Initial Techno-economic Results for OMEGA Home Gigabit Networks

Michalis Fokas, Dimitris Katsianis, Dimitris Varoutas, Theodoros Rokkas
University of Athens
Department of Informatics and Telecommunications
Athens, Greece
mfokas@odt.uoa.gr, dkats@di.uoa.gr, arkas@di.uoa.gr, trokkas@di.uoa.gr

Jean-Philippe Javaudin, Martial Bellec, Gilles Goni
Orange Labs, France Telecom
Cesson Sévigné, France
{jeanphilippe.javaudin, martial.bellec, gilles.goni}@orange-ftgroup.com

Rafael Gonzalez Fuentetaja
Telefonica I+D
Madrid, Spain
rfg@tid.es

***Abstract*—The media richness of the services available to the end consumer has had a constant increase rate over the last century. This leads nowadays to the need of Ultra Broadband at home to handle future services such as 3D video that may reach the Gigabit per second. Moreover, beyond the bandwidth increase, the home network capabilities have to evolve in order to support new usages and to guarantee Quality of Service. This paper describes state of the art issues and typical requirements for the future home network and presents a solution fulfilling these requirements, based on an inter-MAC convergence layer. This solution is developed in the OMEGA FP7 project. It then provides initial results of a techno-economic analysis that studies the case of a hypothetical OMEGA Service Operator (OSO).**

Keywords: Home area networks, techno-economics, business cases, network convergence, Inter-MAC, network architecture

I. 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, which meets the customer's demands with respect to quality of service (QoS), reliability, throughput, ubiquity, and self-configuration (Fig. 1).

The success of this project will depend on a variety of factors and this document attempts to identify these factors and include them in a techno-economic (TE) analysis that aims to predict the financial perspectives of an OSO who will launch the OMEGA system into the market. The analysis aims to simulate the scenario through which this hypothetical operator's services will be delivered to the consumer and accommodates key financial outputs such as Net Present Value (NPV), Internal Rate of Return (IRR) and payback period to estimate the success or failure of the scenario. The results of the model include a detailed analysis of all the investments and the cost components of the operator, its operational expenditures, its revenues and the financial outcome as expressed by the financial indices mentioned above. The final result is an evaluation of the business prospects of Home Networking when it will be introduced into the market and an identification of the most critical parameters and factors that affect its chances of success in terms of time, demand and cost.

The rest of the paper is organized as follows: the typical requirements of a home network are described in section II and in section III a solution investigated in the OMEGA project is presented. Section III also explains the reference architecture of the OMEGA network. Section IV refers to the TE methodology followed in the construction of the model and section V presents the OSO business case. Section VI describes the assumptions and data that fed the analysis and section VII the corresponding results. Section VIII offers the final conclusions.

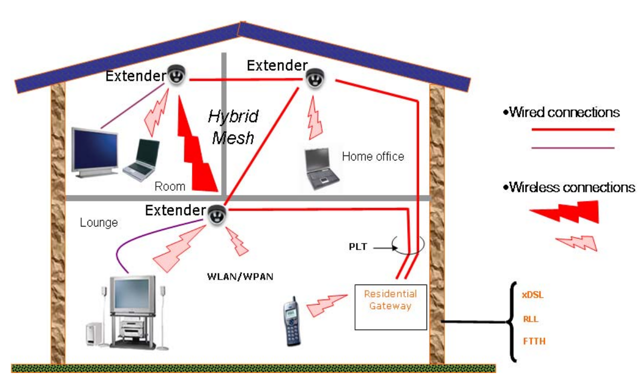

Figure 1. Gigabit home area network – OMEGA concept

II. Typical Home Network Oriented Requirements

Some scenarios have been defined in the OMEGA project [4–6] that correspond to the penetration of Broadband Access to the latest indoor terminals. The list of requirements for the network that can be derived from these scenarios is: (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. Intra-technology (Wifi 2.4 GHz / 5 GHz) but also inter-technology (Wifi / wireless optics / PLC / indoor fibre...) handovers need to be supported with equivalent performance. (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. Figures 2–4 below present use cases that illustrate some of these requirements.

Some network use cases are exemplified and it is of outmost importance for the OSO to operate them: (1) Discover or maintain the network topology so that the home network is monitored in order to make sure that it can transport desired services to the devices and (2) Performance of the (combination) of paths is also required as a key enabler to provide guaranteed QoS. Real time metrics may be the clue to trouble shoot outage or QoS degradation of the user experience, thus reducing installation and maintenance expenses.

III. Network Architecture and Inter-MAC Convergence

A. Main Goal

In order to fulfil the requirements on the home networks listed in section II, the OMEGA project developed a Layer 2.5 solution so-called Inter-MAC. The Inter-MAC layer [7, 17] 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. 5, 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.

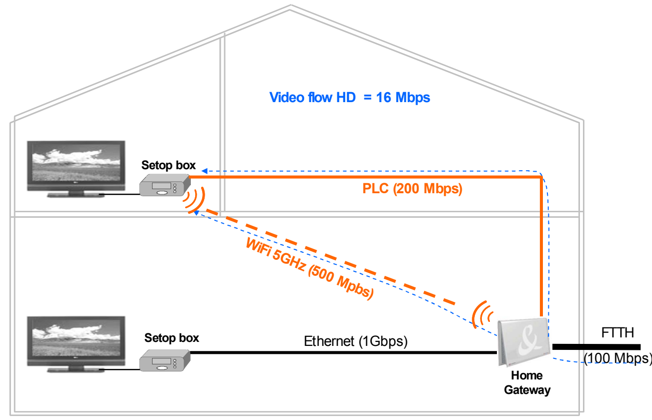

Figure 2. Illustration of the use case "selection of the best link"

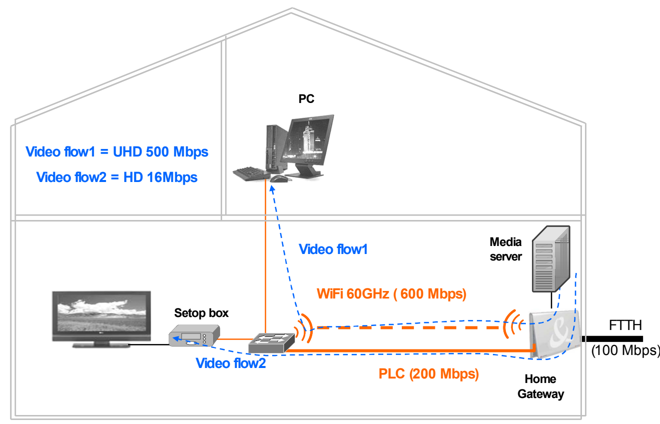

Figure 3. Illustration of the use case "using all links"

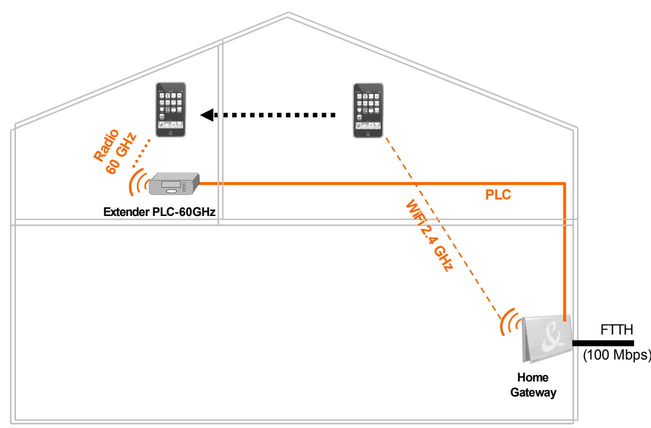

Figure 4. Illustration of the use case "nomadism inter-technology"

B. 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.

C. 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. 6, additional details about OMEGA architecture can be found in [8]. 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. 6 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.

The main components of the OMEGA network are the OMEGA Gateway (OG) and the OMEGA Extenders (Fig. 1). The OG is needed to interconnect the home network with the WAN. Thus, it operates as the boundary element between these two environments. Any information flow exchanged between the home network and an external network passes through the OG. The Extenders are devices used to extend the home network coverage and also allow seamless connection of different networking technologies by allowing communication between devices having different PHY interfaces.

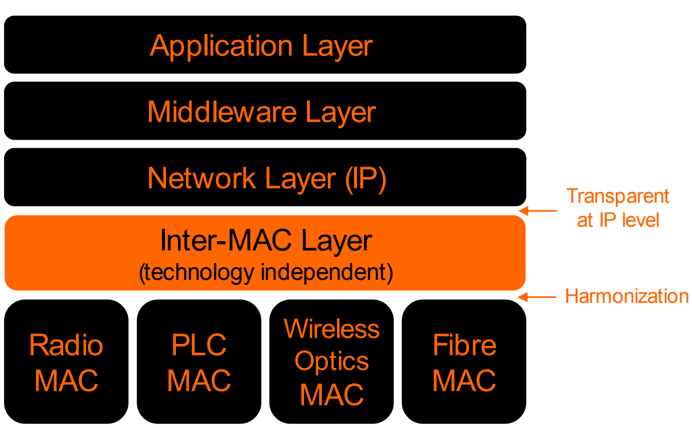

Figure 5. Inter-MAC Layer

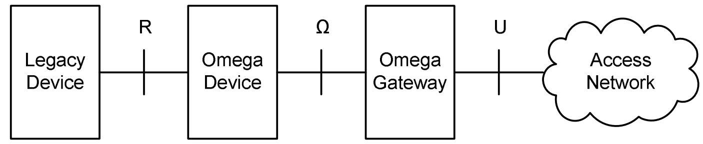

Figure 6. Interfaces of OMEGA Architecture Reference Model

IV. Main Techno-Economic Methodology

The TE methodology adopted for the evaluation of OMEGA technology is based on the TE tool developed within the IST-TONIC and the CELTIC/ECOSYS [10] European projects. The tool has been used for the evaluation of both wireless [11-12] or wired scenarios [13], in several case studies. A study period is first identified, best adapted to the case at hand. In most cases, a study period of at least seven years is used for the estimations regarding the profitability of the cases involving telecommunications players. In this case a study period of 8 years is used starting from 2011 and ending in 2018. Combining service revenues, investments, operating costs and general economic inputs (e.g. discount rate, tax rate) the TE tool can calculate outputs such as cash flows, Net Present Values and other economic figures of merit. Detailed overviews of the methodology can be found in the aforementioned references [11-13].

V. Definition of Business Cases

The home networks market involves many different players and a complex value network. In Fig. 7 a business model is described with all the participating players, relationship interfaces, revenue streams and cost drivers [14]. The direction of the arrows in the model represents the direction of service flow. Revenue flow is considered to be in the opposite direction. In some cases revenue sharing exists between two players, which is bidirectional. The ellipse represents a player. A player may take up one or more roles. The rectangular boxes within the ellipse represent the roles.

This business model describes the basic service provisioning scenario, where the user buys the service from the OMEGA operator. This operator provides telecom services like voice and video telephony and Internet access. In order to reach its customers, the OMEGA operator needs to buy network access and transport services from a network operator. The CPE distribution is directly taken care of by the CPE vendor. Revenue sharing deals may exist between the distributor and OMEGA operator (for subscription distribution).

As far as the provisioning of content is concerned, it can be done either directly by content providers or by the OMEGA operator. In this case, the OMEGA operator purchases wholesale content from various content players such as content providers and producers. The other case is that a third party such as the content aggregator provides content to the subscribers using the OMEGA operator's network capacity. A revenue sharing model can also exist between these players for content usage. Examples of content include news, entertainment, games etc. Value-added services can also be provided through the OMEGA operator by other players. Such services include location-based content, presence services etc.

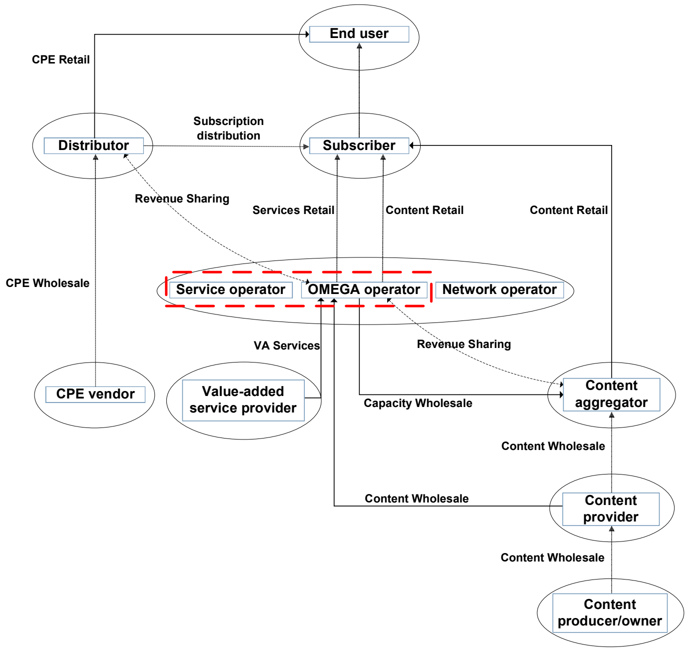

Figure 7. OMEGA Business Model

In this paper the following case is considered: the OMEGA operator is also a service provider (dotted red box). So the entity that is the focus of the ensuing TE analysis is a combination of these two roles presented above. This entity is called OMEGA Service Operator (OSO). Through business deals with a network operator and with content providers it reaches the customers to deliver its services.

VI. Assumptions and Model Description - Data

In this section there is an analysis of the data and the basic assumptions of the TE model.

A. *Geographic Definition*

In order to derive general results for the introduction of the Home Networking in Europe, the OSO is assumed to operate in a hypothetical average European country. This country's market characteristics in terms of population, number of households and number of rooms per household have been calculated so as to reflect the average of the following eight European countries: France, Germany, Greece, Italy, Slovenia, Spain and UK. The initial population of this country in the year 2011 (roll-out year) is about 42M (presenting a 0.04% yearly increase) and the number of households, which is the potential market, is 15.6M. The average number of rooms per household, which, as will be explained, will determine the number of Extenders used in a house, is 3.1. The data have been extracted from Eurostat's statistics database.

B. *Demand data*

Since the OMEGA will be launched in near future and no historical diffusion data are available in most of the European countries, the analysis was based on the historical analogies approach, according to which past diffusion shapes of other, similar, telecommunication and high technology products and services are appropriately used in order to estimate and forecast the expected diffusion shape of the considered innovation [15]. The devices that were considered as "similar" are: TVs, PCs, palmtops, notebooks, netbooks, mobile phones, and game consoles. The data, regarding these devices, were extracted from Eurostat's database. Corresponding results are illustrated in Fig. 8. Extender adoption is closely related to the adoption of OG. According to the network architecture, approximately one Extender is required per room. Based on this assumption the diffusion of the Extender can be forecasted by multiplying the diffusion of the OG by the average number of rooms. For the purposes of price forecasting the extended learning curve model [16] has been used. The advantage of the model is that it can be used even when limited data are available and even if past cost data are partially or totally absent, like in this case.

C. *Services and OMEGA products*

In this section a set of the offered application services and defined products are presented. The customer may choose from one of the following bundles of services: OMEGA Bronze, OMEGA Silver, OMEGA Gold and OMEGA Platinum. The services included in each packet are listed in Table I. OMEGA Platinum offers 5 more free TV channels and 10 free movies per month than the other packets. The tariffs have been chosen so as to reflect current prices in the market. The customer will also be charged with a connection fee of 60€. Throughout the years of the study these tariffs have been assumed to decline with an annual erosion of 5%. Over the years the distribution of users in the OMEGA packets will change, the first years that these packets are introduced most of the users will prefer the lower priced packets but later on a migration to the expensive ones is expected [12].

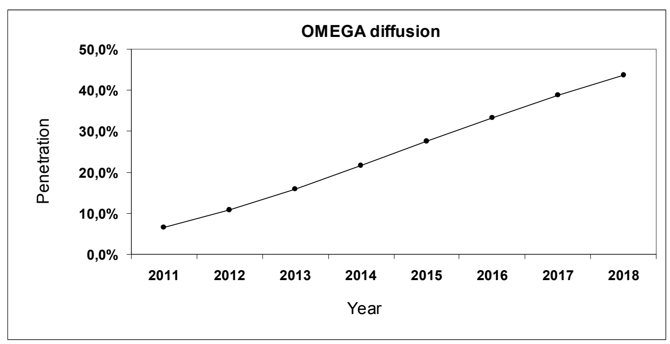

Figure 8. Average OG diffusion in average country

TABLE I. OMEGA PACKETS

	Services included						Initial Prices
	VoIP	*Videophony*	*Broadband access*	*Digital TV*	*Digital TV channels*	*Video on Demand*	
OMEGA Bronze	X		X			X	18€
OMEGA Silver	X		X	X		X	25€
OMEGA Gold	X	X	X	X	X	X	35€
OMEGA Platinum	X	X	X	X	X	X	45€

D. Content provision

During the first year when OMEGA technology will be launched 40 Digital TV channels will be available to the subscribers of which 20 will be freely provided to the OSO as a result of the agreements with the content providers. By 2018 the total number of channels will reach 100 (50 free). Also, every subscriber will have a choice among a variety of movies. For these movies and the initial channels fees will have to be paid to the content providers for copyright. In addition, the OSO will pay 70% of the revenue produced by every movie watched by the subscribers (the cost of movie to the subscriber is 1.5€; every subscriber downloads 5 movies per month and is charged extra, except for the platinum users).

E. Operational expenses (OPEX)

The OSO will be incurred with operational expenses, to assure the proper delivery of its services. These expenses entail the payment of its employees and also the cost for their initial training. In detail, there are three types of employees: executives, engineers and call centre employees. It is assumed that there is a need for one engineer and one call centre employee for every 2,000 subscribers. Additionally, the enhanced information gathered in the OMEGA home networks for management purposes may also be exploited to ease network remote management and network care made in call centres. This can allow a reduction of the OPEX related to these centres. Since it is not yet quantified, this OPEX reduction is not taken into account in this study.

VII. FINANCIAL RESULTS

In this section the results of the TE model are presented and analyzed. The results include a detailed analysis of the investments and the cost components of the OSO, its operational expenditures, its revenues and the financial outcome as expressed by the NPV, the IRR and the Payback Period. In order to calculate discounted cash flows, which take into account the time value of money, a discount rate of 10% has been used. This value is a mean value among the major European Telecommunication Operators for similar projects. The tax rate has been chosen to be 30%.

A. Investment analysis (CapEx)

During the 8 years of the study period the OSO will have to invest in equipment and retail points which are outlets from which its services will be purchased. Since it doesn't own any network infrastructure there must be an agreement with a network provider for the use of its network resources. The equipment, namely the OG and the Extenders will be provided for free to each new subscriber, in order to make the offerings more appealing. Therefore their cost will be entirely covered by the OSO. There is also a need for the purchase of servers for the delivery of video services. In Fig. 9 there is a detailed rendition of these investments throughout the study period. As it is expected there is a significant decline until the year 2018. It is obvious that the costs of the OGs and Extenders dominate the operator's expenditures. Therefore the agreements with the equipment vendor are extremely critical in determining the investments undertaken by the OSO.

B. Operational expenses

Operational Expenses include employee, content delivery and marketing costs, equipment installation cost and administration cost. In Fig. 10 these costs are broken down and presented in detail so that a clear picture can be drawn regarding the basic cost drivers of the OSO. It is obvious that operational expenditures are dominated by the cost of content provision to the subscribers and the cost of employees. Therefore the negotiation with the content providers for better agreements as well as the reduction of the hot lines operation costs is the most critical aspect for lowering the costs of the OSO.

C. Financial indices – General results

The overall profitability of the OSO is analyzed and discussed in Table II and in Fig. 11 through the use of the financial indices that have been stated above. The model calculated a Net Present Value of 34,495,144 € and an Internal Rate of Return of 12.56%. The payback period is 6.69 years, which means that a time length of more than six and a half years is needed so that the overall investment will pay off and generate real revenues (profit). A sensitivity analysis was performed, but due to space restrictions could not be included. It must be mentioned however that the three factors that affect results the most are in order of importance: the monthly tariffs of the packets, the OSO's market share and the level of employee salaries.

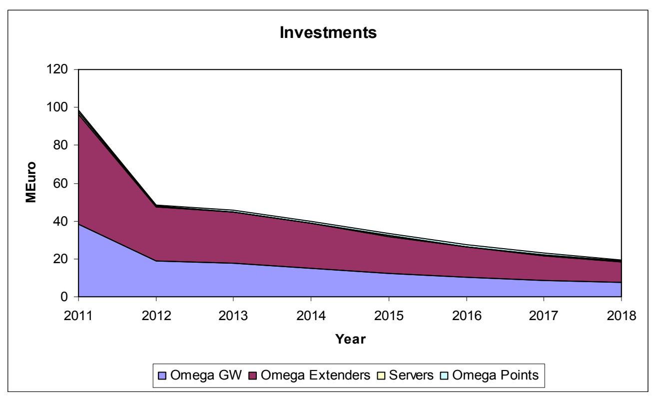

Figure 9. Investments

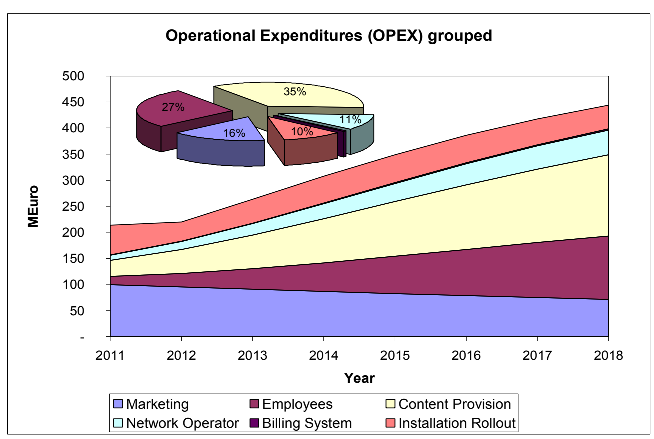

Figure 10. Operational Expenditures (2011-2018), in groups

TABLE II. FINANCIAL INDICES – GENERAL RESULTS

Parameter	Value
NPV	34,495,144 €
IRR	12.56%
Payback Period (years)	6.69
Number of subscriptions in 2011	337,718
Number of subscriptions in 2018	2,319,724
Total Investments	297,949,960 €
Total Running Cost	2,499,124,224 €
Total Revenues	3,171,344,911 €
ARPU (Monthly in 2018)	24 €
NPV (before taxes)	134,801,941 €
IRR (before taxes)	18.9%
Rest Value	47,583,333 €
Maximum Finance needed	277,787,494 €

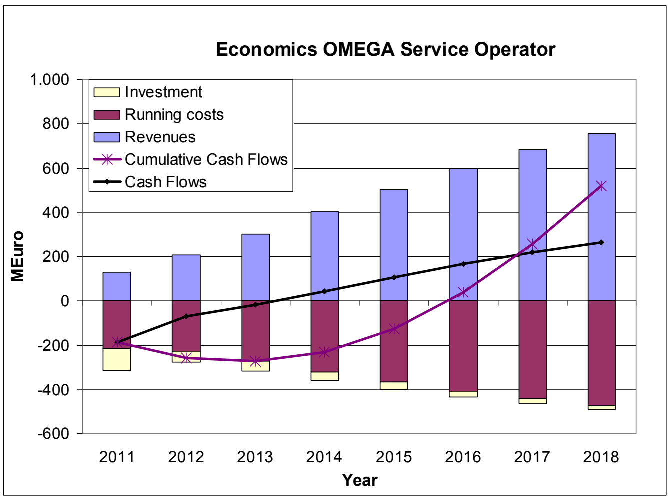

Figure 11. Main economic results

The OMEGA technology shall also leverage the OSO margins when compared to the current situation, thus adding potential gain, through the following ways: (1) by leveraging content consumption: by introducing extenders more devices are "reachable", thus the content consumption will be higher, since the maximum number of simultaneous content consumption will be increased, ideally by the factor of the available devices. So, including the distribution of content among friends, an increase in the number of hours of content per day per family member can be expected. (2) By reducing the OSO's OPEX: with OMEGA technology, the end user will have the capability of self care trouble shooting and in addition for the highest level of maintenance, there shall be enough information about the home network status, so that the operator may quickly provide a solution. (3) Reliability means TURBO consumption: An additional "loop back" phenomenon may happen. Given the feeling to the end customer that the home network is reliable, there will be no more suspicion that e.g. the VOD may be stopped during the show, thus causing further "confident" consumption of the contents.

VIII. CONCLUDING REMARKS

Home area networks face some key challenges today. Future usages imply an increase of the network bandwidth and a convergence among technologies to achieve seamless handovers and ubiquitous coverage in a heterogeneous environment. 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. This article presented the TE study undertaken for the Home Networking roll out as described in OMEGA project. The model simulated the scenario through which an OSO provides services to its subscribers through business agreements with content providers and network operators. Outlining the findings of this effort, acceptable business opportunities can be observed through these calculations. OMEGA can be even more attractive for an incumbent operator that seeks to keep its market share or even increase it with new subscribers who want to enjoy OMEGA's capabilities. European operators and service providers interested in entering the future digital Home Networks' market can exploit this information. The overall results of the work concerning the economic viability of the OSO are positive and forecast a profitable entry in the home networking market.

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