OMEGA: New Use Cases for Future Home Networks

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Abstract. The media richness of the services available to the end consumer has had a constant increase rate of about 8% per year over the last century. This leads nowadays to the need of Ultra Broadband at home to handle future services such as 3D. Ultra Broadband means bit rates reaching the Gigabit per second. Moreover, beyond the bandwidth increase, the home network capabilities have to evolve in order to support new usages. This paper describes typical usage scenarios for the next 2-3 years and derives network oriented use cases that serve as requirements for the home network. Finally a solution fulfilling these requirements, based on an inter-MAC convergence layer, is depicted. This solution is developed in the OMEGA FP7 project.

Keywords: Home area networks, network convergence, Inter-MAC, network architecture.

1 Introduction

Current and future services and contents in home area networks (HANs) put diverse demands on the underlying transmission technology. For example, the use case scenarios for future home networks require an overall network capacity up to the Gigabit per second (Gbps). Moreover in order to avoid inefficient and cumbersome solutions with coexistence problems as experienced today, the OMEGA project [1-3] integrates various appropriate technologies into a converged heterogeneous network (see Fig. 1), which meets the customer's demands with respect to quality of service, reliability, throughput, ubiquity, and self-configuration.

From a race to Gbps perspective,

- the multitude of radio systems operating in a single home network and using the overcrowded frequency bands will create coexistence and performance problems. Convergence at the radio level will consequently be a key concept to be investigated.
- Technological enhancements will be investigated in order to locally optimize the different wireless technologies so that they provide the required performance in a converged network.

P. Chatzimisios et al. (Eds.): MobiLight 2010, LNICST 45, pp. 464–471, 2010.

- In order to meet a full coverage of the home, combination with other technologies such as powerline or wireless optical communications are necessary.

Then, from a quality of service point of view:

- Wireless connectivity with Gbps is not QoS achievable within more than one room
- From a network perspective, IP layer cannot mitigate PHY impairments to QoS acceptance while still being the de facto standard for the connected home.
- Additionally the home network power consumption should be limited. The reasons are twofold: reducing the operational cost of the network for the user and provide a sustainable component to home networks.

From a simplicity point of view:

- Electrical sockets are the most convenient medium term way to bring wire line connectivity in Europe.
- The final link of the in-house communication will preferably be wireless.
- The end customer will have the final word!

In this paper we present in section 2 typical usages of the home network, exemplified by a family composed of four members. These usages are then derived into requirements on the home network. Then we also highlight in section 3 other requirements for the home network as developed in the OMEGA project. Section 4 depicts a solution investigated in the OMEGA project in order to make converge all kind of physical technologies into one coherent framework. OMEGA partners are developing an evolutionary solution based on the Inter-MAC concept to accommodate these challenges by elaborating a minimum upper interface (namely the middleware south interface). Section 4 also explains the reference architecture of the OMEGA network.

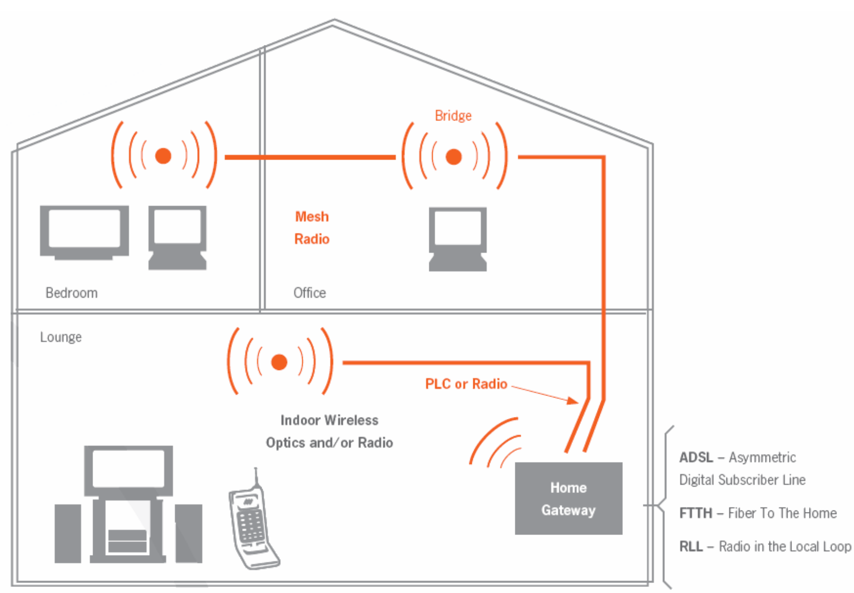

Fig. 1. Gigabit home area network: OMEGA concept

2 Use Cases

2.1 Typical Family Usage of the Home Network

Some scenarios have been defined in the OMEGA project, see [4–6]. These scenarios involve a family of 4 persons at different periods of the day. See for instance on Fig. 2 a representation of the early morning as all family members are still in their respective bedrooms:

- parents are listening music,
- the girl is looking at TV the end of the program from the previous evening,
- the boy is checking his downloads status.

All these flows run in parallel in the home network, which shall convey them while guaranteeing their respective Quality of Service. In the same family, the girl is giving a phone call in the afternoon while moving in the home and enjoying a seamless connection from a room to another. More details on these scenarios are captured in [4–6].

In the next section we derive these usage scenarios into network oriented use cases. These use cases serve as requirements for the definition of home network functionalities.

Fig. 2. Use of simultaneous very high bit rate flows within the home, with guaranteed QoS

2.2 Derivation of the Usage to Network Oriented Requirements

The list of requirements for the network that can be derived from the scenarios above are:

1. Always best connected in the home: When multiple connectivities are available between a source and a destination the network shall automatically select the best one to guarantee the QoS. This shall be transparent both for the user and for the application level in the network.
2. Exploit the whole network: the network shall allow the use of multiple links in parallel from a source to the same destination, either split of the traffic flow by flow or even split a single flow.

3. Mobility: the nomadism of a terminal in the home network shall be made possible, in a seamless way, regardless of the connectivities
    a. Intra-techno (Wifi 2.4 GHz / 5 GHz)
    b. Inter-techno (Wifi/wireless optics ...)
4. Ubiquitous coverage in the home network: Not to increase extensively the network elements in the home, future end devices shall act as network extenders by relaying the flows.
5. Compatibility with legacy: all devices already on the market shall be supported and their performance shall not be degraded.

Figure 3 to figure 5 present use cases that illustrate some of these requirements.

3 Further Requirements for the Home Networks

3.1 Compatibility with Future Access Networks

Another major concern for the architecture is the fact that the OMEGA home network design should keep in mind continuity of the access network to a certain extent. The home gateway is commonly considered as the border network element between the home network and the access provider network. This does not imply that there may not exist some continuity between these two network segments. On the opposite, one of the purposes of the OMEGA architecture is also to highlight how the evolutions expected in the access network may impact the operation of the OMEGA home. Deep evolutions are expected in the operator access and regional network, even if their roadmap is slower than that of the area of home networking:

- the dramatic increase of the data rates in the access and, as a result of this fact, the emergence of optical fibre in the access, likely up to the client's premises, with the prospect of reusing the potential of that technology in the Gigabit home network,
- a packet oriented handling of the QoS,
- the emergence of an IPv4/IPv6 coexistence, with the prospect of some simplification of the configuration process of the client installation,
- the emergence of an integrated IMS as a new (SIP based) intelligent network based on an IP network,
- the consolidation of new powerful means of management of large scale networks.

Therefore, one clear ambition of the OMEGA architecture is to assess the impact of these evolutions on the organization of the Gbps home area network, and how the protocols implemented in the access/regional network can be profitably extended in that context. These aspects will be elaborated in a later stage of the OMEGA project.

3.2 Compatibility with Future Middleware

A common definition is that middleware is the "glue" between software components or between the software and the network. The goal of the middleware is therefore to make different devices inter-work for the delivery of the service to the end user and thus its main goal is to hide the complexity of the inter-working devices under the service layer and abstracting it from the physical evidence of the home network. Several middleware solutions already exist: UPnP/DLNA, DPWS, IGRS, BONJOUR, HAVI, but they are not interoperable. There is no standardised and widely accepted middleware standard so far, while the IP layer is addressing some of the middleware core functions as a pivot convergent technology.

In this context, the task for OMEGA will be to elaborate a minimum upper interface (namely the middleware south interface) in order to provide:

- the requesting/maintaining/releasing of service flows,
- guaranteed QoS requirements to these flows, and report limitations, instantaneously, to the middleware so that relevant means are taken by the application (renegotiating the QoS in a SIP/SDP-like way or even dropping the flow),
- easy local or remote management given a top level view to the end user or the ISP.

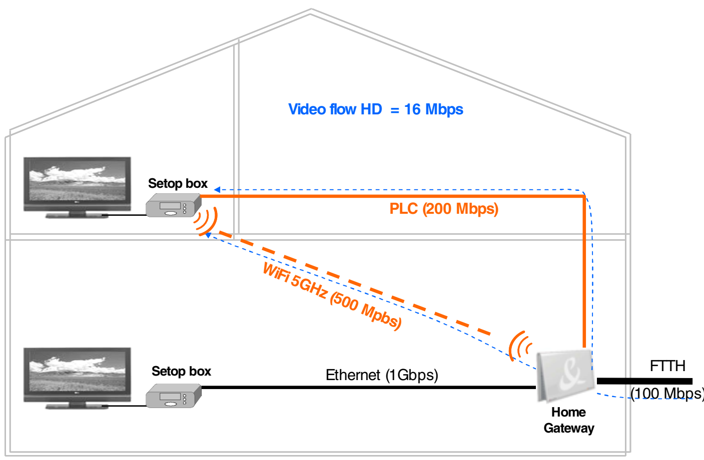

Fig. 3. Illustration of the use case "selection of the best link"

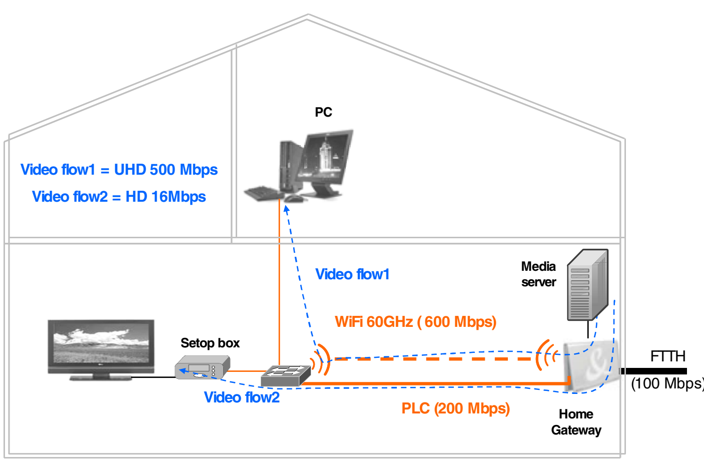

Fig. 4. Illustration of the use case "using all links"

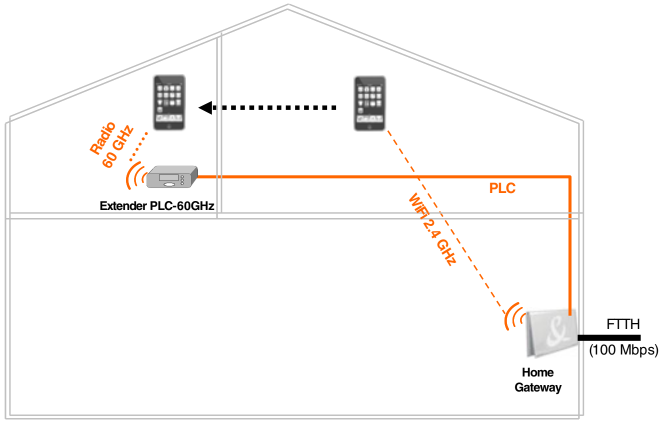

Fig. 5. Illustration of the use case "nomadism inter-technology"

4 Network Architecture and Inter-MAC Convergence

4.1 Main Goal

In order to fulfil the requirements on the home net works listed in section 2, the OMEGA project developed a Layer 2.5 solution so-called Inter-MAC. The Inter-MAC layer [8] may be seen as a global resource manager over the heterogeneous technologies in use in the HAN. To achieve that goal it plays the role of adapter between the logical links and the network layer. It operates at Layer 2, as shown in Fig. 6, but it is technology-independent and uses the information received from the underlying technologies to select the most appropriate one fitting to services requirements. The Inter-MAC is able to control every communication between two and more devices in the home network, with functionalities such as path selection or technology handover. The Inter-MAC interacts with the signalling, the management and the data plane to transparently setup a home network giving a sensation to the applications that the home network is a unique and homogeneous technology and not a cooperation of extremely different communication technologies. Thus, the Inter-MAC convergence layer integrates arbitrary heterogeneous communication technologies in a single home network.

4.2 Inter-MAC Connectivity

Thanks to the Inter-MAC layer, the OMEGA network, from an IPv4/IPv6 point of view, is a unique local area network (LAN). No layer 3 routing is needed within an OMEGA network. The frames/packets are forwarded to the correct destination node thanks to a path selection algorithm.

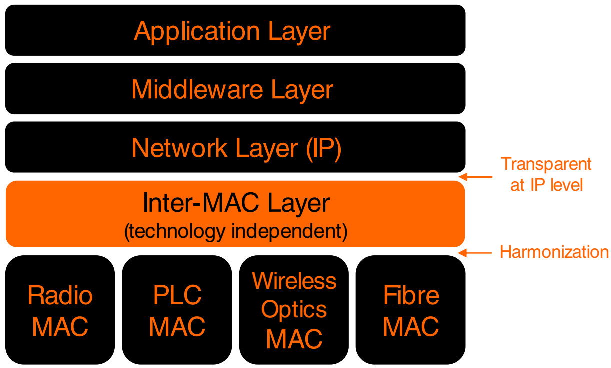

Fig. 6. Inter-MAC Layer in the OSI protocol stack

4.3 Reference Architecture Model and Interfaces

The Inter-MAC concept applies to a set of OMEGA devices constituting the OMEGA network which is organized in the form of a mesh architecture bringing in the advantages of multi-path capabilities for traffic reconfiguration. Their association can be represented under the global name of "OMEGA device", keeping apart the OMEGA gateway in order to highlight the interface with the access network. This leads to the OMEGA architecture reference model presented in Fig. 7, additional details about OMEGA architecture can be found in [7]. In a real network, several end devices, extenders and legacy device adapters can be interconnected in a ramified and extensive way. Then, the OMEGA network can be considered as a set of OMEGA devices, i.e. devices implementing the Inter-MAC layer described in the previous section. We refer hereafter as *legacy* the devices connected to the home network but not implementing the Inter-MAC.

Fig. 7 shows all the interfaces of the OMEGA architecture reference model. For simplicity, only one OMEGA device is shown. It represents a multitude of OMEGA devices connected by Ω links with Ω interfaces in a mesh topology. By reference to the documents from the ITU-T and from the Broadband Forum, the *U interface* is defined as the interface providing connectivity between the OMEGA network and the access network. The U interface relies on a broadband access technology, for instance, ADSL2+, VDSL2, FTTH GPON, CATV or WiMAX. In the same way, the *R interface* is defined as the interface ensuring the connection of legacy devices and networks (which do not support the Inter-MAC framework) to the OMEGA network. The R interface may rely on various home networking technologies such as USB, SCART, IEEE1394, Wi-Fi, UWB or Bluetooth.

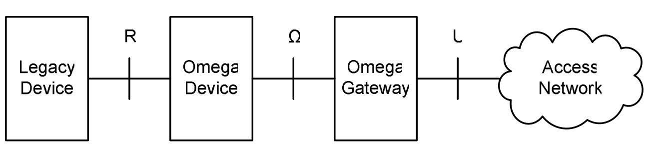

Fig. 7. Interfaces of OMEGA Architecture Reference Model

5 Conclusion

This paper describes the key challenges a home area network able to support future usages. These are exemplified by a typical 4 person's family. This implies an increase of the network bandwidth and a convergence among technologies to achieve seamless handovers and ubiquitous coverage in a heterogeneous environment.

We also explained how the inter-MAC solution and associated architecture proposed in the OMEGA European project is felt as one of the most promising solutions for the future.

All project results are captured in a number of public deliverables to disseminate these findings [1]. The OMEGA project is now ready to come to hardware/software design to produce an initial prototype of convergent home network in 2010. More advanced features will be simulated and evaluated so that a second version of the project prototype with advanced functionalities will become a reality before end of 2010.

Acknowledgement

Part of the research leading to these results has received funding from the European Community's Seventh Framework Programme FP7/2007-2013 under grant agreement n° 213311 also referred as OMEGA.

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