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ALPHA

Architectures for fLexible Photonic Home and Access networks

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Deliverable D3.7

Standardisation of optical in-building and home networks

White paper for input to standardisation bodies

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PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Executive Summary

This ALPHA Deliverable D3.7 gives an overview of all standardisation activities relevant to the domain of in-building and home networks and contributions hereto from ALPHA partners during the ALPHA project. The contributions and participation in standardisation activities carried out during the project are focused on the deployment of optical fibres for in-building and home networking, in particular on the system certification and guidelines.

This document summarizes also the recommendations of the companies dealing with in-building and home networks within the ALPHA project.

The ALPHA project contributions to standardisation bodies include, in particular:

- ETSI TS 105 175: Contribution to basic document and amendments (France Telecom, Homefibre) and a proposal for further actions (as described in this Deliverable)
- EN 50173 and ISO/IEC 11018 via DKE-715 working group with active contribution regarding home network architecture, experience from field trials and proposing extensions and amendments (see Chapter 2.2 in this document) (Acreo, France Telecom, Homefibre, Telekomunikacja Polska, Technical University of Eindhoven, Telefonica I+D)
- ISO/IEC 61754 by contributions with results from measurements and field trials (Telekomunikacja Polska, Telefonica I+D, Homefibre)
- Gigabit Ethernet Standardisation DKE 412-3 working group with contribution regarding home network architecture, technical concepts and system requirements (Acreo, Homefibre) as well as technical solutions, testing results and measurements (Luceat, Politecnico di Torino, Telekomunikacja Polska, Technical University of Eindhoven).

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1 Introduction

1.1 Purpose and Scope

Optical fibre infrastructures are widely used and standardised for MAN and large in-building networks like office- and industrial buildings. The benefits of an optical in-house infrastructure (such as ease of installation, ease of upgrading, economics, sustainability) have been shown with the support of the ALPHA project. The experience gained during the project has been contributed to relevant standardisation bodies. A summary of these activities is described in this document.

1.2 Reference Material

1.2.1 Reference Documents

[1]	EN 50173
[2]	ETSI TS 105 174-5-1-1
[3]	ISO/IEC 15018
[4]	ISO/IEC JTC 1/SC 25 N 1758
[5]	ISO 60793-2-40
[6]	DKE 715 – 3 Working Papers, Minutes & presentations
[7]	DKE 412-7-1 Working Papers, Minutes & presentations
[8]	Cenelec Smart House Roadmap 2011
[9]	IEC 60793
[10]	IEC 60794
[11]	IEC 62457
[12]	Systems First Demonstration of Real-Time LED-based Gigabit Ethernet Transmission on 50m of A4a.2 SI-POF with Significant System Margin / Gaudiono; ECOC 2010
[13]	
[14]	
[15]	

1.2.2 Acronyms and Abbreviations

ACLR	Adjacent Channel Leakage Ratio
ACP	Area Connection Point
ACS	Auto Configuration Server
ADSL	Asynchronous Digital Subscriber Line
AH	Authentication Header
AMOOFDM	Adaptively Modulated Optical OFDM
AN	Access Network
AON	Active Optical Network
AP	Access Point
ASP	Application Service Provider
BBP	BaseBand Processor
BCT	Broadcast and Communication Technologies
BEF	Building Entrance Facility
BO	Broadcast Outlet
BRAS	Broadband Remote Access Server
BSP	Broadband Service Provider
BTS	Base Transceiver Station

CATV	Cable Television
CCBB	Command, Control and Communication in Buildings
CDMA	Code division Multiple Access
Cli	Client
CO	Control Outlet
CPE	Customer Premises Equipment
CSE	Carrier Suppression Effect
CWMP	CPE-WAN Management Protocol
DAS	Distributed Antenna System
DHCP	Dynamic Host Configuration Protocol
DIY	Do It Yourself
DL	Down Link
DMD	Differential Mode Delay
DMT	Discrete Multi Tone
DN	Domestic Node
DNS	Domain Name System
DSL	Digital Subscriber Line
ED	End Device
EI	Equipment Interface
ENI	External Network Interface
EQP	Transmission Equipment
ESP	Encapsulation Security Payload
FOT	Fiber Optical Trancseiver
HAG	Home Access Gateway
HAN	Home Area Network
HCC	Home Communication Controller
HG	Home Gateway
HN	Home Network
HSDPA	High Speed Downlink Packet Access
HSUPA	High Speed Uplink Packet Access
HTTP	Hyper Text Transfer Protocol
ICT	Information and Communication Technologies
IGMP	Internet Group Management Protocol
IKE	Internet Key Exchange
IM	Intensity Modulation
IMDD	Intensity Modulation Direct Detection
IP	Internet Protocol
IPSec	Internet Protocol Security
IPTV	Internet Protocol TeleVision
L2	Layer 2
L3	Layer 3
LAN	Local Area Network
LLC	Logical Link Control
LTE	Long Term Evolution
MAC	Medium Access Control
MCast	Multicast
MGDM	Mode Group Division Multiplexing
MGMT	Management
MMF	MultiMode Fibre
MPLS	Multi Protocol Label Switching
MS	Mobile Station
MSLR	Main to Second Lobe Ratio
MZI	Mach Zender Interferometer

MTBF	Meantime Between Failure
NAT	Network Address Translation
NAT-T	NAT Traversal
NTP	Network Time Protocol
OAM	Operations, Administration & Maintenance
OFDM	Orthogonal Frequency Division Multiplexing
OFM	Optical Frequency Multiplying
OLT	Optical Line Termination
OMC	Optical Media Converter
ONT	Optical Network Terminal
OSS	Operation Support System
PAM	Pulse Amplitude Modulation
PB	Provider Bridging
PBB	Provider Backbone Bridging
PBB-TE	Provider Backbone Bridging – Traffic Engineering
PCE	Path Computation Element
PCS	Physical Coding Sub-layer
PHD	Primary Home Distributor
PHY	PHYsical layer
PHY-TC	PHY-Transmission Convergence
POF	Plastic Optical Fibre
PON	Passive Optical Network
POTS	Plain Old Telephone System
PPP	Point-to-Point
PPPoA	Point-to-Point over ATM
PPPoE	Point-to-Point Protocol over Ethernet
QAM	Quadrature Amplitude Modulation
QoS	Quality of Service
RAD	Remotely Accessible Device
RG	Residential Gateway
RMS	Remote Management System
RNC	Remote Node Controller
RPC	Remote Procedure Calling
RTP	Real-time Transport Protocol
SA	Security Association
RoF	Radio over Fibre
SCB	Spatial Channel Beam forming
SCM	Sub-Carrier Modulation
SDM	Spatial Division Multiplexing
SHAP	Secondary Home Access Point
SHD	Secondary Home Distributor
SIP	Session Initiation Protocol
SMF	SingleMode Fibre
SNR	Signal to Noise Ratio
SOAP	Simple Access Object Protocol
Srv	Server
SSL	Secure Socket Layer
STB	Set Top Box
TBCO	Telecommunication Broadband Communication and Control Outle
TCP	Transmission Control Protocol
TDD	Time Division Duplex
TE	Terminal Equipment
TELNET	TELecommunication NETwork

TFTP	Trivial File Transfer Protocol
TLS	Transport Layer Security
TO	Telecommunication Outlet
TVoIP	TV over IP
UDP	User Datagram Protocol
UE	User Equipment
UL	Up Link
UPnP	Universal Plug'n'Play
UWB	Ultra Wide Band
VAP	Value Added Provider
VHT	Very High Throughput
VLAN	Virtual LAN
VoIP	Voice over IP
WAN	Wide Area Network
WLAN	Wireless Local Area Network
WP	Work Package
WPAN	Wireless Personal Area Network
WPx	Work Package x

1.3 Document History

Version	Date	Authors	Comment
01	5.11.2010	Homefibre	
02	20.12.2010	Homefibre, FT, TP	Summary of standardisation activities and content of D3.7
03	10.1.2011	Homefibre, FT, PoliTo; TP, TUE	Adaptation of schematics and architecture
04	19.2.2011	FT, PoliTo, Homefibre	Integration of latest input FT, Polito; Up-Date Gigabit & Connectors
05	21.2.2011	FT, TP, PoliTo, Homefibre	Update certification chaper 3 Improvement 2.3 Connectors
06	23.2.2011	TP, Homefibre	Gigabit Standardisation; Connectors
06	24.2.2011	TP, Telefonica, Homefibre	Review and correction
07-08	25.2.2011	Acreo, TUE, Homefibre	Review and clarification; editing, finalisation

2 Standardisation activities regarding optical in-building and home networks

The following picture gives an overview of relevant standards and standardisation activities for the in-building and home network.

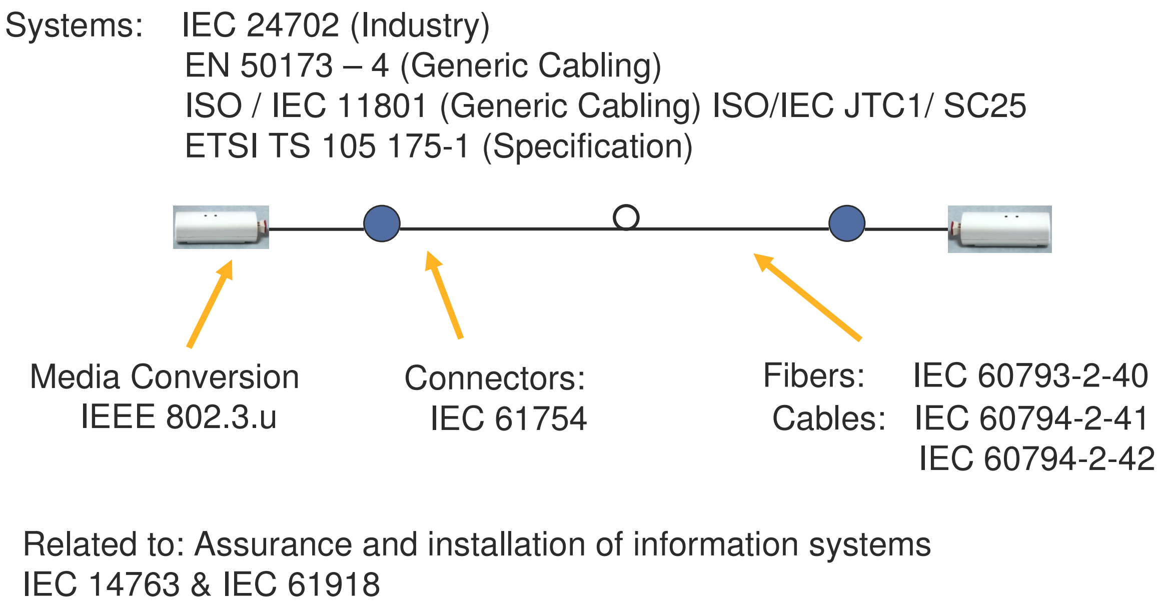

Figure 1: Overview about standards and committee related to optical home networking

2.1 ETSI TS 105 175-1

This document is a specification for POF home networking and has been published in Jan. 2010.

The document has been reviewed by ALPHA project partners and it has been decided to send an input to the ETSI working group for amendment or changes, as outlined in the following.

2.1.1 Contributions

The following topics have been contributed to the ETSI working group (via FT and a liaison with Telecom Italia):

R5 - The BER 10^{-12} is the same value same as defined in the IEEE 1000FX standard at Phy Level - Layer 1. In the paper it might be misunderstood that this number is only related to the physical layer on transceiver level. This fact should be described more precisely. (Compare also the BER at paragraph R18)

Does the BER 10^{-12} refer to a packet error rate of 10^{-6} (value of Ethernet Standard)

(1500 with 8bits per byte gives 10^{-10} packet error rate)

- POF transceiver should have the same performance.

- Measurement for Gigabit ?

- Specs for 100Mb/s
- how has it to be tested ?
- Recommendation: 10^{-9} or 10^{-6} for the complete link ?.
- How to compare with R18?

R31 We propose to exclude A4a1 from the specification. A4a1 fiber does not fulfill the technical requirement for data transmission, mainly not for 1 Gb/s.

R35 Fire resistant / retardant: is it the same?

What is the difference?

Fire retardant is only required in public areas and buildings.

Proposal for new text:

For specific applications as e.g. public buildings Cable must be available in a fire retardant version according IEC 60332 according to the national standards and specifications for public buildings.

For installation in public areas POF cable MUST be Low Smoke Zero Halogen (LSZH)

For residential installation POF cable SHOULD be Low Smoke and Halogen Free (LSZH).

R37 It is recommended to clarify the terminology: Transceiver and / or Converter...in full operation 100MbE media converter per port...

What is the maximum Power consumption per Port of a switch?

Should any Co-sinus power (blind power) be considered in the specification?

Recommended:

<3,5Watt per full operation Gigabit Media Converter (1 port)… (substitute “port” by “Media Converter”)

R41 Power Voltage should be between 110VAC and 230VAC

R42 Clarification to what is indicated in R39

R44 MTBF with 300k hours seems to be too high.

(e.g. Homefibre’s devices have a MTBF of 33 years = around 280 k hours, according Telcos this is already more than the MTBF of a typical DSL-modem, hence this value should be discussed)

The ETSI specification should also mention the possibility of passive wall outlets (transparent POF to POF) in two different variations:

A: with connector to the outside of the wall outlet (SMI?, SC?)

Example: connector-less in the wall, SMI outside the wall; allows low-cost patch cord.

B: as an alternative also a connector-less solution should be allowed

(e.g. Optolock)

Remark: For connector less interfaces the mechanical dimensions of POF cable should be standardized. Values not standardized today: concentricity, dimensional tolerance of jacketing (outer diameter).

Application: e.g. for STB with optical interfaces or USB - Dongle with POF interface.

2.1.2 Further Steps / Roadmap

Proposal for further actions:

We propose to create an Annex to ETSI TS 105 175 -1 including the content described in 2.2.1.1, giving recommendations to the System Architecture like e.g. pure star topology, mixed star – daisy chain topology.

This Annex may include a chapter to describe POF as a generic backbone to be used also for IP-based control and management data in the home network. Such backbone would offer easy implementation and deployment of new devices and services (see also proposal in chapter 2.2).

Furthermore it could be useful to describe the role und function of cluster switches (switches inside each room in order to link IP-devices together e.g. IP-TV STB and Play Station; PC and Printer, both connected to the same link in the room) and cluster gateways (e.g. wireless access points inside the room).

2.2 EN 50173 (also applicable to ISO/IEC 11801)

The current version of the EN 50173, ISO/IEC 11801 and ISO/IEC 15018 as well as related working group documents of DKE 715-3 working group have been evaluated and a proposal for an amendment or extension to create a new class of infrastructures for an optical backbone has been developed within the ALPHA project.

Introduction:

The EN 50173 is focused on a passive structured cabling infrastructure. The standard specifies a generic cabling for three groups of applications in homes:

- Information and Communications Technologies (ICT);
- Broadcast and Communications Technologies (BCT);
- Commands, Controls and Communications in Buildings (CCCB);

The partners participating in this WP have evaluated the impact of three new optical concepts on the existing standards:

a) The "All-IP" optical backbone for all kinds of IP-based home network applications including the categories ICT, BCT and CCCB and its impact to the proposed cabling architecture.

b) A mid-term architecture proposed by FT and based on an active star and centred on a multiformat switch.

c) A long-term solution called multiformat passive architecture, based on a fully transparent infrastructure, associated with optical wavelength multiplexing

With the multiformat solutions b) and c) (that are based on silica fibre, either multimode or single-mode), the same infrastructure carries all the services, and there is no distinction between IP network, TV broadcast network or command network.

2.2.1 Contribution

The following topics have been discussed among ALPHA partners and a proposal for further action has been prepared.

2.2.1.1 A combined ICT-BCT –CCCB infrastructure for an optical backbone.

a. The generic cabling standard claims to be "application independent", but it distinguishes between applications using coaxial cable and HF (see classes specified in ISO/IEC 11801) as well as different cables to be used for Ethernet and HF, specified classes.

The working paper with the title "3rd PDAM 2 to ISO/IEC 15018: Information technology — Generic cabling for homes – with the reference number ISO/IEC JTC 1/SC 25 N 1758 has proposed to add the optical fiber into the ISO/IEC 15018.

Justification of a combined ICT-CCCB infrastructure architecture

With the optical fibre backbone it is possible to install a backbone which can cover all IP-based applications in the home. Such infrastructure solution is described below, combining the existing ICT – BCT and CCCB concepts to a single integrated infrastructure.

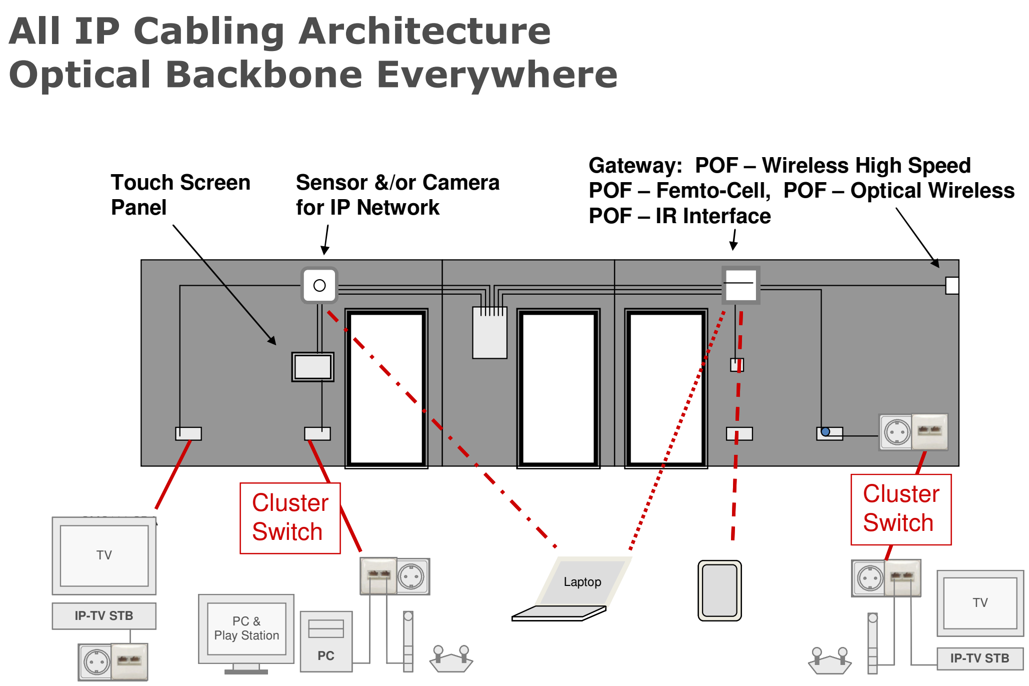

Figure 2:Example showing the installation of an optical IP-Backpone

In future home networks an increasing number of IP applications will be used, not only in multimedia (CE, TV, PC etc….) but also for smart home applications. Even if proprietary or separated eco-systems are used, they will be equipped with gateways with an IP interface to be connected to an IP backbone.

Also today BCT applications like DVB-S, DVB-T and DVB-C can and will be converted to IP-signals and transmitted to all rendering devices via IP streams.

Therefore the ICT and CCCB infrastructure will merge (see picture below).

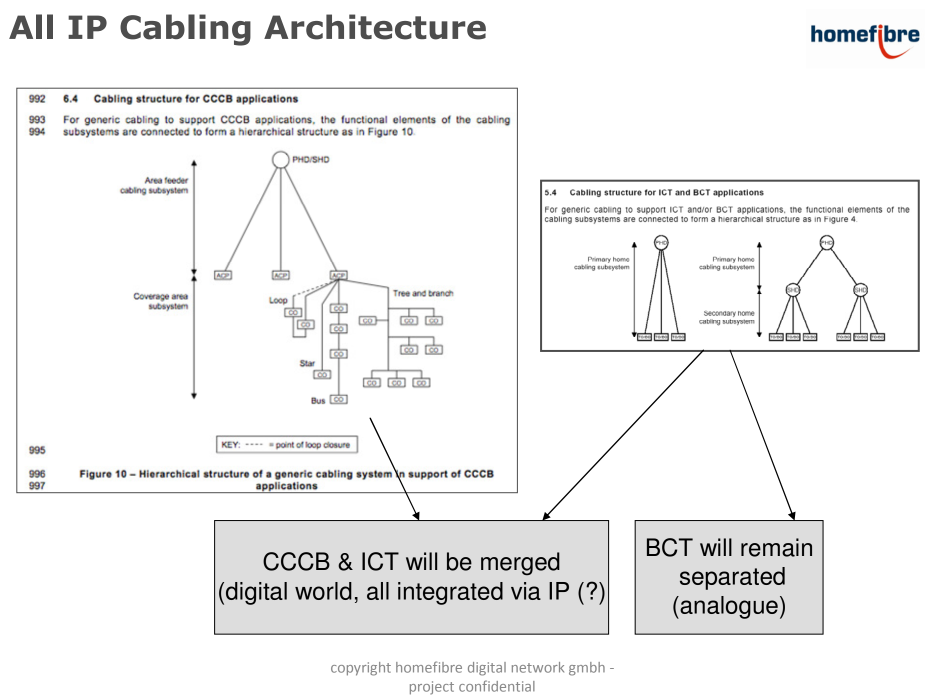

Figure 3:Illustration to merge ICT & CCCB

A new infrastructure solution may look like the one sketched in the following picture:

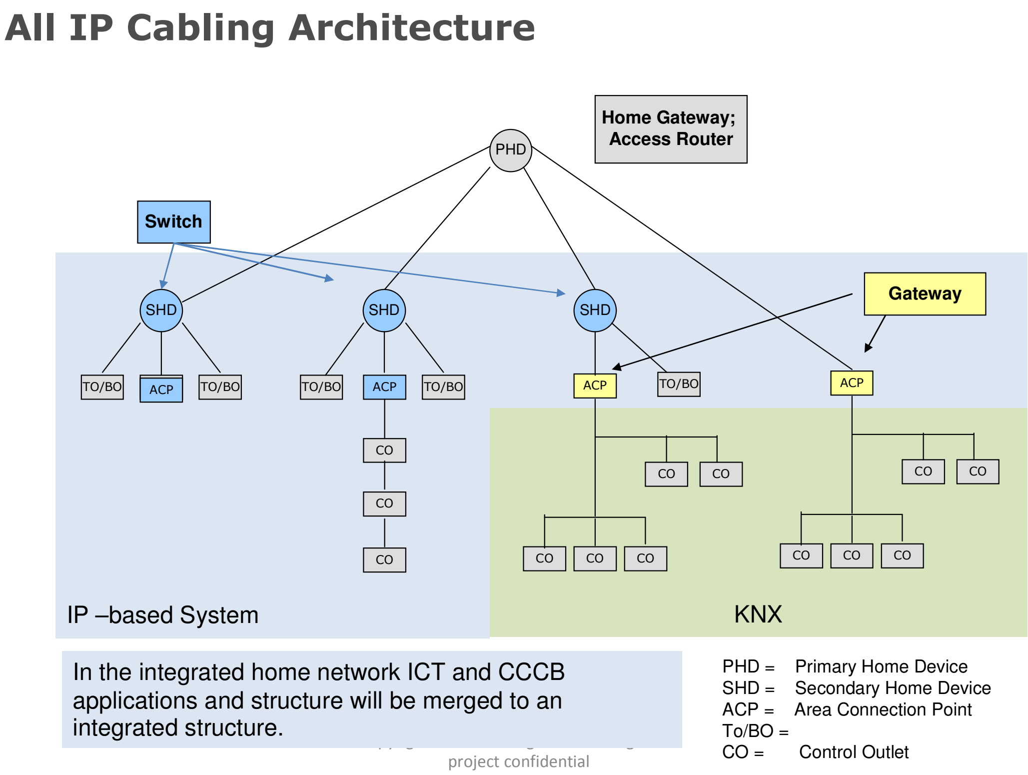

Figure 4: Active components in the definition of the generic cabling standard

The definition of SHD and ACP can remain and will keep their function. SHP will not be only passive devices but can also be switches or routers, ACPs can be media or- cluster gateways from subsystems to the star wired IP backbone.

2.2.1.2 Multiformat Cabling Architecture adapted to ISO/IEC 11801/ ISO/IEC 15018 and/or EN 15073.

In the framework of the ALPHA project, FT proposes mid- and long-term visions of optical Home Area Networks, based on multiformat architectures, able to support several types of signals. Actually, the challenge in home network is not only to increase the bit rate, but also to take into account the great heterogeneity of the signals which have to be conveyed: Ethernet, RF TV (terrestrial and satellite) and radio signals (GSM, UMTS, LTE, WiFi, UWB, 60GHz, …) for wireless-end-connectivity. Today, specific networks working on specific media are dedicated to each application. For example, Ethernet cables for IP data carry triple-play services, coaxial cables convey Radio Frequency (RF) signals for terrestrial or satellite television broadcasting, specific cables are used for HDMI links, for instance between a High Definition (HD) player and a television set. This situation will soon become unacceptable for the customer, and a single integrated infrastructure supporting all these signals will be widely preferred. This will be made possible thanks to the large possibilities provided by optical technologies to transmit a multiplex of various signals

Two solutions are being studied: a mid-term solution, based on an active star and centred on a multiformat switch, and a long-term solution based on a fully signal-format transparent infrastructure, associated with optical wavelength multiplexing and wavelength routing.

2.2.1.2.1 The multiformat active star architecture

This architecture is depicted in Figure 5. The different signals, including Ethernet for IP data, terrestrial and satellite broadcast TV and cm-wave radio signal, converge towards a Multiformat Switch (MS). This device integrates an Ethernet switch and is also able to process the additional analog signals. These signals are then are multiplexed at each port of the MS, and conveyed on multiformat links towards remote plugs or extenders, located in the different rooms. Signals are then demultiplexed and delivered to connected devices, using the adapted interface. A similar process is applied for the uplink.

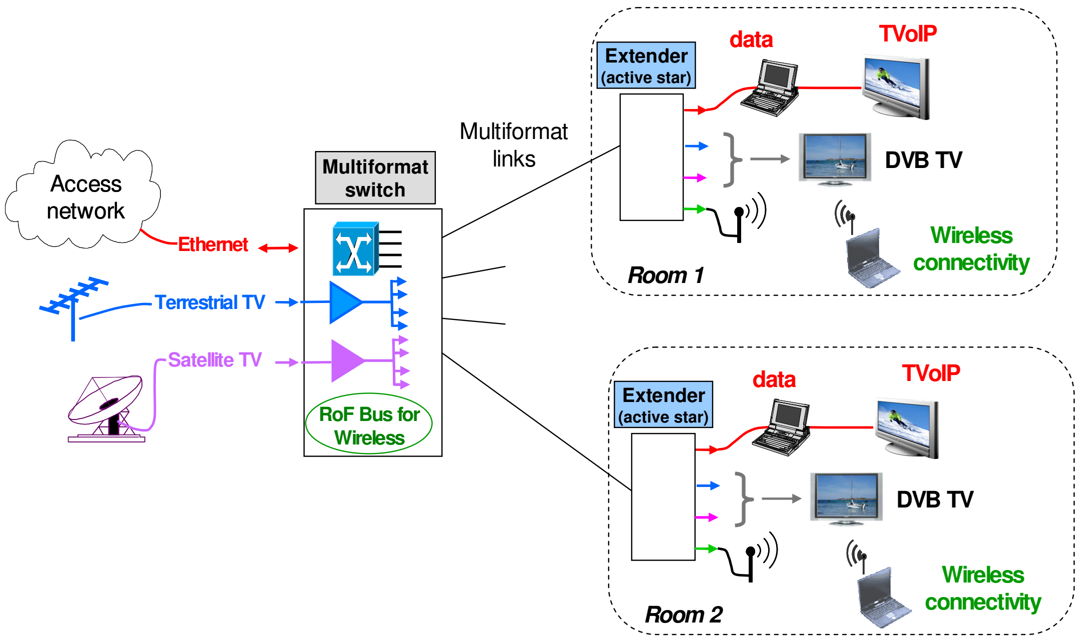

Figure 5: concept of the multiformat active star

If IP data are carried by 100 Mbit/s Ethernet (Fast Ethernet), multiplexing the different signals may be achieved in the electrical domain (Figure 6), as there is no spectrum overlapping. To reach 1 Gbit/s Ethernet (ore more), multiplexing in the optical domain (Figure 7) is preferred, as spectrums of Gb Ethernet and terrestrial TV would overlap.

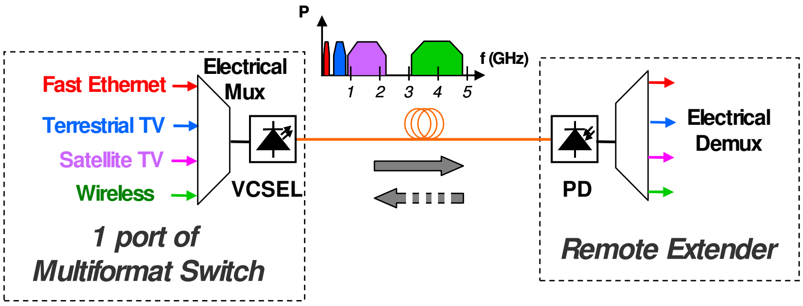

Figure 6: multiformat link based on electrical multiplexing

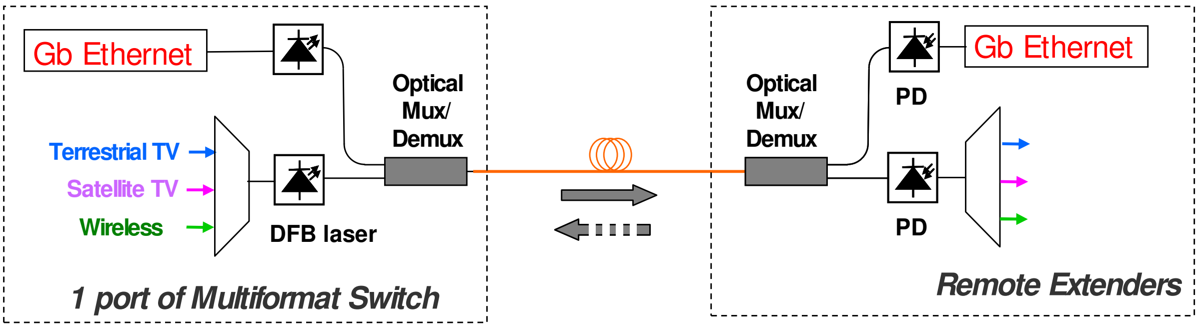

Figure 7: multiformat link based on hybrid optical / electrical multiplexing

With the multiformat solutions, the same infrastructure carries all the services, and there is no distinction between IP network, TV broadcast network or command network. For this reason, we merge the different types of outlets in Figure 8, in a common OO (Optical Outlet). For the simplest implementation, the multiformat switch is located close to the Primary Home Distributor (PHD), Secondary Home Distributors being optional. Signals are demultiplexed in the extender and are available at the different outlets at the user's side of the extender (TO, BO or CO in Figure 8) these outlets being dedicated to the different services (IP, broadcasted TV, control) and used to connect related devices.

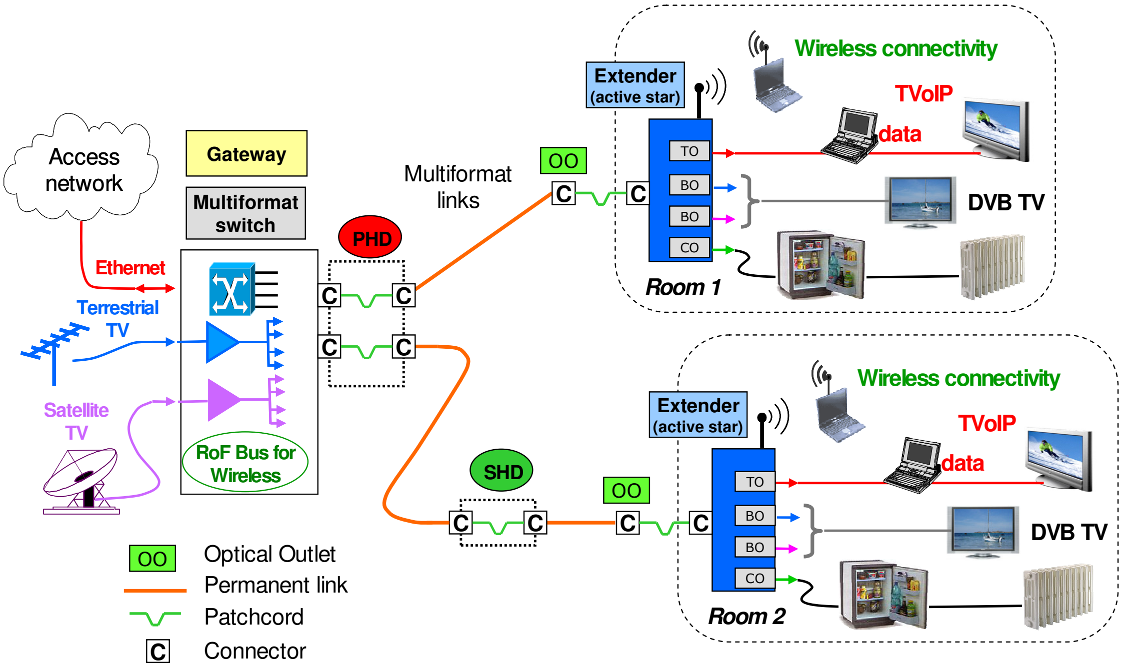

Figure 8: active star detailed architecture

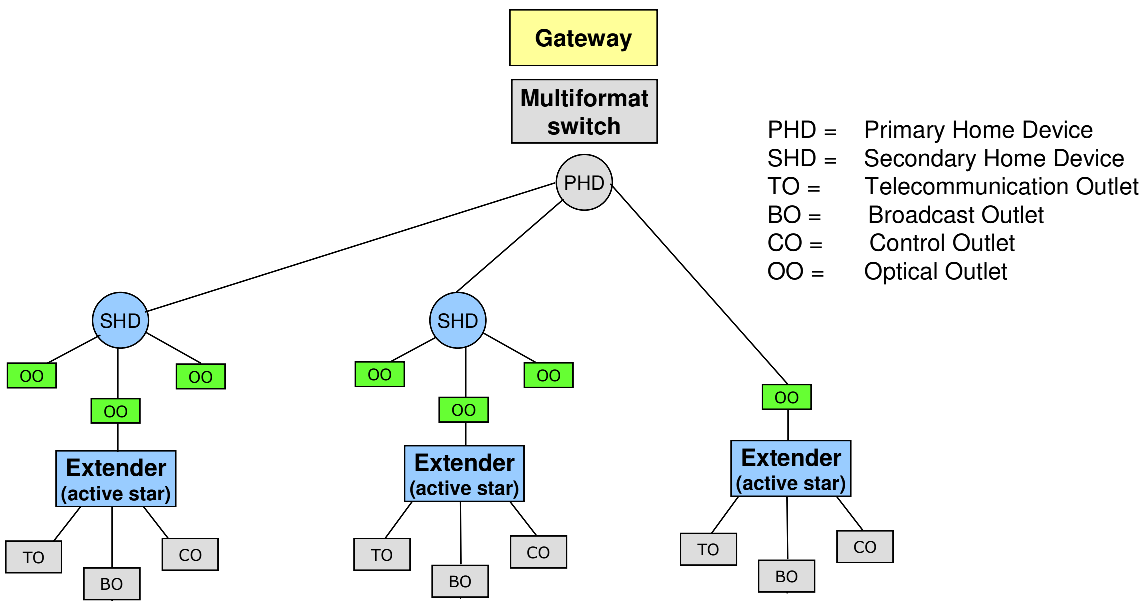

Figure 9: active architecture, network organization according to standardization

2.2.1.2.2 The multiformat passive star architecture

The second multiformat solution studied in the ALPHA project is the CWDM Broadcast & Select architecture. This longer-term solution, based on a central NxN optical splitter is depicted on Figure 10. Thanks to this splitter, a signal transmitted by any connected device is broadcasted to all the device receivers. The CWDM technology is used to separate the various types of signals, and, at the reception side, an optical filter extracts only the wavelength corresponding to the application wanted.

Compared to the multiformat active star, this solution provides a far greater flexibility, as several network topologies (point to point, bus, point to multipoint) can be simultaneously emulated on this infrastructure. But, specific protocols dedicated for shared medium have to be used.

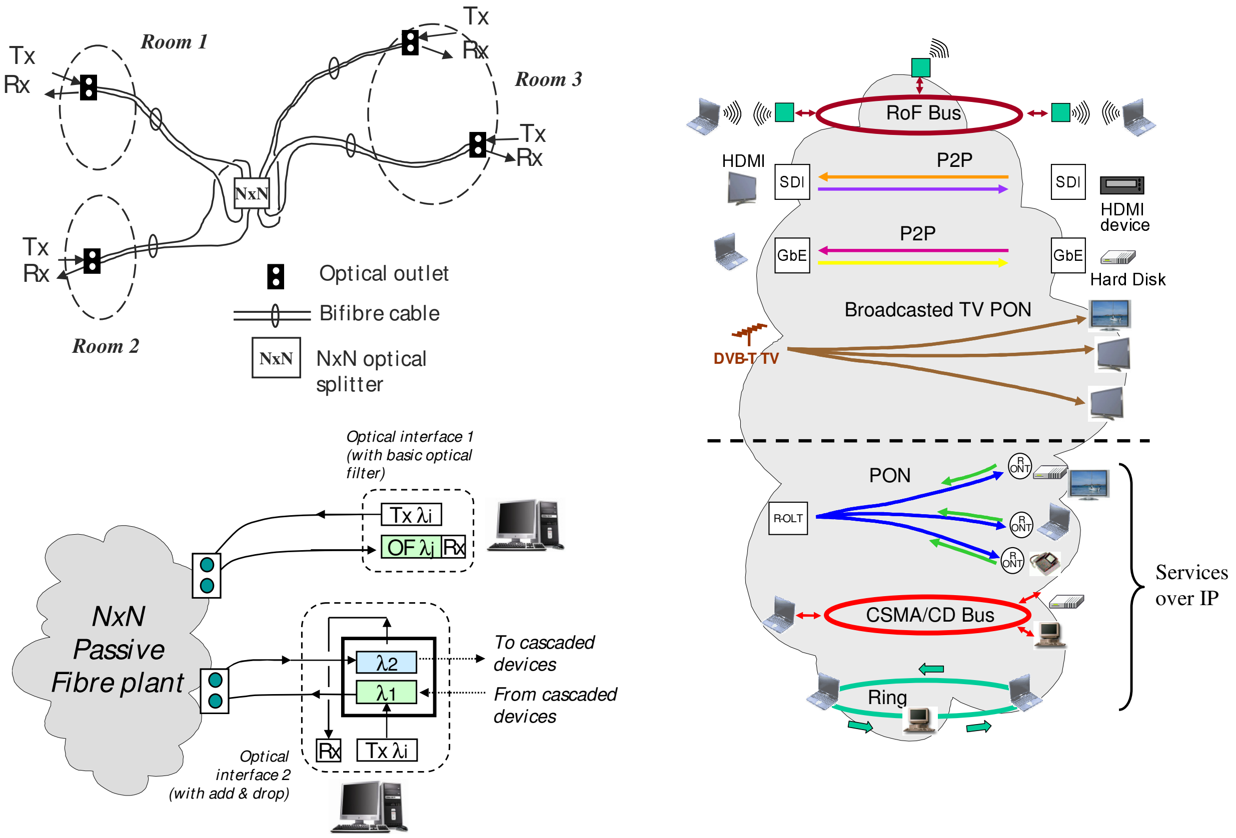

Figure 10: The multiformat passive star solution (CWDM Broadcast & Select.architecture)

Some differences exist between this passive architecture and the active star described above:

- No active function is achieved at the PHD level: only the NxN splitter is located at this point.
- It is a distributed architecture: the gateway may be located at any node of the network.
- Regarding the services, the same convergence exists for the outlets, which become once again common Optical Outlets OO, while TO, BO or CO outlets are available at the user's side of the extenders.
- As illustrated on Figures 11, 12 and 13, several options are possible: the SHD may be optional, extenders may also be cascaded.

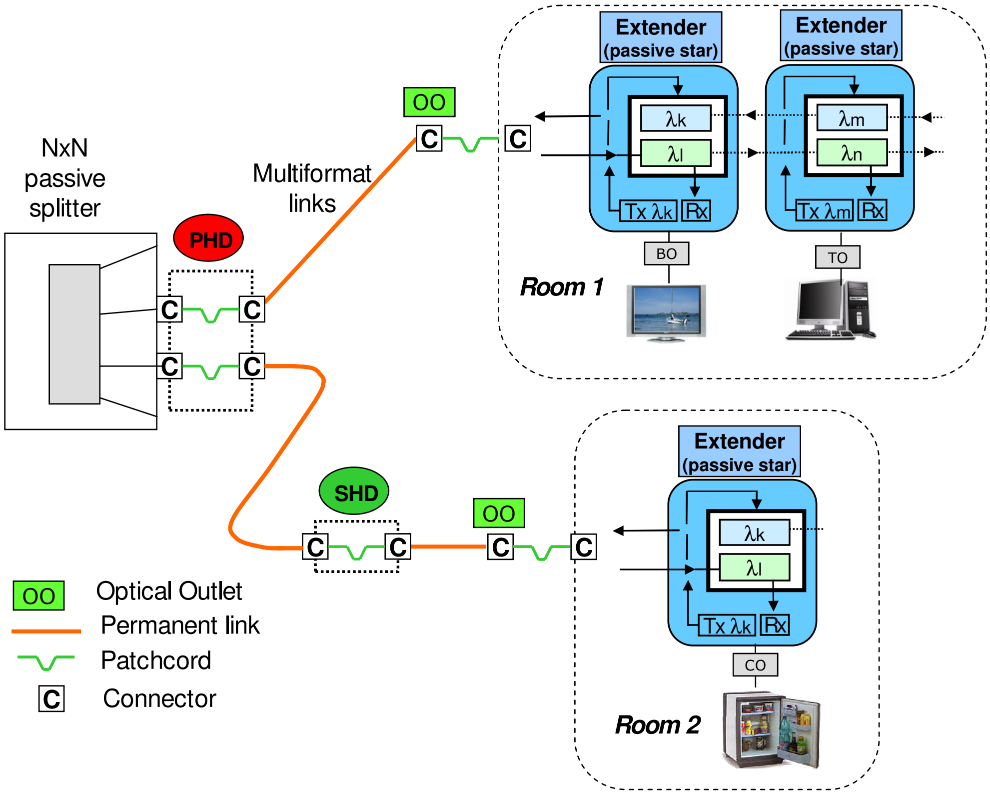

Figure 11: passive star detailed architecture, option 1

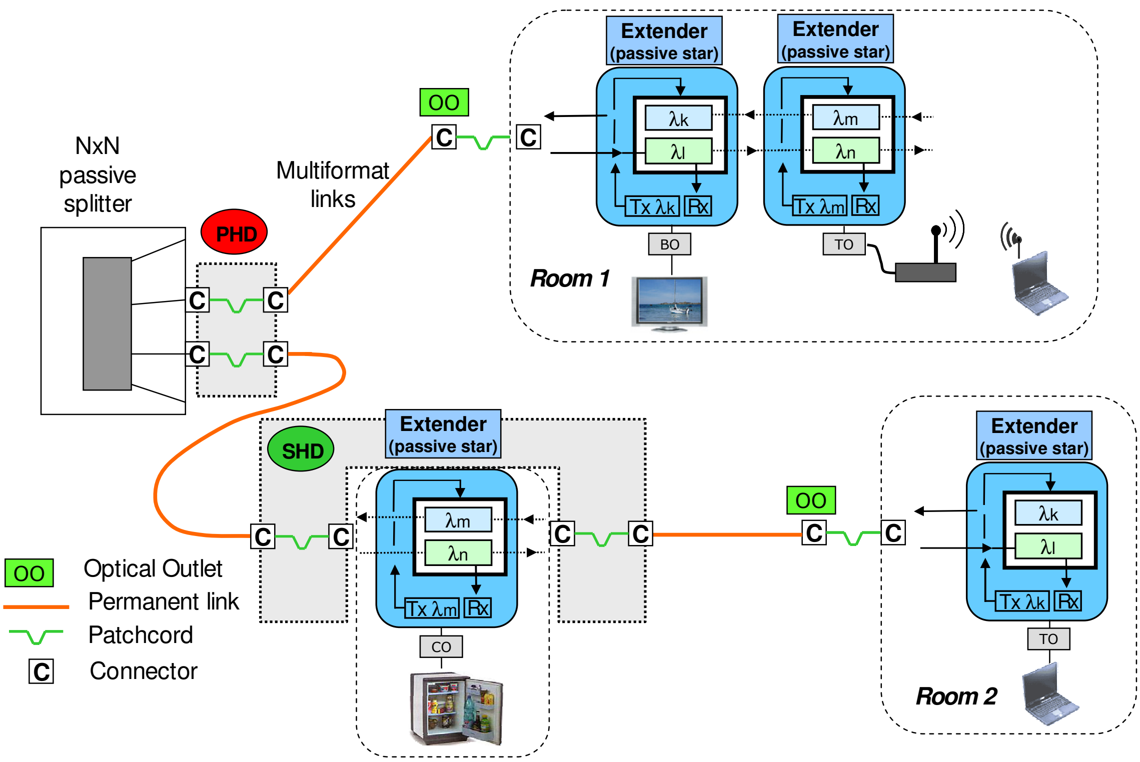

Figure 12: active star detailed architecture, option 2

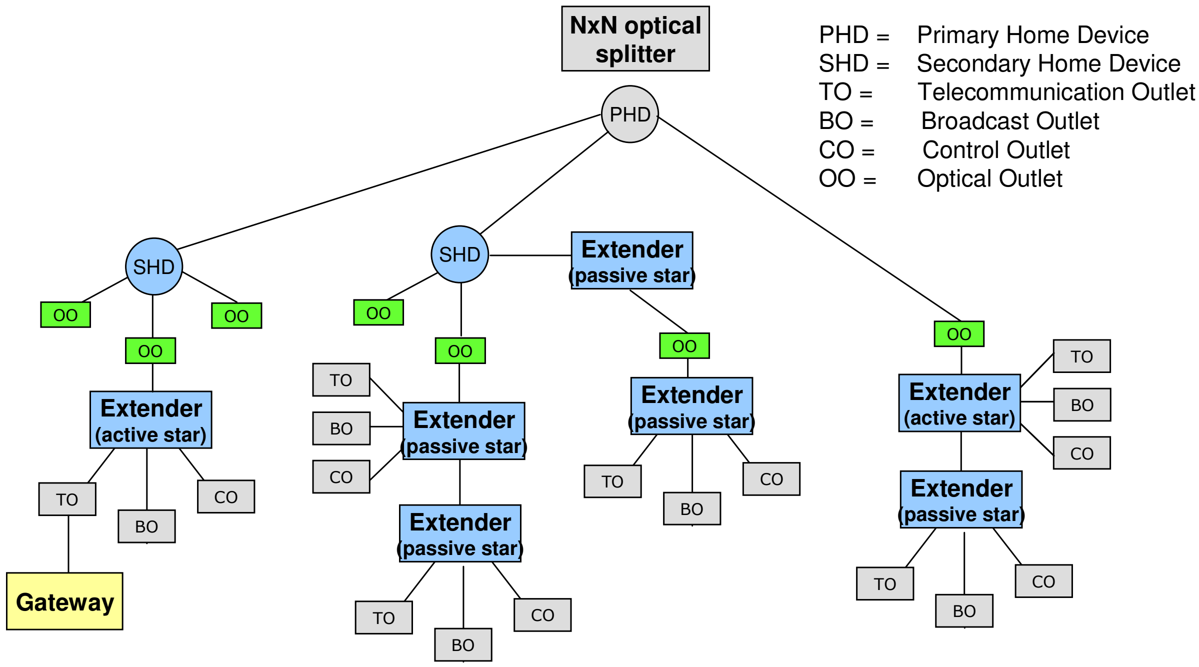

Figure 13: Passive architecture, network organization according to standardization

2.2.2 Further steps / Roadmap

The topics described above are to be presented in one of the next EN 50173 or ISO/IEC 11801 meetings by an ALPHA partner who is member of this working group.

Homefibre plans to discuss this proposal in the DKE/VDE working group DKE 715-3.

Furthermore the proposal is to be presented to the ETSI Home Networking working group.

2.3 ISO 61 754 Connectors

In ISO/IEC JTC 1/SC 25 WG3 *Customer premises cabling* decided to make a choice of one connector style to be used a standard for 1mm POF installations. As a result of discussions an LC style connector was chosen as a standard POF-dedicated connector which was reflected in IEC 61754-20-series documents. According to IEC 61754-20 Ed. 2.0: Fiber optic interconnecting devices and passive components – Fiber optic connector interfaces – Part 20: Type LC connector family (currently at ADIS stage) there have been assigned the following numbers for various 1 mm POF interfaces:

- Interface 20-9: simplex plug connector interface – POF 1,25 mm OD
- Interface 20-10: duplex plug connector interface – POF 1,25 mm OD
- Interface 20-11: simplex plug connector interface – POF 1 mm
- Interface 20-12: duplex plug connector interface – POF 1 mm
- Interface 20-13: simplex adaptor connector interface - POF 1 mm
- Interface 20-14: duplex adaptor connector interface - POF 1 mm
- Interface 20-15: simplex active device receptacle interface - POF 1 mm
- Interface 20-16: duplex active device receptacle interface - POF 1 mm

Interface 20-11 to 20-16 is a bare fibre interface. For the time being a limited number of product is market available and no results of practical field installations are available.

2.3.1 Contribution to POF connectors

The following topics have been discussed among the ALPHA partners and a proposal for amendment has been made to the ISO/IEC JTC 1/SC 25 WG3 working group.

The work and investigations in the ALPHA project came to the conclusion, that the decision to choose the same connector interface for all optical fibres in home networking can cause issues if it is applied for optical home networks based on plastic optical fibers for the following reasons:

- Mechanical dimensions of SM and MM fibres as well as the wavelengths used differ significantly from those for PMMA POF.
- The LC connector can and should be mechanically differentiated by a mechanical key at the housing or differentiation by colour. The same connector interface for different transmission media and transmission technologies (e.g. wavelength and power budget) might create confusion for the end-user as well as the installer.
- End-user and installer should be able to identify any optical network infrastructure easy and without doubt by the mechanical design of the cable and connector interfaces.
- A LC-connector should be approved in practical field tests.

In the project and various field tests the optical connectors have been evaluated by Telekomunikacja Polska, France Telecom, Homefibre and Luceat.

To be applied for home networks some basic requirements have been identified:

- size of the connector needs to fit to small form factor
- termination needs to be as easy as possible
- licensing conditions must be possible for fair and reasonable conditions (following the rules of IEEE and ISO/IEC)
- the connector should be applied in the mass market and hence needs to be a low cost device

In case that no LC – POF connector is available on the market within 2011 the companies of the ALPHA project have agreed to consider the following connector interfaces as an alternative for voting to ETSI TS 105 175 and ISO/IEC 15018 respectively ISO/IEC 60793-2-40.

SC-RJ	
SMI	
RJ45 – POF (new concept proposed by Firecomms in 2010)	This concept is described in the Annex to deliverable 3.7

During the project time also new concepts regarding POF connectors have been shown e.g. from Firecomms. They propose a combined RJ45 – POF connector and interface in order to have only 1 physical interface for devices and to be flexible to choose the same interface either for RJ45 copper or POF connector with RJ45 shape.

For more details, see the Confidential Annex to Deliverable 3.7 – Chapter 2.3.1.

2.3.2 Contribution to Connector-less Interfaces:

Due to the requirement of easy installation the POF market has accepted connector-less interfaces.

During the ALPHA project it became obvious, that the performance of a connector-less interface depends also on criteria which are not well standardised today. These criteria include the mechanical structure of the cable, specifically the following parameters:

- concentricity of the core
- tolerance of the outer jacketing
- max. tensile force of the connector

These topics are under discussion and will be specified begin of 2011 in cooperation with the OpTechNet initiative in Germany and the ETSI DTS 105 174-5-1-1 working group.

Connector-less interfaces are very well suited to be used in devices and applications with low number of connecting cycles. In case of passive interfaces in wall outlets connecting cycles might be higher and connectors should be considered. To support easy installation and to save installation time, various combinations of passive wall outlets can be considered. These proposals should be discussed in the ETSI optical home networking working group.

Also further testing and measurements regarding the comparison of different A4a2 fibers (e.g. SI-POF and MC-POF) has to be done.

2.3.3 Further steps / Roadmap

The following activities and steps will be considered for the future:

- Input of ALPHA results to ETSI DTS 105 174-5-1-1and ISO/IEC 15018 respectively EN 50173 working groups
- Input of ALPHA project to national standardisation bodies working groups (e.g. DKE/VDE…)

2.4 Gigabit Ethernet Standardisation

Since the benefits of POF for the future home network have been more and more recognized by the market, the topic of the Gigabit – transmission has gained attention also by other companies outside the ALPHA project.

In Germany a working group has been installed under the umbrella of VDE/DKE to proceed with standardisation of POF for home networking. One working group (DKE 412-7) has started to work for standardisation of modulation techniques for 1 Gb/s over POF. In the first approach three methods have been chosen to be evaluated.

In the ALPHA project the development and implementation of Gigabit Ethernet transmission has been investigated by France Telecom, Technical University of Eindhoven and Luceat. The technical constraints and standardisation activities have been followed by Telekomunikacja Polska, Homefibre and PoliTo.

The PoliTo group, also in conjunction with other work carried out in the POF-PLUS project contributed with technical presentations on the best physical layer solutions to reach the target of 1 Gbps, focusing on modulation formats, electronic equalization structures and error-correction codes. The TUE and Bangor groups have contributed with studies on multitone (DMT, OOFDM) formats for multi-Gbit/s transmission over large-core POF.

The DKE working group is now (February 2011) finalizing its preliminary decision on what type of physical layer will be selected for 1 Gb/s over POF, but results are not yet public and thus cannot be disclosed in this white paper.

During the project it became visible that different modulation technological concepts and approaches can meet the requirements of the Gigabit Ethernet transmission over POF.

A: NRZ with digital Equalization (ISMB, Luceat, Fraunhofer)

B: M-PAM with digital equalization (Siemens, Fraunhofer, POFAC)

C: PAM-THP with KDPOF coding (KDPOF)

D: DMT based - (Innodule)

During 2010 also new approaches have been proposed e.g.

D: Ghn (DMT based) over POF (latest approach by Teleconnect, proposal to ITU)

E: OFDM modulation (Polito, Luceat, Technical University of Eindhoven, Bangor)

Based on experiences and discussions from various field installations in different European countries and on communication with the market (service provider, installer and end user) , the ALPHA project has defined several selection criteria important for a POG Gigabit solution:

- Minimum length for 1 Gb/s link 50m (according ETSI)
- Expected time to market max. 1 to 1,5 year
- Final price: should be max.2 x today's FOTs (depending on number of gates/ size of silicon)
- Size of the transceiver same as today's FOTs and RJ45 transceiver
- Transceiver applicable for A4a2 fiber (Step Index Fiber)
- Connectorisation also for connector-less systems (like e.g. Optolock..)
- Power class same as today's RC-LED (eye safety class 1)
- Low power consumption and power sleep mode

As mentioned above in the January 2011 meeting of the DKE 715-417 working group in Berlin, the working group has voted to start with the standardisation of the PAM – THS modulation method proposed by KD-POF.

As mentioned above, it is recognized that there are other concepts besides the KD-POF approach which claim to meet the required performance, but at the current state and time these alternatives have not been considered for the following reasons :

a) Companies did not offer the resources to specify the standard, and

b) Companies could not show the way to a final product within the time frame of 1 to 1,5 years, and

c) Companies did not attend the working group or did not disclose sufficient information to enable the standardisation of their concept.

The current state is in progress and is depending on technological and economical results presented in 2011. All ALPHA activities showed a clear demand for Gigabit-POF solutions but techno-economical parameters are still under investigation and/or are still assumptions. We expect the situation will become clearer in 2011 as soon as announced products will be available to be commercialised and finally accepted by the market.

3 Recommendations for further actions regarding system certification and guidelines for optical in-building and home networks

The open topics to be specified and to be reported in guidelines for future All-IP networks are described below.

3.1 LSZH (Low Smoke Zero Halogen) requirement for POF cable

According today available information and measurement results POF cable is LSZH since the small amount of halogen included in the polymer material is so small that it can not be measured according the ISO/IEC regulation. This is the current state of the art, the topic is under further investigation.

The ALPHA investigation showed that LSZH is still an open topic. Luceat and IMQ (an Italian institute) have explored the status; they have found that there is still a lot of confusion about a meaningful definition of LSZH, and about the applicability of this concept to fiber optics, in particular to POF.

The state of the art can be summarized as following:

1. At the moment the PMMA 1mm core POF (with a LSZH jacket) complies with existing standards (cf IMQ reports).

2. Today there is no homogeneous international point of view on the subject. Nordic countries seem to be more sensitive to this topic, but the requirement for LSZH cable has to be put explicitly in the project specification (e.g. required by the housing or construction company or by local authorities as e.g. municipalities).

3. This shows that the requirements are strictly related to the field of application (private building, public buildings, train, aircraft, etc.). In general public constructions and buildings e.g. hospitals, children garden, schools, etc intend to specify LSZH and fire-retardant cabling all over Europe.

3.2 Gigabit transmission over POF

Regarding the standardization of POF systems at the physical layer, we believe that there is still a significant amount of work to be carried out. In particular:

- For the Physical Coding Sub layer (PCS) for 100 Mb/s (Fast Ethernet) there is a de-facto standard, so that most of the already commercially available devices uses IEEE 100Base-X PHY and the related commercially available chipsets. This is perceived as a good solution, since a dedicated PCS for Fast Ethernet POF is not necessary, being the very simple 100-Base-X system (pure on-off binary modulation, 4B-5B line coding) good enough for achieving the target distance.
- For the PCS 1 Gb/s the situation is still open and there is not yet a consensus. It is clear today clear that a dedicated PCS is necessary, since the re-use of other already existing PCS (such as IEEE 1000-BaseX) does not allow to reach the target performance, due to the severely bandwidth limitation of step-index POF. As previously mentioned, there is an ongoing effort in DKE that is specifically focused on this point
- For both data rates (100 Mb/s and 1 Gb/s) there is still a lack of a clear and agreed standardization at the optical level, and in particular on:
    - The target distances

- The optical connectors and/or optical ports
- The optical launching conditions
- The testing procedures.

We believe that what is still clearly to be defined is a Physical Media Dependent (PMD) specification on these POF optical questions. The definition of these (and others) parameters is key in defining a "certification process" for POF devices.

Example for technical parameter in optical networks:

- Transmission parameters: jitter, delay, packet loss
- Request on switching and media conversion functionalities related to today and future services: e.g. store forward, loop through
- Methods and procedures to certify an optical in-building network (measurement tools)
- Application of power-safe mode according IEEE 802.xy to POF home networking components and devices such as switches and converters.

3.3 Link certification procedure

Due to the multimode nature of POF, any link may be attenuation- or dispersion-limited. IEC 61280-4-1 Ed.2.0: "Fibre-optic communication subsystem test procedures - Part 4-1: Installed cable plant - Multimode attenuation measurement" provides information on measurement of attenuation of installed fibre optic cabling using multimode fibre, typically in lengths of up to 2000 m. The cabling can include multimode fibres, connectors, adapters and splices.

Measurement methods as described in IEC 61280-4-1 can be used for testing cabling designs following the rules stated in ISO/IEC 11801, ISO/IEC 24702 and ISO/IEC 24764 specifications. Additionally, ISO/IEC 14763-3 makes reference to the test methods of this standard.

However, it is important to note, that the standard at the current stage addresses only categories A1a (50/125 µm) and A1b (62,5/125 µm) of multimode fibres, as specified in IEC 60793-2-10. The attenuation measurements of the other multimode fibre categories can be made, using the approaches of this standard, but the source conditions for the other categories have not been defined yet.

While looking deeper into IEC 61280-4-1 one may note that the most critical parameter for reliable, repeatable and traceable multimode measurements is a stable and proven launch condition. Therefore, to make the IEC 61280-4-1 standard fully applicable to POF-based links, it is advised that further work should be carried on 1 mm POF launch conditions, and after working out these out they could be incorporated into IEC 61280-4-1 standard to make it automatically useful for POF based links.

Obviously care must be taken while working on the launch conditions for various classes of POF since due to their different propagation characteristics they will need to be different for each class.