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SERIES G: TRANSMISSION SYSTEMS AND MEDIA,
DIGITAL SYSTEMS AND NETWORKS

Access networks – In premises networks

Mitigation of interference between DSL and PLC **Corrigendum 1**

Recommendation ITU-T G.9977 (2016) –
Corrigendum 1

TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

For further details, please refer to the list of ITU-T Recommendations.

Recommendation ITU-T G.9977

Mitigation of interference between DSL and PLC

Corrigendum 1

Summary

Recommendation ITU-T G.9977 specifies functionality of a mechanism to mitigate interference caused by in-home powerline communication (PLC) devices to an x-type digital subscriber line (xDSL) network termination (implementing transceivers in compliance with ITU-T Recommendations such as ITU-T G.993.2 and ITU-T G.9701). This Recommendation addresses various in-home network types and wiring topologies.

Corrigendum 1 fixes a few errors and inconsistencies.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
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* To access the Recommendation, type the URL <http://handle.itu.int/> in the address field of your web browser, followed by the Recommendation's unique ID. For example, <http://handle.itu.int/11.1002/1000/11830-en>.

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Recommendation ITU-T G.9977

Mitigation of interference between DSL and PLC

Corrigendum 1

Editorial note: This is a complete-text publication. Modifications introduced by this corrigendum are shown in revision marks relative to Recommendation ITU-T G.9977 (2016).

1 Scope

This Recommendation specifies functionality of a mechanism to mitigate interference caused by in-home powerline communication (PLC) devices to an x-type digital subscriber line (xDSL) network termination (implementing transceivers in compliance with ITU-T Recommendations such as [\[ITU-T G.993.2\]](#) and [\[ITU-T G.9701\]](#)). This Recommendation addresses various in-home network types and wiring topologies.

The coordination of both the xDSL access network and in-home PLC network is facilitated by an arbitration function (AF), in order to reduce interference and optimize the performance of both networks and meet the throughput requirements to the end customer across both networks, by appropriately configuring relevant parameters of PLC devices and xDSL network termination (NT) based on a coordination policy that is usually determined and provided by the operator.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

- [\[ITU-T G.993.2\]](#) Recommendation ITU-T G.993.2 (2015), *Very high speed digital subscriber line transceivers 2 (VDSL2)*.
- [\[ITU-T G.994.1\]](#) Recommendation ITU-T G.994.1 (2012), *Handshake procedures for digital subscriber line transceivers*.
- [\[ITU-T G.997.1\]](#) Recommendation ITU-T G.997.1 (2012), *Physical layer management for digital subscriber line transceivers*.
- [\[ITU-T G.997.2\]](#) Recommendation ITU-T G.997.2 (2015), *Physical layer management for G.fast transceivers*.
- [\[ITU-T G.998.4\]](#) Recommendation ITU-T G.998.4 (2015), *Improved impulse noise protection for digital subscriber line (DSL) transceivers*.
- [\[ITU-T G.9701\]](#) Recommendation ITU-T G.9701 (2014), *Fast access to subscriber terminals (G.fast) – Physical layer specification*.
- [\[ITU-T G.9961\]](#) Recommendation ITU-T G.9961 (2015), *Unified high-speed wireline-based home networking transceivers – Data link layer specification*.
- [\[ITU-T G.9962\]](#) Recommendation ITU-T G.9962 (2014), *Unified high-speed wire-line based home networking transceivers – Management specification*.

- [ITU-T G.9979] Recommendation ITU-T G.9979 (2014), *Implementation of the generic mechanism in the IEEE 1905.1a-2014 Standard to include applicable ITU-T Recommendations.*
- [IEEE 802.3] IEEE Std 802.3-2008, *IEEE Standard for Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks--Specific requirements Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications.*
- [IEEE 1905.1] IEEE Std 1905.1-2013, *IEEE Standard for a Convergent Digital Home Network for Heterogeneous Technologies.*
- [IEEE 1905.1a] IEEE Std 1905.1a-2014, *IEEE Standard for a Convergent Digital Home Network for Heterogeneous Technologies, Amendment 1, Support of New MAC/PHYs and Enhancements.*

3 Definitions

3.1 Terms defined elsewhere

None.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 arbitration function (AF): Entity that facilitates coordination between the xDSL and PLC systems in order to reduce interference on the basis of coordination policy, by appropriately configuring parameters of the xDSL and PLC devices. The coordination policy is expected to be determined and provided by the operator. In the case where such a policy is not determined or provided by the operator, the AF works according to a predefined default policy.

3.2.2 centralized control mode (CCM): A mode of a PLC network in which devices do not exchange information directly with the AF but via the PLC-NC.

3.2.3 distributed control mode (DCM): A mode of a PLC network in which PLC devices exchange information directly with the AF.

3.2.4 IEEE 1905: Devices implementing the abstraction layer specified in [IEEE 1905.1] and [IEEE 1905.1a]. In this Recommendation, the term IEEE 1905 is used to refer to the technology, the term IEEE 1905.1 is used to refer to the base standard [IEEE 1905.1] and the term [IEEE 1905.1a] is used to refer to the Amendment [IEEE 1905.1a].

3.2.5 power line communication (PLC) devices: Components of a PLC network that are intended to be connected to each other via power line and that communicate with each other using appropriate coding and modulation methods.

3.2.6 PLC network: A set of interconnected PLC devices that communicate with each other. The in-home PLC network uses in-home power line wiring as the transmission medium.

3.2.7 PLC network controller (PLC-NC): In CCM, one of the PLC devices in the PLC network that is assigned to control all other devices in the network.

3.2.8 xDSL access network: A network that comprises customer premises equipment and the exchange (or cabinet or DP) equipment implementing xDSL functionality that is compliant with at least one of the ITU-T Recommendations of the ITU-T G.99x or ITU-T G.970x-series.

3.2.9 xDSL network termination (NT): A customer premises equipment implementing xDSL transceiver and associated functionality that is compliant with at least one of the ITU-T Recommendations of the ITU-T G.99x or ITU-T G.970x-series.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

ACS	Auto-Configuration Server
AF	Arbitration Function
AL	Abstraction Layer
CCM	Centralized Control Mode
CMDU	Control Message Data Unit
CO	Central Office
CO-MIB	Central Office-Management Information Base
CPE	Customer Premises Equipment
CWMP	CPE WAN Management Protocol
DCM	Distributed Control Mode
DLL	Data Link Layer
DP	Distribution Point
DPU-MIB	Distribution Point Unit Management Information Base
DPM	xDSL and PLC interference Mitigation
DPU	Distribution Point Unit
EMS	Element Management System
LAN	Local Area Network
MAC	Media Access Control
ME	Management Entity
NMS	Network Management System
NT	Network Termination
OLR	On-line Reconfiguration
PHY	Physical Layer
PLC	Powerline Communication
PLC-NC	PLC Network Controller
PSD	Power Spectral Density
QLN	Quiet Line Noise
QoS	Quality of Service
RGW	Residential Gateway
SAVN	Showtime-Adaptive Virtual Noise
SNR	Signal-to-Noise Ratio
SNRM	Signal-to-Noise Ratio Margin

TLV	Type, Length and Value
WAN	Wide Area Network
xDSL	x-type Digital Subscriber Line

5 **Conventions**

None.

6 **Reference models**

6.1 **Generalized reference model**

The generalized reference model addressing the interference mitigation mechanism is presented in Figure 6-1. The arbitration function (AF) facilitates resource allocation between the powerline communication (PLC) network and the xDSL NT. The communication between the PLC and the AF and between the xDSL NT and the AF are defined over logical interfaces Φ_P and Φ_C , respectively, while the operator may control the AF via the logical interface Φ_A . The operator’s control on AF, as well as other elements of the customer premises network, is usually implemented via the network management system (NMS). In the case where operator control of the AF is not established for any reason, the AF may use its internal arbitration and coexistence policies to facilitate xDSL-PLC coordination (e.g., the default policies or those downloaded during previous session). This includes the following cases:

- xDSL line is inactive and thus no connection to the NMS is available;
- xDSL line is active, but no connection to the NMS is established or NMS is unavailable.

In these cases the AF should be able to function without operator control.

NOTE – To support the coexistence mechanism during the time when operator control is not available, the AF may (either partially or entirely) reside inside the residential gateway (RGW).

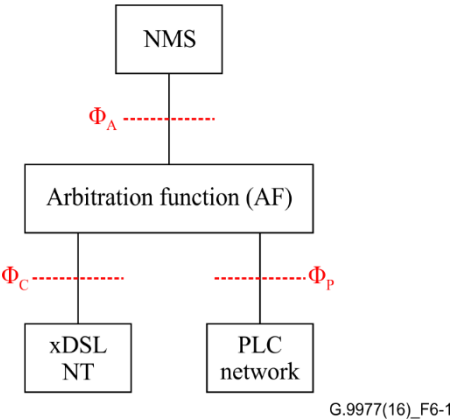


Figure 6-1 – Generalized reference model

An application of the generalized reference model showing more details of the xDSL and the PLC network is presented in Figure 6-2.

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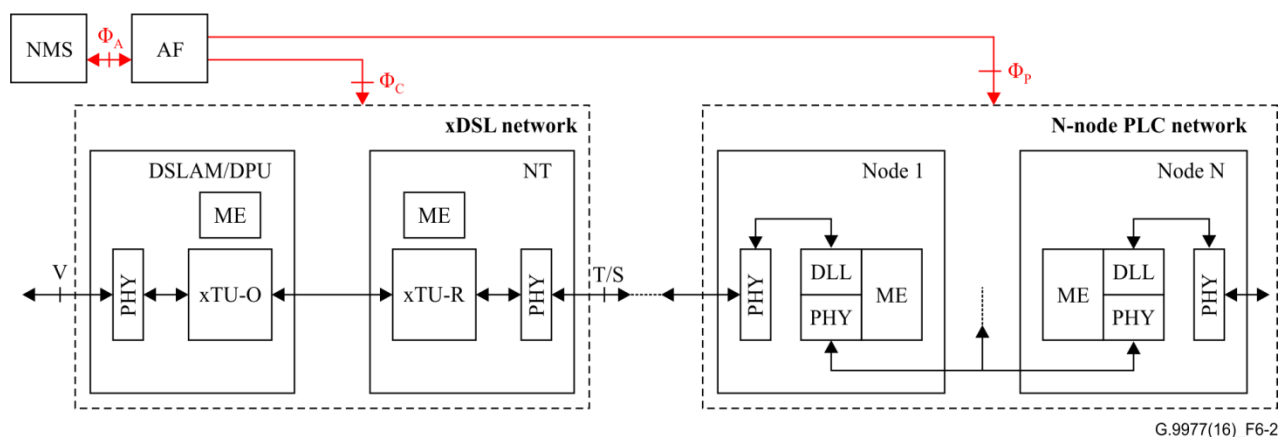


Figure 6-2 – An application of the generalized reference model

The first example of a system functional model corresponding to the reference models in Figure 6-1 and Figure 6-2 is presented in Figure 6-3. It represents the case in which the AF resides entirely in the RGW. To address a generic case of user installation, both the PLC network and the xDSL NT are connected to the RGW using 802.3 local area network (LAN) interfaces (RGW is a stand-alone device that incorporates AF).

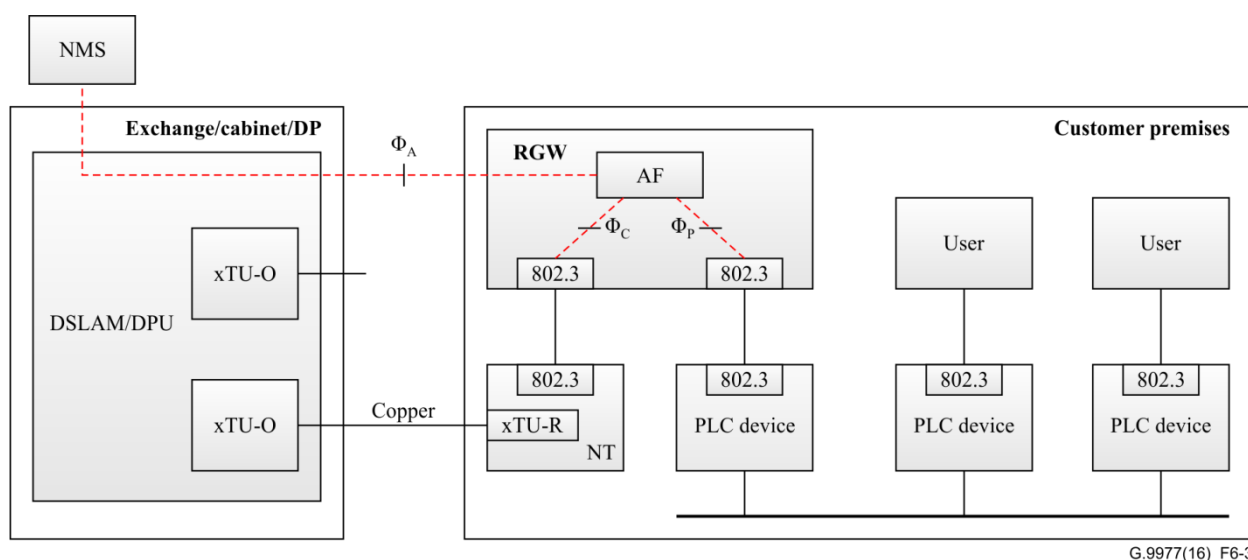
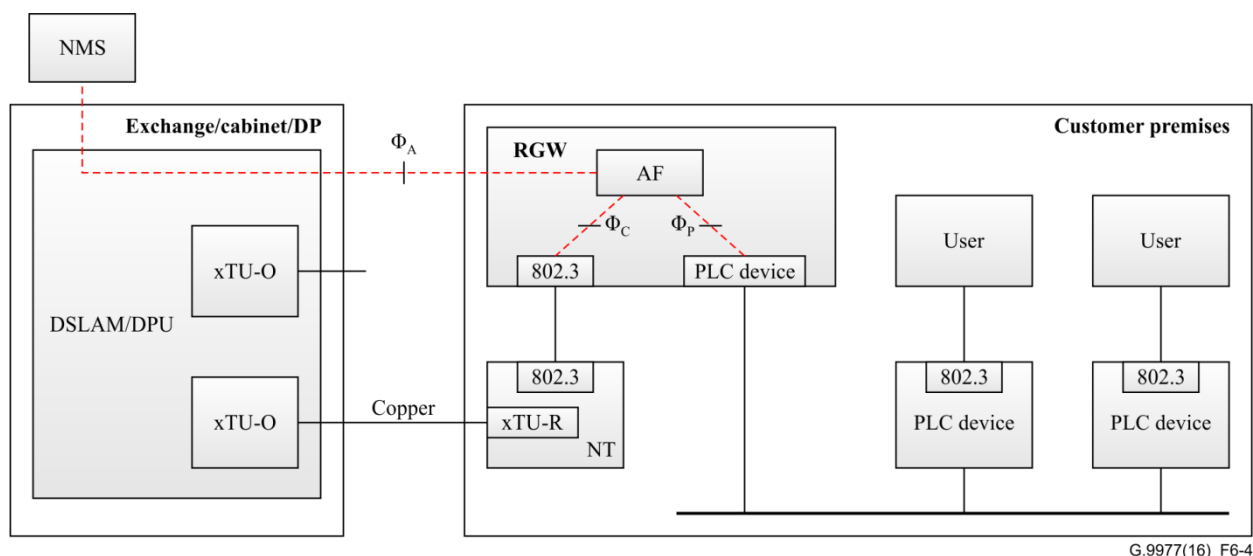


Figure 6-3 – An example of a system functional model for the case when the xDSL access network and PLC network are associated with the same operator network (AF resides inside the RGW)

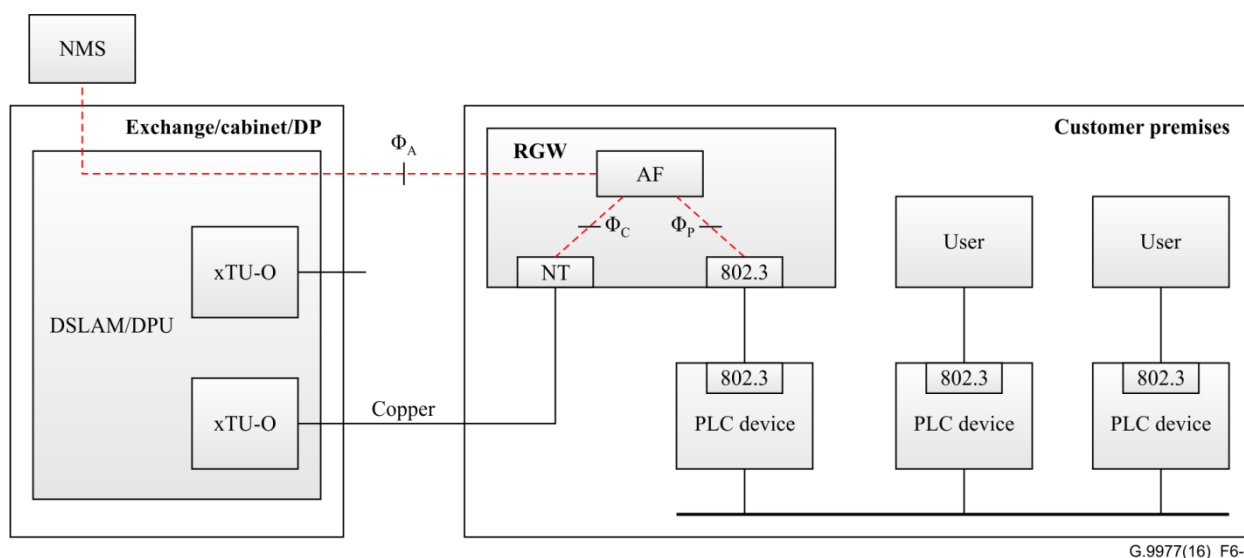
A second example of a system functional model corresponding to the reference models in Figure 6-1 and Figure 6-2 is presented in Figure 6-4. It represents the case in which the AF resides entirely in the RGW and a PLC device is also part of the RGW. The xDSL NT is connected to the RGW using 802.3 LAN interfaces.



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Figure 6-4 – An example of a system functional model for the case when the xDSL access network and PLC network are associated with the same operator network (AF and a PLC device reside inside the RGW)

A third example of a system functional model corresponding to the reference models in Figure 6-1 and Figure 6-2 is presented in Figure 6-5. It represents the case in which the AF resides entirely in the RGW and the xDSL NT is also part of the RGW. The PLC network is connected to the RGW using 802.3 LAN interfaces. In this case, the NT functionalities are integrated into the RGW.



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Figure 6-5 – An example of a system functional model for the case when the xDSL access network and PLC network are associated with the same operator network (AF and xDSL NT reside inside the RGW)

A fourth example is the case in which both the xDSL NT and PLC device are implemented as a part of the RGW is presented in Figure 6-6. In this case, the xDSL NT functionalities are integrated into the RGW.

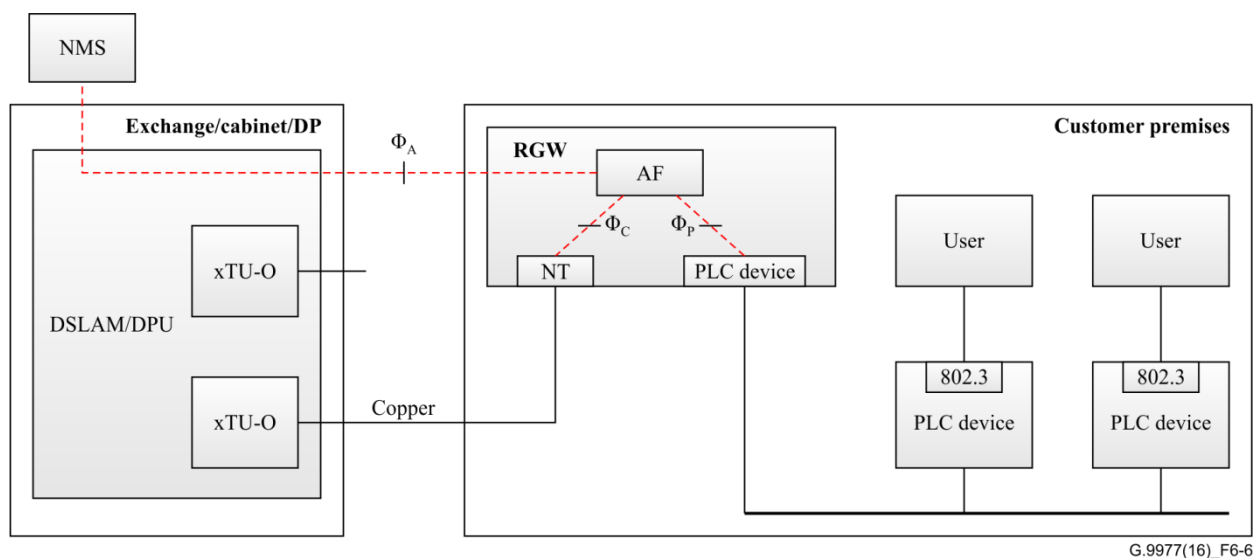


Figure 6-6 – An example of a system functional model for the case when the xDSL access network and PLC network are associated with the same operator network (AF, xDSL NT and a PLC device reside inside the RGW)

A fifth example of a system functional model corresponding to the reference models in Figure 6-1 and Figure 6-2 is presented in Figure 6-7. It represents the case in which the AF resides in the broadband network, remote from the customer premises. The AF implementation may be virtualized, hosted in the cloud, be a part of NMS or element management system (EMS) functionality, etc.

NOTE – A network-located AF may use [ITU-T G.997.1] and [ITU-T G.997.2] for much of the functionality of the Φ_C interface, and may use CPE WAN management protocol (CWMP) [b-BBF TR-069], [b-BBF TR-181] for much of the functionality of the Φ_P interface. For example, for xDSL, SNR(f) may be read across the network using [ITU-T G.997.1] and [ITU-T G.997.2] and the PLC PSD shaping mask (PSM) [ITU-T G.9961] may be configured across the network using CWMP.

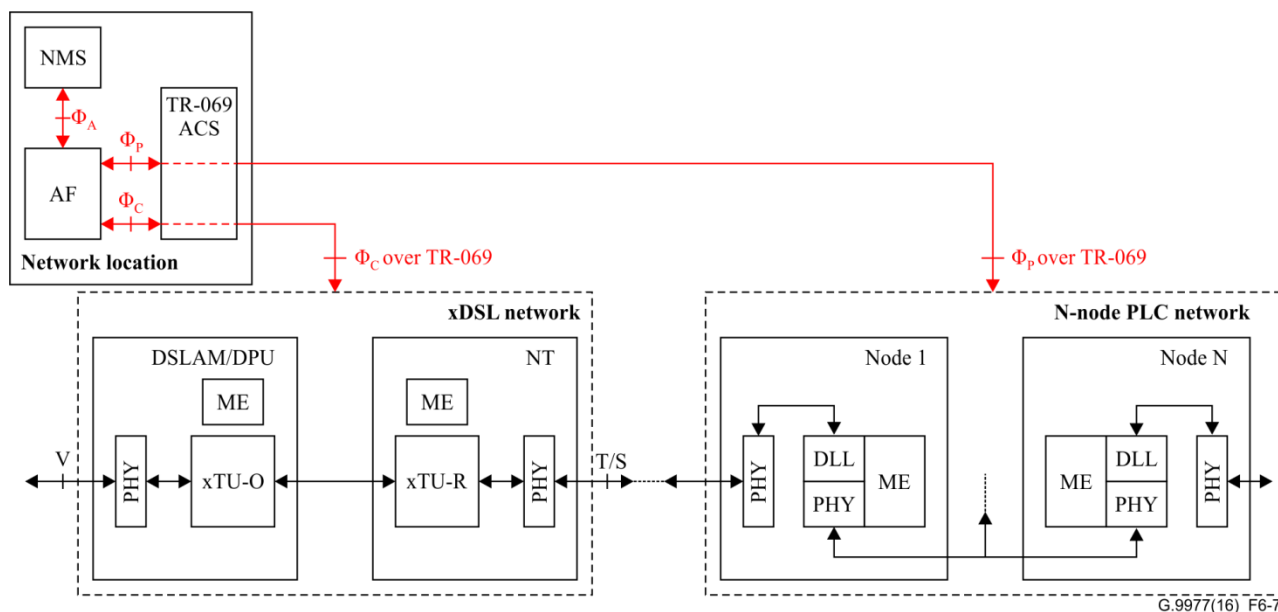


Figure 6-7 – An example of a system functional model for the case when the AF is located in the broadband network

In Figure 6-7 the AF communicates to the xDSL NT and the PLC devices using the TR-069 protocol [b-BBF TR-069]. This is possible when both the xDSL NT and the PLC device(s) support TR-069.

In the distributed mode all the PLC devices need to support TR-069 in this example. In the centralized mode, at least one PLC device needs to support TR-069 [ITU-T G.9962].

The TR-069 protocol is defined such that customer premises equipment (CPE) (i.e., xDSL NT, RGW and PLC devices) communicates with an auto-configuration server (ACS) using corresponding data models [b-BBF TR-181]. The ACS encapsulates AF primitives passed across the Φ_P and Φ_C interfaces, respectively, into corresponding TR-069 data models and passes them transparently, so that the primitives sent from the AF to the ACS are passed to the xDSL NT and the PLC devices, and the primitives sent from the xDSL NT and the PLC devices are passed from the ACS to the AF. In the case where TR-069 connectivity is lost (e.g., due to loss of broadband connectivity), a local AF using a predefined default policy should be invoked. The network-located AF and the ACS could be part of the same system.

6.2 Details of the interfaces

The defined interfaces of the generalized reference model (Φ_C , Φ_P , and Φ_A , Figure 6-1) are logical, which means:

- the interface is defined by sets of primitives to be exchanged (see clause 7.5);
- no L1-layer protocol (physical signals) is specified.

The Φ_C , Φ_P , and Φ_A interface primitives are exchanged by using protocols specified in this Recommendation and messages with transmission formats defined in Annex A.

7 General approach

7.1 Interference mitigation mechanism

7.1.1 Overview

The coexistence mechanism defined in this Recommendation provides mitigation of the PLC interference into xDSL line and mutual optimization of the performance of the xDSL line and PLC network. It facilitates normal initialization and stable steady-state operation of a xDSL line within the quality of service (QoS) requirements defined by the operator, in the presence of PLC and endeavours to provide minimal performance degradation for PLC devices and seamless PLC operation (i.e., no service disruption during xDSL initialization).

The mitigation of PLC interference is accomplished by an AF implementing the following AF device discovery, AF coordination, and AF policy functionalities:

AF device discovery functionality includes the following:

- discovery of the media access control (MAC) addresses of the xDSL NT and PLC devices;
- identification of the type and status of each device;
- monitoring of device presence and status changes.

AF coordination functionality includes the following:

- establish communication with PLC devices and xDSL NT;
- coordinate interference measurement, i.e., trigger measurement modes and retrieve results;
- collect interference data and report it to the AF;
- coordinate start-up procedure of xDSL and PLC devices;
- coordinate parameter reconfiguration of PLC devices and xDSL to mitigate interference based on AF policy.

AF policy functionality includes the following: The AF implements a provided coordination policy from an operator. In the case where such a policy is not provided or available the AF works according

to a predefined (default) policy. The coordination policy may be provided via a static definition (e.g., autonomously implemented within the unit embedding the AF) or via a dynamic definition using a remote management protocol (e.g., [b-BBF TR-069]).

Operator control of the AF and the applied coexistence policies prevent conflicting goals that PLC devices and xDSL NT may have, while the overall goal is to optimize the overall performance.

The coexistence mechanism defined in this Recommendation facilitates operation for the following cases:

- when xDSL line is inactive – the PLC devices should be allowed to use all network resources;
- when xDSL line starts initialization – the PLC network and/or devices should facilitate xDSL initialization such that the QoS targets defined by the operator are achieved at the transition to showtime;
- when xDSL line is active – the xDSL line in showtime should maintain the QoS targets set by the operator and should not be disrupted by reconfiguration of the PLC network (e.g., when new PLC devices are added to the network or PLC devices are moved to another location).

7.1.2 Scenarios

This clause provides an overview of the operation of the xDSL access system and PLC network under different coexistence scenarios. The details of the mechanisms that are used are explained in clauses 7.2, 7.3 and 7.4.

7.1.2.1 Scenario #1: PLC is active while xDSL is OFF

In this scenario no broadband service and no management from the operator is available. The PLC network is standalone, operates autonomously and no additional limits on transmit power spectral density (PSD) or other parameters of PLC devices related to coexistence apply.

In order to monitor the status of the PLC network and xDSL NT, the AF shall poll those from time to time using STATUS.request primitives over Φ_P and Φ_C interfaces, respectively (see clause 7.3). The xDSL NT and the applicable PLC devices shall reply with STATUS.confirm primitives, respectively, indicating status updates whenever polled by the AF. If the STATUS.confirm primitives from the xDSL NT are not received, the AF shall monitor discovery messages from the xDSL NT to detect when it turns on.

7.1.2.2 Scenario #2: xDSL line turns active in presence of an active PLC network

NOTE 1 – During initialization, the xDSL NT exchanges special training signals with its peer installed at an exchange, a cabinet, or a distribution point (DP). The xDSL NT is effectively disconnected from the exchange, cabinet, or DP; no broadband service and no management communications are available. In this state the AF can set parameters of the PLC network so that the necessary conditions for the xDSL line to initialize with QoS parameters required by the operator for broadband connection (based on SLA agreement with the customer) are facilitated. At the end of the initialization xDSL line transitions to showtime, allowing the operator to deliver broadband services and remotely manage the RGW, the AF and the PLC network.

The xDSL NT indicates to the AF that it starts initialization by sending a STATUS.ind primitive or indicating start of initialization in STATUS.confirm primitive after receiving a STATUS.request primitive from the AF across Φ_C interface.

Upon reception of the xDSL NT indication of initialization, the AF may send to the PLC network a CONFIGURE.request defining a reduced PSD setting if it expects possible initialization issues, setting the PLC devices in a state in which they do not disturb the initialization process. Upon reception of a CONFIGURE.request primitive, the PLC network shall reply to the AF by sending a primitive CONFIGURE.confirm, which confirms that the requested PSD is applied to all relevant PLC devices.