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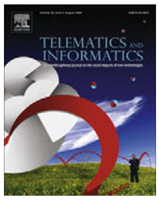

Business modeling and financial analysis for Metropolitan Area Networks: Evidence from Greece

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A B S T R A C T

A sustainable business model is necessary for viable and future proof fiber-based Metropolitan Area Networks (MANs), in light of FTTH/O developments, which necessitate public initiatives, towards the leverage of broadband adoption. Following a detailed analysis and benchmarking of international practices, a pool of business solutions for the MANs development, especially for the Greek case, is presented. Taking into account pros and cons, a set of four appropriate business models is analyzed, and a quantitative financial analysis concludes the findings. Guidelines for the further development of these initiatives, useful for other countries with low broadband penetration, are presented and discussed.

1. Introduction

Demand for higher bandwidth is rapidly increasing world widely, as fuelled by Internet-based TV, video streaming and file sharing/downloading. This demand is currently served by copper-based (xDSL) and wireless (mainly WiFi and 3G) connections, but in light of new services, such as High Definition TV, online gaming, multicasting, and remote surveillance, telecom operators and service providers are well advised to seek access network solutions that can support higher bandwidths for the end user. However, the existing communication solutions such as xDSL and WiMAX in fixed and fixed-wireless communications, respectively, or Long Term Evolution (LTE) in future mobile technology, reach their limits faster than initially estimated, mainly because of their limited physical transmission properties. Therefore, the safest investment to achieve sustainable high bandwidths in access networking is, for the time being, the fiber optics (Green, 2004). For this, telecom operators and service providers are compelled to push fiber closer to their customers and Fiber-to-the-Home/Office (FTTH/O) deployments are probably the ultimate solution for future broadband access networks (Benjamin et al., 2001). In addition to the FTTH/O cases, the cases of Fiber-to-the-Curb (FTTC) and Fiber-to-the-Building (FTTB), which utilize the existing copper-based network, are fuelling the demand for fiber-based installations in a Metro Access level, in order to serve the concentrated traffic caused by the end users in urban areas.

The European Commission (EC) addressed these issues early and indicated the necessity of broadband development in all member countries, aiming to offer "an Information Society for all" citizens by adopting the "i2010" Policy Framework in June 2005 (EuropeanCommission, 2005). The "i2010" aims to "*promotes the positive contribution that information and communication technologies (ICT) can make to the economy, society and personal quality of life*" and therefore to address the manifold Information Society issues. In response to this policy, "*Member States through the National Reform Programmes … should define*

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Information Society priorities ..., which stress the importance of ICT uptake, ICT infrastructure .... These programmes could help Member States to ... adopt ambitious targets for developments of the information society at national level." (EuropeanCommission, 2005).

As the main issue for "an Information Society for all" remains the lack of competition in infrastructures, any attempt for ICT uptake and infrastructure development is bounded by the required investments, which are still remaining a major obstacle for the private sector (Crandall, 2005). Although the development of fiber-based networks closer to the end-user incorporates many advantages especially for urban and rural areas (Lehr et al., 2006; Firth and Mellor, 2005), due to their economical growth (Ramaswami and Sivarajan, 2001), the associated risks in these investments discourage the telecom operators and service providers (Monath et al., 2003) to invest. As a consequence, broadband infrastructure competition remains low, although this kind of competition has an important and positive impact on broadband development (Höffler, 2007).

In this fashion, the role of governments, regulators and local authorities appears as key players or broadband stakeholders in rising broadband infrastructure competition. The importance of governmental initiatives towards the encouraging of ICT investments and uptaking is of paramount importance (Picot and Wernick, 2007). Local Loop Unbundling as a medium-term measure for BB uptake in an infrastructure monopoly is critical but infrastructure competition through public subsidization should follow as medium intervention strategy (Cava-Ferrerula and Alabau-Munoz, 2006).

Among the large number of investments that have been made in fiber optics networks, FTTx is one of the most rapidly evolving European markets (Gruber and Ramaswami, 2000; Ireland's NDP, 2006). The European investments in fiber networks are underway and telcos are already operating FTTx/xDSL networks and making plans regarding FTTH/O deployments. Through its decisions, which include financial support, prosperous telecommunication policy, etc., the European Union contributes to the development of the necessary telecommunications' infrastructure across its member states, including Greece. Since these infrastructures should be effectively operated, business modeling must be applied, in order to ensure a future-proof solution (Casier et al., 2009).

Greece holds one of the lowest positions in the European map, in terms of broadband penetration, as broadband diffusion in the country is still in its early stages of growth, having a penetration level of 13.53% (Eurostat, 2008). Subscribers claim that broadband services in Greece are too expensive and limited, as compared to the rest of European member states. The reason for this slow development is probably due to the lack of co-operation between the state itself, the private sector and the citizens (Observatory for the Greek IS, 2008).

There are two major directions in the work presented in this paper. At first, it aims to define and develop business models for operating open access fiber optics MANs, proposing the most appropriate for the case of Greece. To achieve this, the internationally used business models were initially studied and four of them, which were considered as the most appropriate for Greece, were proposed, after performing the necessary modifications. These models were derived by composing the relevant studies of the Greek state Technical Support Consultants, one for each of the 12 Greek regions excluding Attica and Thessalonica, as well as by an opinion survey of experts in the area of broadband networks.

The importance of this approach lies in the fact that similar conditions, in terms of social and economic characteristics, hold for several new entrant member states of the European Union, especially for the countries of South-Eastern Europe, in both demand and supply sides. More specifically and regarding the demand side, these countries present similar demographic and regional characteristics as, for example, same population sizes, densities and growth rates, similar ICT skills and resources to take advantage of broadband services, as well as similar low levels of broadband penetration. On the supply side, the costs for the development of the necessary network infrastructures, the lack of knowledge and experience in operating such networks, the availability of services, the policy environment in terms of the forms of local governments and communities' finances are quite similar between the Greek regions and the regions of the aforementioned countries. Consequently, it is very probable that the analysis and the results of this work can be applied to these countries as well.

As a second direction, this work analyses the investments of MAN service providers (SPs), from the perspective of viability and profitability, performed in two steps. As a first step, a cost-oriented technoeconomic financial analysis is conducted, by evaluating the cases of either each municipality performing alone or clusters of municipalities performing as a single business realization. The proposed business model is examined from a service provider's point of view, in order to evaluate the corresponding economies of scale, in the context of the administrative structure of Greece. As a second step, the optimal combination between demand and market share is calculated, for all considered regions, seeking to derive a minimized (equal to zero) Net Present Value (NPV) of the network within a certain, predetermined, period of time. Following this, a sensitivity analysis is performed between total service demand and a provider's market share, in order to calculate the minimum threshold each time that makes the investment attractive for the provider.

2. Business models for Metropolitan Area Networks

In this section, an analysis of world wide frequently met business models, deployed for the development, operation and maintenance of fiber-based open access MANs, is presented and discussed, in order to reveal the most appropriate for the Greek situation.

In the context of the Operational Program "Information Society" and the action "growth of broadband networks for local access", the largest municipalities across 12 Greek regions are funded to deploy and operate broadband networks by the end of year 2009. Following this, the construction of fiber optics Metropolitan networks in less developed regions is decided and specifically in 75 participating municipalities with at least 10,000 inhabitants. Both Attica and Thessalonica, where more than half the country's population is concentrated, are excluded from this initiative. The 75% of the financing comes from the above European Union funding and 25% from national sources. The total cost of the project is 65M€ (without expansions), with the participating into this initiative municipalities being the legal owners of these infrastructures. The initial subscribers will be the public sector with at least 20 points of presence in each municipality, connected according to the project. All networks will be open access and the availability of the infrastructure should be cost-effective (InformationSociety, 2007b). The development and operation of these networks would be based on a complete business model. For this, the Technical Support Consultants, one for each participating Greek region, are commissioned to provide their suggestions.

A business model should determine the following (Parr Rud, 2001):

- The layers of the network.
- The owner of each layer.
- The administrator of each layer.

All the above Metropolitan networks are currently deployed by local authorities in order firstly to provide basic access to governmental buildings and secondly to offer open access networks, for all telecom stakeholders on a transparent equal-opportunity cost-oriented basis. As stated previously, the main objective of this initiative is the development of infrastructure competition in the served areas, in order to increase the service level for the benefit of the end users. Therefore, the business models and the associated technoeconomic analysis should be seen from the service provider point of view, in order to ensure the market success and the sustainability of the initiative. Open access networks provide wholesale access for service providers (telcos, ISPs, media providers, etc.) or any third party willing to lease a part of this infrastructure. The typical service basket will most likely be a triple-play service (voice, data and video) but an evolution to quadruple-play portfolio can be also foreseen in the long-run, by including mobile or fixed-mobile converged (FMC) services.

The open access infrastructures can be modeled as three-layer architectures, comprising of the passive, the active and the service layers. The passive layer consists of the ducts, the microducts and the dark fibers, whereas the active layer includes any type of active network equipment, such as switches, routers, modems, optical multiplexers and demultiplexers. Finally, the service layer comprises of basic, advanced and value-added network services, even media and content ones. Therefore, a complete business plan should incorporate all aforementioned network layers, from the passive layer up to the service level, which will be open to providers for broadband service provisioning (Bouras et al., 2009). Consequently, the analysis of the business models which follows concerns the infrastructure, network and service providers and offers a framework for the investigation of their roles, potential market opportunities, ownerships and the potential transactions (Owen and Raj, 2003).

2.1. Public Private Partnerships (PPPs) in the active layer

The main characteristic of this business model is that the active layer will be administrated and operated by a Public Private Partnership (PPP). The "PPP in active layer" model will be implemented in two phases. At first, municipal authorities which own the passive layer are responsible for network design, construction, maintenance and future expansions. During this phase, they provide broadband services to end users and, consequently, operate all network levels. Thus, in the case where no other ISP is interested in meeting the aggregate and increasing demand for services, especially for the public sector, municipalities which own these networks may start up a full ISP operation by themselves. The main drawback in such a business scenario is often the lack on know-how and "culture" for commercial competitive responsibilities. Thus, they may outsource this operation to (or cooperate with) an experienced third-party operator. In this case, municipal authorities participate to the PPP, by leasing the whole passive layer to the PPP, which defrays the operational cost of the active layer.

The PPP will be established between municipalities and private companies. The latter will offer the active equipment, the associated network management and the provisioning of IT platforms. The PPP will be responsible for network operation, administration, and maintenance as well as for the marketing and business administration activities. It will sell access to the service providers and in return PPP revenues will come from the rental fees of ISPs using the PPP infrastructure.

During the second phase of this "PPP in active layer" model, municipalities will stop offering broadband services on their own, after a short period of time – six or more months – when competition on service level is expected to be developed in an adequate and sustainable level. All players' decisions should be made in such a way that they do not limit or obstruct competition and networks' expansion.

As most of the municipalities which develop such MANs are usually small, in terms of population, an effective approach to gain economies of scale would be to proceed into joint actions, in a regional or even wider level. But the scheme should be carefully discussed, especially regarding the way the municipalities will participate.

The whole model, which is depicted in Fig. 1, has been successfully applied in a similar way in Amsterdam (Bbned, 2007; Chew, 2006) and Rotterdam (City of Rotterdam, 2007; SURFnet, 2007).

2.2. Private initiative in active layer

This model is characterized by the openness of the active layer to competition, in the sense that private companies may lease the passive infrastructure owned by the municipalities, invest in active equipment and provide access to SPs or become

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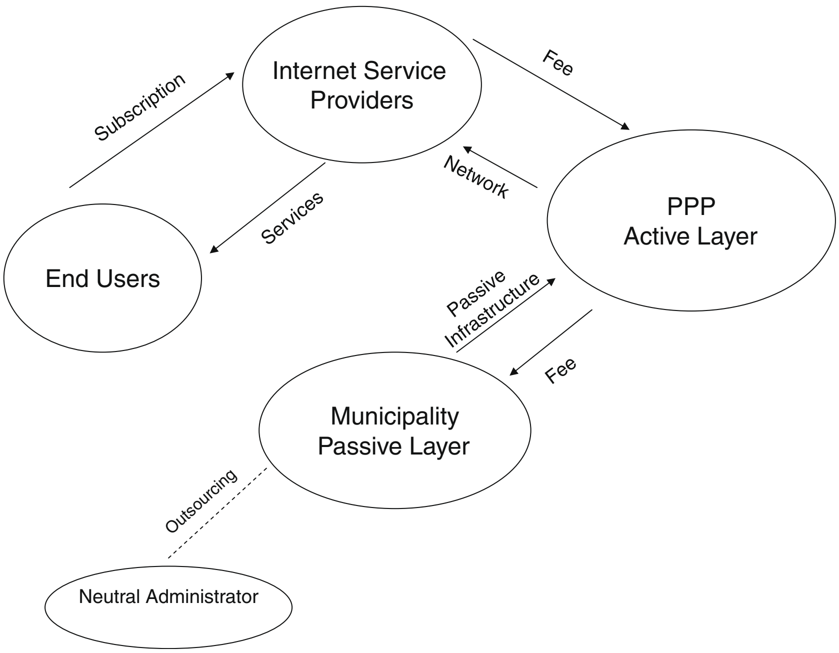

Fig. 1. The "PPP in active layer" business model. Municipalities own the passive layer, but a PPP is established for the deployment of the active layer and the business transactions with the service providers.

a provider itself. Municipalities, due to the lack of the necessary know-how and expertise, may assign the administration to a neutral (independent) third party which has the adequate experience. The third party is responsible for operating, maintaining and expanding the fiber and ducts' installations, on behalf of local authorities. In addition, the neutral administrator has to guarantee broadband connections for the public organizations and collect the fees from active network providers. The above-described scheme is illustrated in Fig. 2.

The neutral third party, acting as administrator of the passive layer, should ensure the openness of the fiber plant, by limiting the entry barriers to enter the market thus enhancing competition. Specific obligations about the neutrality of this administration, as well as cost-oriented and effective operations should also be applied, in order to ensure cheaper and affordable broadband services to the end user. A long-term agreement should be established between the neutral administrator and municipalities, in order for the former to have the necessary time to develop its market plans.

In the case of joint actions among municipalities, the third party administration will probably benefit from economies of scale, but a wrong decision-making process may eliminate these advantages.

2.3. Public ownership-outsource administration

In this model, municipal authorities own both passive and active layers of the infrastructure. Therefore, they should raise funds for construction, maintenance and expansion of the networks. The lack of previous experience in such activities is more critical in this model. Thus, a third party is required for each network or a group of networks. Two options can be foreseen; either an outsourcing to a private company or the founding of a specific entity, which directly operates these networks. The business roles of this model are illustrated in Fig. 3.

The neutral third party which acts as an administrator will provide open access, on equal terms, to all SPs. The latter should pay a rental fee to the administrator, on a cost-oriented basis, from which the municipalities' revenues will derive.

Under this business model, important investments are required on behalf of the municipalities which should meet the financial requirements on their own. However, the simplicity of this model ensures functionality, competition enhancement and operational effectiveness, as there is only one part responsible for the decision-making process.

2.4. PPP in infrastructure

According to this business model, municipalities and private sector will work together through a Public Private Partnership (PPP), administrating both the passive and the active layers. In the cases of joint actions, all the involved municipalities will decide in common for their private associates that will take part in the PPP. They may come from a variety of business fields such as construction, management, consulting, and advertising. The above are illustrated in Fig. 4.

However, municipalities remain the legal owners of initial infrastructure, the use of which is transferred to the PPP.

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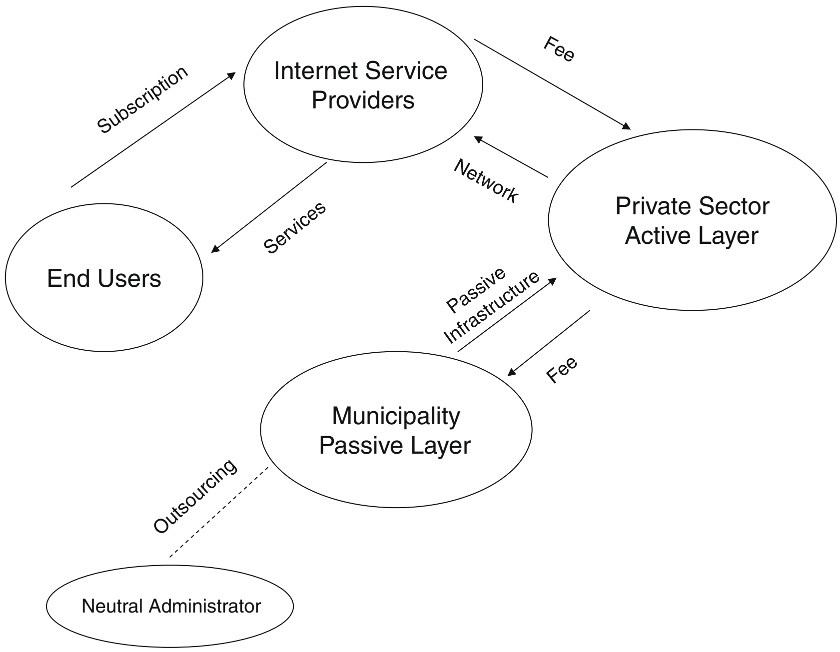

Fig. 2. The "private initiative in active layer" business model. Municipalities own the passive layer of the MAN, which is operated by a neutral third party which acts as an administrator. The active and service layers are to competition by private companies.

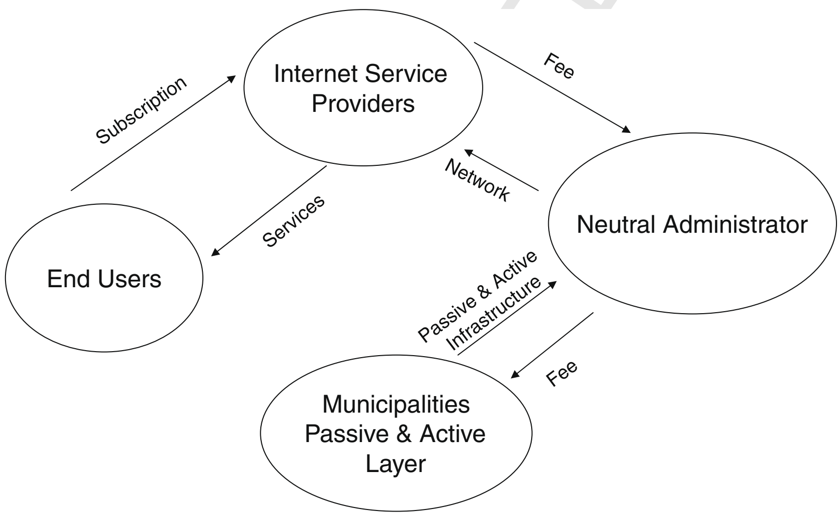

Fig. 3. The "public ownership-outsourcing administration" business model. Municipalities own passive and active layer as well. They outsource the operation of the infrastructures to a neutral administrator, which is responsible to transact with SPs.

A detailed agreement should be made between municipalities and private companies participating in the PPP in such a way that responsibilities will be clearly distinguished and no operational gap will show up. Revenue sharing should also be clearly stated.

The PPP company will have the responsibility for the business relations with SPs on a transparent basis and the pricing schemes should be clearly agreed.

Municipal authorities will not be involved in the network operation, which will be run from the private participating companies. This collaboration will bring, aside from economic benefits, a more efficient and citizen-centric public operation, as municipalities participate in both the passive and the active layers. Municipalities and their private associates should agree on a revenue-shared model that will give economic benefits to municipalities and guarantee their participation towards the expansion of the networks initially built.

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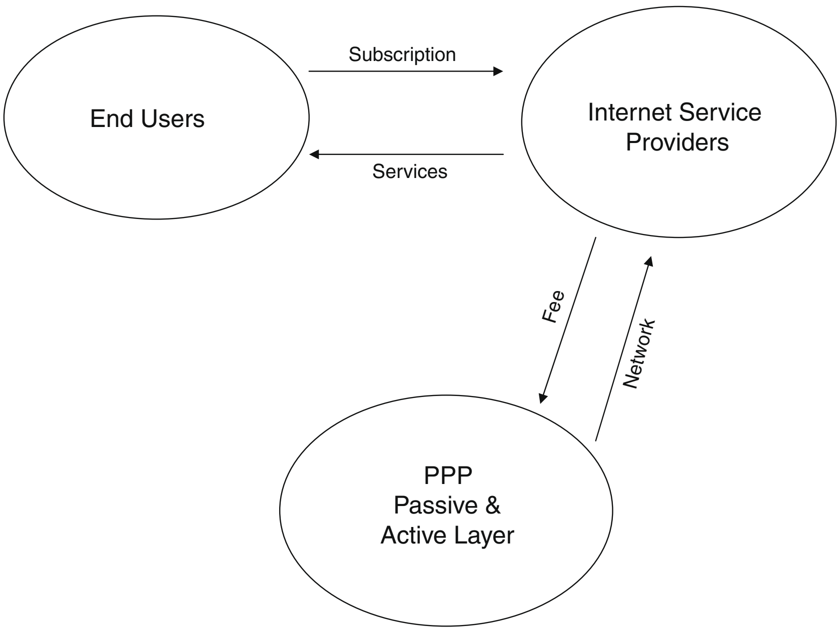

Fig. 4. Business model "PPP in infrastructure": in this model municipalities participate in a PPP which administers both passive and active layers. PPP will take the responsibilities to operate infrastructures and transact with SPs.

This model has been applied, in a similar way, to many MANs cases such as UTOPIA project (Marinkovich and Sybrowsky, 2003; UTOPIA, 2006), Stockholm (AB Stokab, 2006a,b), Almere (Cisco Systems, 2004; Sara, 2005), Sollentuna (Ericsson AB, 2002a; Sollentuna Energi, 2002), Reykjavik (Gislason, 2004; Rosen, 2004) and Hudiksvall (Ericsson AB, 2002b; Hudiksvallsbostäder, 2007).

3. Qualitative analysis

The evaluation of the above business models is of paramount importance for a successful sustainable exploitation of the MANs to be built. A qualitative analysis with a number of criteria, introduced by the Greek state Technical Support Consultants and other experts in the area of broadband networks, is needed and therefore performed hereafter.

The 10 criteria used are as follows: social aspect of pricing policy, complexity, transparency, total value of networks, risk and required investments, technological dependency, required knowledge, competition, operational effectiveness, and architectural flexibility.

The criterion regarding the *social aspect of pricing policy* has been introduced, aiming to identify the business models which better ensure an affordable price to both wholesale and retail services offered. Although a cost-oriented rule has been enforced during the implementation of the networks, different advantages and disadvantages could be identified in each model, as described above.

The *complexity* factor, which in many cases is proportional (or even exponential) to the number of players and stakeholders involved in any business model, reflects the difficulties introduced in the consensus-building and decision-making processes.

Transparency refers to the provision of comprehensible, accessible and in timely manner objectives of policy to the public in order to increase citizens' confidence, which in turn will lead to demand raising.

Although the commercial value of networks is similar in all business models discussed, the *total value* factor is greater when municipalities have a more active role, since the social and political aspects of the initiative are better served.

As far as the *risk and the required investments* are concerned, they reflect the market risks and the investments required from the municipalities' point of view. It is obvious that the greater the share to which municipalities participate in the network ownership and operation, the higher the associated risk and capital expenditure required.

Technological dependency is related with the business models in the active layer, where the necessary equipment is characterized by faster obsolescence, in contradiction to passive layer where fiber and ducts/microducts are characterized by a longer life cycle and thus can be written off in the foreseeable future.

Regarding the *required knowledge*, business models incorporating outsourcing activities (administration, operation, etc.) have a definite advantage over public administration, due to previous experience of the private sector. Municipalities could decide to keep a high-level of involvement and outsource the administration and operation of the networks, although they should have the required knowledge to evaluate the administrators' decisions.

On the other hand, the decisive role of the private companies in the active layer could pose barriers to *competition*. Furthermore, the models having a complexity in the required procedures to be performed on behalf of the SPs, could also harm competition.

Operational effectiveness will depend on network operation and planning, where the private sector can be more effective. This factor is directly dependent on the effective utilization of the developed networks.

Finally, as fiber optics networks are considered as state-of-the-art future-proof infrastructures, any active equipment deployment and the related models will be susceptible to lock-in effects and thus will be characterized by lower *architectural flexibility*.

Table 1 summarizes the performance of the proposed business models, with respect to the above-described and -discussed criteria.

According to the above qualitative analysis, the "PPP in active layer" business model seems to highly satisfy only 2 of the 10 criteria, which are "social aspect of pricing policy" and "transparency", whereas it significantly fails to satisfy three of them ("complexity", "competition" and "operational effectiveness").

The "private initiative in active layer" seems to highly satisfy seven factors, in particular "transparency", "social value of networks", "risk and required investments", "technological dependency", "required knowledge", "competition" and "architectural flexibility". On the other side, it fails significantly to satisfy only one factor, which is "social aspect of pricing policy".

The "private ownership-outsource administration" business model seems to highly satisfy four criteria, particularly "social aspect of pricing policy", "complexity", "competition" and "operational effectiveness". On the contrary, it fails significantly to satisfy four criteria, which are "transparency", "risk and required investments", "technological dependency" and "required knowledge".

Finally, the "PPP in infrastructure" business model seems to highly satisfy only one criterion, that is "complexity", but it fails significantly to satisfy five ("social value of networks", "technological dependency", "required knowledge", "competition" and "architectural flexibility").

Based on the above analysis, it can be concluded that the "private initiative in active layer" is the most appropriate model for such networks, taking into account the above-described criteria. Especially in the case of Greece, where most of the funded municipalities are located in less developed regions, this model will ensure low risk and required investments, low level of responsibilities on behalf of municipalities, high-level of competition and the advantage of learning, by companies having the adequate know-how.

4. Financial analysis

This section is devoted to the evaluation of the optical MANs in Greece, in terms of their viability and profitability. The corresponding analysis is performed taking under consideration a number of conditions, like the number of providers offering services over these MANs and the expansion of the initial networks, with or without additional subsidization for the government. The viability of these networks, from the service provider point of view, was examined according to two scenarios, the first one assuming that municipalities operate their MANs independently (scenario A) and the second assuming that groups of municipalities cooperate, in the context of an administrative region, in order to operate a common network (scenario B).

The technoeconomic analysis was performed for the most appropriate business case (private initiative in active layer), derived from the qualitative analysis of the previous examined business models. Its characteristics were incorporated into the corresponding technoeconomic model, including all the factors affecting the profitability of the Municipal Optical Networks (e.g. Capital Expenses – CAPEX, Operational Expenses – OPEX, demand for services, etc.). The analysis was based on real data, describing the installed MANs of an average sized region, in terms of population and demand for services (i.e. the region of Central Greece).

The main assumptions for this technoeconomic analysis are:

The initial networks offer 35% coverage in each municipality (network expansion decided in January, 2009).
Municipalities will expand the initial infrastructures in 2 years, so that networks will offer 100% coverage through FTTCurb (with VDSL connectivity).

The discount rate for the analysis was set at 10%, which is a typical value of such projects among the major telecommunications operators (Olsen et al., 2006).

The analysis of the two scenarios (A and B) includes the required CAPEX and OPEX for all the players, as technoeconomic analysis is based on the determination of these factors along with operation costs (Ims, 1998; Katsianis et al., 2001; Olsen et al., 2006).

- *CAPEX include: office* requirements (software licenses i.e. CRM/ERP/desktop software and desktop computers), coverage cost (fiber), active equipment will be covered by the telecom operators.
- *OPEX* include: employees, training, space rental (offices, etc.), maintenance for passive network, administrative expenses (personnel).

Table 1
Business models' evaluation: in that table each one of the driving factors which influence the efficiency of a business model is evaluated.

	PPP in active layer	Private initiative in active layer	Public ownership-outsource administration	PPP in infrastructure
Social aspect of pricing policy	High – municipalities participate, in a larger extent, in ownership, administration and pricing of almost the whole infrastructure	Low – municipalities own, administrate and price only passive infrastructure	High – municipalities own, administrate and price the whole infrastructures	Medium – municipalities share ownership, administration and pricing with private partner
Complexity	High – the substantial number of involved parties increases the complexity with respect to required agreements	Medium – the expansion of competition to the active layer necessitates agreements concerning the installation of active equipment	Low – the number of involved parties is limited to the outsource administrator and SPs	Low – the number of involved parties is limited to the PPP administrator and SPs
Transparency	High – municipalities' participation in passive and active infrastructure would ensure transparency	High – municipalities' participation in passive infrastructure would ensure transparency	Low – the small number of decision makers reduces transparency	Medium – municipalities' participation as partner in PPP would ensure an acceptable degree of transparency
Social value of networks	Medium – municipalities will have the complete authority to deploy the networks in a social view	High – municipalities will enhance the social aspect of networks	Medium – external administrators could limit the social aspect of networks	Low – private partner in PPP will promote mainly commercial plans
Risk and required investments	Medium – municipalities will cover all required investments in passive infrastructure	Low – municipalities will invest only in development of passive infrastructure	High – municipalities will cover full cost for both passive and active infrastructures	Medium – municipalities will share full cost for both passive and active infrastructures with private partner in PPP
Technological dependency	Medium – municipalities will invest in passive and partially in active equipment	Low – municipalities will invest only in passive equipment	High – municipalities will invest in both layers, passive and active	High – municipalities will invest in both layers, passive and active
Required knowledge	Medium – municipalities should take decision concerning mainly the passive infrastructure but partially for active infrastructure	Low – municipalities should decide only for passive layer	High – municipalities should evaluate administrator's decisions regarding passive and active layers	High – municipalities should participate in decision making equally to private partners in PPP regarding passive and active layers
Competition	Low – the number of involved parties is a deterrent factor for SPs	High – municipalities own only passive infrastructure and higher layers are open in competition	High – public ownership in active and passive infrastructures would keep prices in a cost-oriented basis enhancing competition in service layer	Low – the ownership of passive and active infrastructures could lead to a vertical integration limiting competition
Operational effectiveness	Low – municipalities usually operational less effective are involved in the administration of both passive and active infrastructures	Medium – municipalities would keep an observatory role in operation as they own only passive infrastructure	High – operation would be more effective as private sector has previous experience and required knowledge	Medium – operation in both active and passive infrastructures would be influenced by municipalities as partner in PPP
Architectural flexibility	Medium – networks' development will be defined by PPP in active infrastructure and by municipalities in passive one	High – the development of passive networks gives to SPs the choice to develop active infrastructure independently	Medium – outsource administrator will design networks based on municipalities' directions	Low – networks are designed by PPP in order to supply needs specified mainly by private partner

The main difference between the two scenarios A and B is the construction cost of the Optical Network. The municipalities could gain approximately 20% of the total infrastructure cost in the case of joint action in the region (scenario B), each region including about 8–12 municipalities. In addition, Operational Expenses could be also less for a joint effort (i.e. a single contract for a common neutral administrator).

Scenarios A and B are evaluated under two different alternatives. Municipalities can expand initial networks, either through own investments or by claiming extra subsidization. For each municipality the following are evaluated, based on real data and mean values (customers per employee) arising from major European Telecom Operators (CELTIC-ECOSYS, 2002–2006):

- Installed fiber path length (fiber always comes in a pair, up link–down link).
- Networks CAPEX and OPEX.
- Mean rental price per meter of fiber, for each municipality or region.

Table 2
Differentiations between scenarios A and B.

Quantity	Results from scenario A	Relative percentage difference of scenario B over scenario A	Results from scenario B
Customers per employee	1500	150%	2250
Maintenance of active layer	5%	70%	3.5%
Maintenance of passive layer	2%	70%	1.4%
Installation cost VDSL	50€	80%	40€
Installation cost optical	150€	80%	120€
National circuits	90%	75%	68%
Cabinet cost	4500€	90%	4050€
CRM_ERP	20,000€	50%	10,000€
InterConnection	16.67€	80%	13.336€
CPE_customer	70€	70%	49€
Fiber cost per meter (including installation)	60€	80%	48€

Table 3
CAPEX in €: scenarios A and B (2009–2014) for the average sized region.

Main cost parameters	CAPEX A		CAPEX B	
	Cost	%	Cost	%
Access equipment (customer)	674,720	19.05	472,304	16.00
Optical access equipment	202,800	5.73	162,240	5.50
Switches, routers, modems	376,703	10.64	376,703	12.76
Cabinet cost	1,404,000	39.65	1,263,600	42.80
Software licenses (CRM/ERP/desktop software)	147,700	4.17	76,300	2.58
Desktop computers	44,500	1.26	41,500	1.41
BBras	35,451	1.00	35,451	1.20
Coverage cost (Fiber)	655,200	18.50	524,160	17.75
Total	3,541,073	100	2,952,257	100
B/A	83.37%			

In order to evaluate scenarios A and B, the CAPEX and OPEX are calculated for the region under consideration. According to the results presented in Table 2, there is a significant expenditures' decrease in scenario B. This decrease causes economic improvement and ensures profitability for the SPs, mainly due to the decrease of access equipment (sharing of expensive equipment, like video head end, network operations and dispatch center, business support system, operations support system, intercity links) and Optical Network cost, the latter being respectably more significant. There is a total expenditures' decrease that reaches 20%, as compared to scenario A. Furthermore, Operational Expenditures decrease because of the lower maintenance and first installation costs. The above are presented in Tables 3 and 4, where CAPEX and OPEX are, respectively, calculated for both scenarios, excluding VAT.

About 40% of Operational Expenditures are related to interconnection and connection with other municipalities. According to service provider's cost, Local Loop Unbundling (LLU) reflects about 18% of the total cost (these costs are inelastic due to

Table 4
OPEX in €: scenarios A and B (2009–2014) for the average sized region.

Main cost parameters	OPEX A	OPEX A	OPEX B	OPEX B
	Total	%	Total	%
Employment	1,404,593	12.2	1,226,858	12.3
Training	75,000	0.6	70,000	0.7
Rents	212,400	1.8	201,600	2.0
Maintenance of active layer	555,389	4.8	351,016	3.5
Maintenance of passive layer	441,456	3.8	288,489	2.9
First installation cost	594,850	5.2	475,880	4.8
Interconnection	2,429,631	21.0	1,943,705	19.6
National circuits	2,723,206	23.6	2,269,338	22.8
Administration cost	1,019,992	8.8	1,019,992	10.3
LLU	2,090,664	18.1	2,090,664	21.0
Total	11,547,181	100.0	9,937,541	100.0
B/A	86.06%			

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Table 5
Total Operational Expenditures for municipalities in €, excluding VAT (2009–2014).

	OPEX – scenario A	OPEX – scenario B
Employment	1,404,593	1,226,858
Training	75,000	70,000
Rents	212,400	201,600
Maintenance of passive layer	441,456	288,489
Administration cost	1,019,992	1,019,992
Total	3,153,441	2,806,939
B/A	0.89	–

the charge to the incumbent operator). Municipalities achieve at least 10% decrease in OPEX in scenario B, by deciding to act jointly, as shown in Table 5.

The differentiations between scenarios concerning the employment cost are due to economies of scales, which derive from the number of employees which, in turn, derive from the estimated demand, based on the assumption that each provider will gain a market share of 20%. Total demand was forecasted by using the logistic diffusion model (Michalakelis et al., 2008). The specific region has a total population of 177,849 inhabitants, across seven municipalities. In 2013, according to the estimated broadband demand, the 20% of the market share would be about 13,000 people. In that case, there is a necessity of at least one employee for technical support and one for administration in each municipality (all other employees involved will be engaged thought subcontractors).

The mean value per year for the rental of fiber is estimated based on annual discounted expenses that should be diminished to zero so that municipalities avoid losses and moreover add a fair profit margin based on Net Present Value (NPV) rule, as shown below.

$$\begin{aligned}&\sum_{i=1}^{n}\mathrm{DCF}_i=0\\&\sum_{i=1}^{n}\mathrm{DCF}_i=\frac{\mathrm{Income}-\mathrm{Expenses}}{(1+r)^i}=0\\&\sum_{i=1}^{n}\mathrm{DCF}_i=\frac{\mathrm{Length}*\mathrm{Price}}{(1+r)^i}-\frac{\mathrm{CAPEX}+\mathrm{OPEX}}{(1+r)^i}=0\end{aligned}\tag{1}$$

where DCF = discount cash-flows, r = discount rate (10%), i = years, n = study period.

Although the financial analysis, which consists of the calculation of cash-flows, cash-balance, NPV, etc., was performed for both scenarios, results indicated that scenario A is not viable under any assumption and any calculation made. Therefore, the results of only scenario B are presented in the following sections.

Based on cost-oriented approach, prices for optical fiber per year will depend on future funding for networks' expansions. Prices are presented in Table 6 assuming that two service providers will lease the passive infrastructure.

For the examined region (scenario B, municipalities join action), each service provider should pay, for the total network (100% coverage of the municipalities), the cost illustrated below in Table 7.

Municipalities, with or without subsidization for future expansions, will face losses during the first year of networks' operation. More specifically, the first two years' losses will grow but after that period there would be an increase in revenues and losses would be limited, Fig. 5. The results in terms of payback period could be improved by almost two years in case of subsidization in future expansions.

Table 6
Rent prices of optical fiber per km per year.

	Number of service providers	Price (km, Y)
Price with subsidization	2	0.28€
Price without subsidization	2	0.43€

Table 7
Cost of optical fiber per year in € (rental cost 100% coverage).

	Revenue	2009	2010	2011	2012	2013	2014
Scenario B	Without subsidization	191,876	459,711	676,445	676,445	676,445	676,445
Scenario B	With subsidization	121,459	291,001	428,195	428,195	428,195	428,195

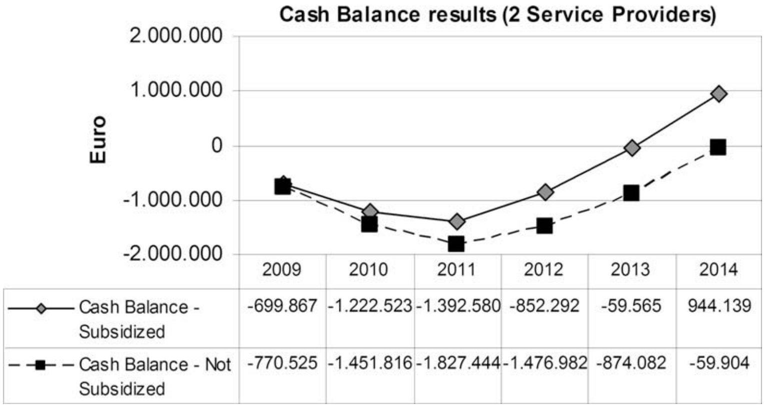

Fig. 5. Cash-balance of service provider, scenario B in € (with and without subsidization).

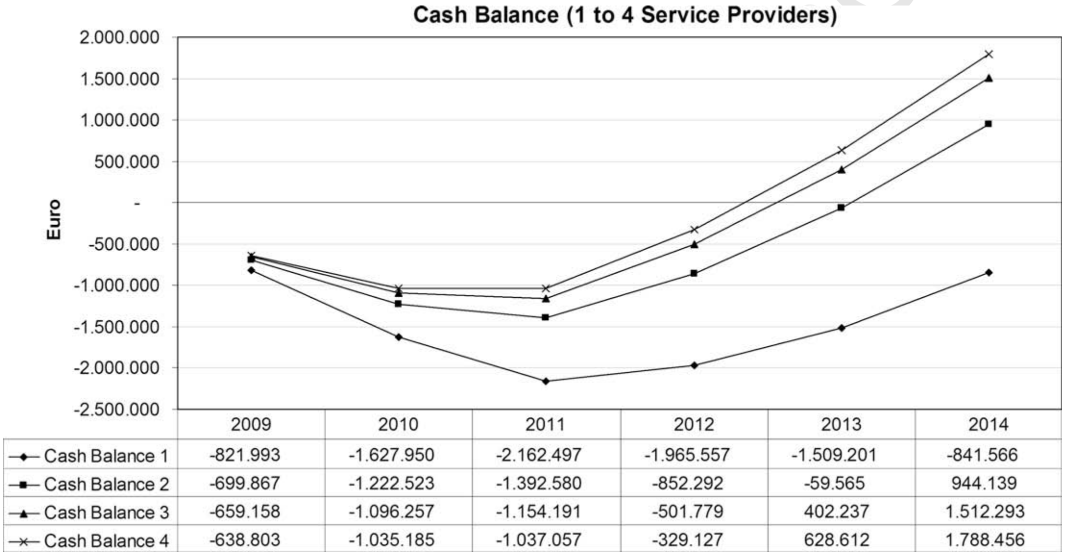

Fig. 6. Cash-balance of service providers, scenario B with subsidization (different numbers of service providers).

In the case that more service providers exist, offering at least double play services (assuming average revenue per user almost 30€), the financial results of this example region would be further improved. It is expected that in each MAN at least two SPs will offer services. The reason is that in another governmental initiative and in each region, one, or two, alternative service providers have been subsidized (excluding the incumbent) and they have developed their own optical fiber core networks. In the case where four SPs are leasing the whole infrastructure of municipalities (i.e. cash-balance 4 in Fig. 6) the payback period is 5 years instead of 6, which is quite improved as compared to the case of two SPs (i.e. cash-balance 2), as illustrated in Fig. 6. It is again assumed that each operator has a share of 20% of the total broadband market in this region.

5. Sensitivity analysis

Since the results presented above were based on forecasts regarding the diffusion of broadband services and a fixed, assumed market share for each service provider, it is necessary to perform a sensitivity analysis, in order to evaluate the effect of these two important factors over the financial results. This approach, of performing a sensitivity analysis, is an important stage during the elaboration of a business plan, as it provides valuable information to the potential service providers regarding their investments.

Table 8 presents the NPV (€) for different market shares and for different values of the penetration level of broadband services, for years 2009–2014. More specifically, each row presents the calculated NPV corresponding to a different market share for the same penetration level and each column the same information for a given market share and different penetration levels, calculated as a percentage difference from the initially estimated demand.

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Table 8
Sensitivity (market share – penetration level, NPV in €).

Penetration variation (%)	Market share					
	10.0%	15.0%	20.0%	25.0%	30.0%	35.0%
−25.0	−2,959,903	−1,433,041	−159,548	976,668	2,086,320	3,185,778
−15.0	−3,046,091	−1,325,482	82,499	1,357,128	2,608,970	3,850,243
−10.0	−3,070,545	−1,259,318	214,088	1,558,692	2,880,852	4,193,910
0.0	−3,156,248	−1,157,312	448,953	1,936,351	3,401,677	4,857,865
+10.0	−3,221,021	−1,040,164	697,656	2,326,683	3,934,100	5,534,648
+15.0	−3,283,575	−1,010,703	798,556	2,498,383	4,178,342	5,849,723
+25.0	−3,370,152	−916,973	1,032,287	2,873,329	4,695,903	6,510,598

As observed, if the expected market share reduces to 15%, from the initially assumed 20%, the corresponding NPV also reduces at an amount of about 1.6M€ (and sign changes to negative), thus making the investment highly unprofitable. On the contrary, if it increases to 25% the corresponding NPV increases about 1.5M€. In addition, market share turns out to be a more crucial factor than the penetration level with respect to the payback period and a market share of 20% is the threshold value, independent of the penetration level.

6. Conclusions

There is a variety of business models for open access broadband networks that have been either proposed or implemented worldwide. Through an extensive benchmarking from national practices this paper examines four models, which were suitably adjusted for the case of Greece. These models could be applied as well over the countries exhibiting similar characteristics. Since each country and region are described by their own, distinctive, characteristics they should choose the model that matches better their needs and peculiarities.

According to the quality analysis performed to the above models, the "private initiative in active layer" business model seems to fit better the Greek reality. According to this model, active layer is open to competition, in the sense that the private sector can lease the passive infrastructure owned and administrated by the municipalities, which assigns the operation of the passive network to a neutral (independent) entity. Municipalities should act jointly in order to gain economies of scale and ensure future profitability, as shown by the financial analysis.

Expansions of the implemented networks are very important, in order to achieve a decent coverage which would provoke demand increment. Moreover, the number of MANs' service providers seems to play a crucial role to the networks profitability, as rent prices depend on this number. The financial analysis revealed that the operation of service providers in these MANs may, under certain conditions, be profitable and, thus, attractive to invest.

Finally, the establishment of a detailed agreement regarding the co-operation between public and private sectors, in the context of the proposed business models, may provoke relative changes to financial results.

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