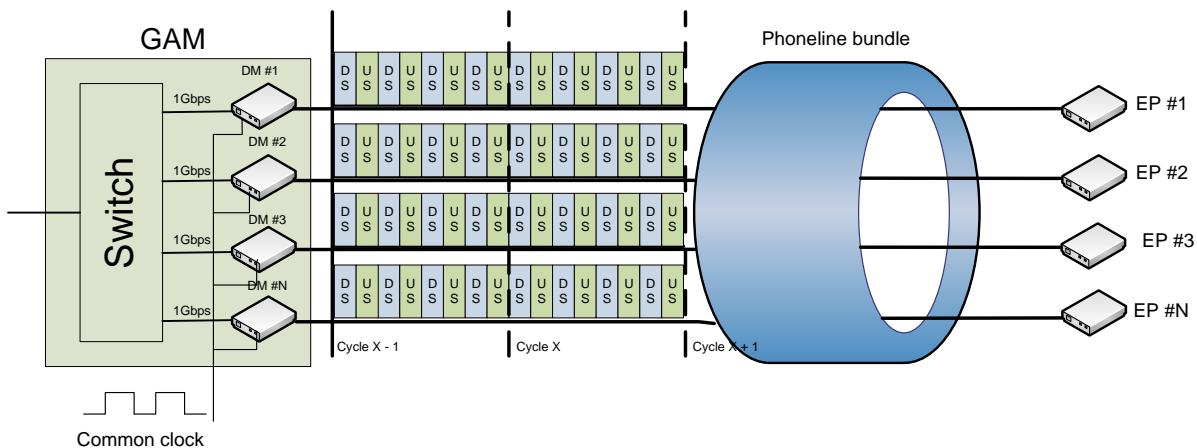

Figure 6-5: DS/US scheduling

For this, the MAP-As (see clause 8.8.1 of [ITU-T G.9961]) of the different domains composing the network allocate transmission opportunities for downstream followed by upstream transmission opportunities. The GAM Manager ensures that the scheduling is common for all the G.hn domains of the Coordinated G.hn Network, including the exact start and stop time of each DS or US slot.

When setting up the domains, the DM of each G.hn domain of the Coordinated G.hn Network allocate a registration opportunity at the beginning of an upstream slot in order to let the GNT register with the domain.

A typical example of a possible distribution of DS/US slots is shown in Figure 6-6 using the following parameters:
- MAC cycle length: 40 ms
- MAC cycle divided in 8 regions
- 50/50 ratio: 50% of the time allocated to downstream direction – 50% of the time allocated to upstream direction
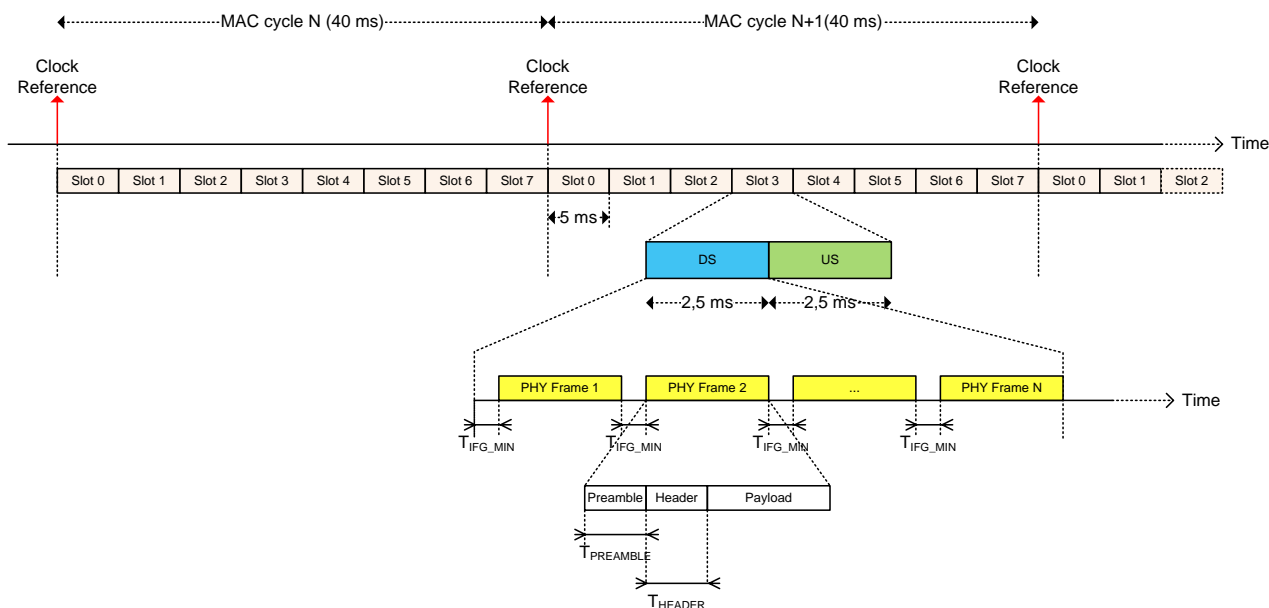
Figure 6-6: Example of G.hn framing in an access system

In this example, the MAC cycle is divided in 8 slots, each one of them divided in two parts or sub-slots (DS and US). Each of the DS or US sub-slots contains one or more G.hn PHY frames with the format as specified in clause 7.1.2.1 of [ITU-T G.9960] (e.g. MAP, MSG, ACK or PROBE frames) separated by T_{IFG} (see clause 8.4 of [ITU-T G.9961]), covering the whole sub-slot allocated time.

The description of a PHY frame can be found in clause 7.1.4.5.3.3 of [ITU-T G-9960]. The following table provides a brief overview of the timings described in G.hn Recommendations:

Table 6-1 – Timing information of G.hn PHY frames

Parameter	Description	Value
T_{IFG_MIN}	Duration of inter frame gap	55 μs
f_{OFDM}	Symbol rate	48.828125 kHz
T_{SYMBOL}	Duration of a symbol	20,48 μs
$T_{PREAMBLE}$	Duration of the preamble (1,25 symbols)	25.6 μs
T_{HEADER}	Duration of the header (1 symbol)	20.48 μs

In order to satisfy G.996x recommendation, one of the DS slots contains a MAP structure describing the schedule of the next MAC cycles.

6.5.1.3 Selective Acknowledgements

G.hn provides two possible ways to acknowledge a received frame (delayed acknowledgement and immediate acknowledgement). In order to maintain DS/US synchronization of the different interfering lines, only delayed acknowledgement mechanism is used in this kind of systems (see clause 8.9.1.2 of [ITU-T G.9961).

The delayed acknowledgement is used in both downstream and upstream direction. It is up to the nodes in both sides of the link to decide when an acknowledgement is needed and how it is sent.

However, the next figure shows a possible acknowledgement scheme, using the example provided in clause 6.5.1.2.
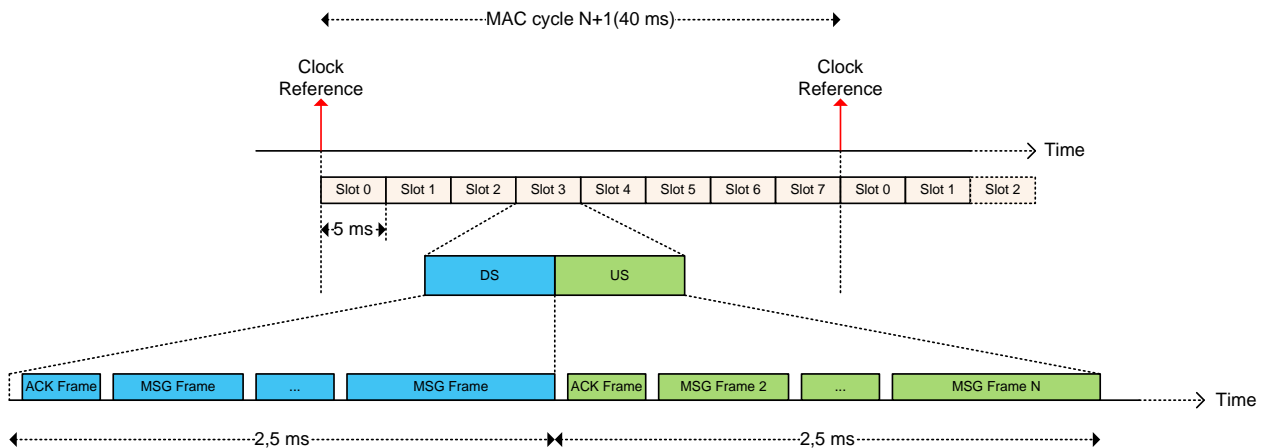
Figure 6-7: Example of acknowledgement scheme using delayed acknowledgements

In this example, every DS or US frame requests a delayed acknowledgement; the nodes in both sides of the communication link schedule an ACK PHY frame at the beginning of each sub-slot in order to acknowledge all the frames received during the previous sub-slot (corresponding to the opposite direction).

NOTE – The ACK frame does not need to be the first frame in the time slot.

7   Network initialization

Domain initialization of a Coordinated G.hn Network is the same as for any other G.hn domain (see clause 8.6.1 of [ITU-T G.9961]. The DM located in the GAM of the domain will:

- Send periodically a MAP-D (see clause 8.8.1 of [ITU-T G.9961]) frame (during a downstream time slot) in order to announce the registering parameters to the GNT. This MAP-D includes all the information for registration and all the parameters needed to establish a connection.
- Assign a registration opportunity in the upstream time slot in order to allow the EP node to register into the domain.

The MAP-D frame will, at least, contain the following auxiliary information fields:

- Domain Information auxiliary information sub-field (see 8.8.5.2 of [ITU-T G.9961])
- PSD-related domain Info auxiliary information field (see clause 8.8.5.5 of [ITU-T G.9961]
- Additional Domain Information auxiliary information sub-subfield (see clause 8.8.5 of [ITU-T G.9961]), containing the seeds to be used in the domain

8   Network management

The GAMs and GNTs of Coordinated G.hn networks are managed through the use of standardized protocols such as [BBF TR-069] using the G.hn data model defined in clause 7.7 of [ITU-T G.9962]

9   Summary

This document described the use of G.996x transceivers over phone line infrastructure in a neighbouring domains architecture as guidance to system vendors and service providers to define, configure, deploy, and network various devices using G.996x transceivers in this type of deployments.

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