

“Which way to a (judicious) municipal wireless network? An assessment of the different alternatives for municipal participation in wireless local networks”

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Abstract

In recent years, a broad interest has arisen in public circles for the deployment of municipal networks based on wireless technologies, as well as for the direct participation of city councils in such projects. The goal of this paper is first to identify, and then to assess the key forms that public participation in wireless municipal networks can take, under the light of the different goals put forward by city councils in pursuing such projects, as well as their diverse socioeconomic, legal and strategic contexts.

This paper first reviews the reasons why municipalities decide to embark in wireless network projects. Then, the different forms in which city councils can involve themselves in municipal network projects are analyzed, namely through granting privileged access to public infrastructures, usage, ownership, funding, deployment, management and exploitation of such networks, and by cooperating in different forms with other actors as telcos, grassroots organizations and private companies. Next, the constraints imposed by the legal framework on the different forms of participation, centred on the EU case, are reviewed, together with other key context variables such as the chosen business model and its viability. By crossing the constraints with the diverse participation forms, we obtain an evaluation of the key factors with which to judge the adequacy of the different public participation models to the goals set and to the existing context. The ultimate result of this work is the elaboration of a set of decision processes that should inform the municipal representatives in choosing the most adequate form of involvement, if any, for their specific situation.

1. Introduction

The pervasiveness of wireless technology in everyday life is an undeniable fact since the mass adoption of cellular telephony and Wi-Fi access networks. In recent years, a broad interest has arisen in public circles for the deployment of municipal networks based on wireless technologies, as well as for the direct participation of city councils in such projects. Much has been written about the goals that such projects pursue (e.g. increase the economic dynamism of the municipality, increase the efficiency of public service provision, enhance competition, closing the digital divide at the local level, foster civil engagement, etc.), as well as their degree of success or failure. The *adequacy* of the different forms of public involvement in municipal networks, according to their diverse needs and goals is an important aspect in order to articulate these objectives.

This paper is oriented to first *identify* and then *assess* the key forms that public participation in wireless municipal networks can take, under the light of the different goals put forward by city councils in pursuing such projects, as well as their diverse socioeconomic, legal and strategic contexts.

Furthermore, this work puts forward a decision scheme that can help public local authorities choose the most adequate participation model for their case, by elaborating and sequencing the questions that they should ask themselves (and be sure to thoroughly answer) before jumping into such a project.

Based on a broad range of empirical evidence (namely, a number of interviews with key actors in municipal network projects and their entourage, supplemented by the authors' own direct experience in the design, deployment and management of several such initiatives in Spain [Infante et al., 05]) as well as analytical data collected from international examples of municipal networks, this paper first reviews the different forms in which city councils can involve themselves in municipal network projects, namely through ownership, funding, deployment, management and exploitation of such networks, and by cooperating with other actors as the telecom operators, grassroots organizations and private companies. Then, the constraints imposed by the legal framework on the different forms of participation, centered on the EU case, are reviewed, together with other key context variables such as the chosen business model and its viability, and the socioeconomic structure of the municipality. By crossing the constraints with the diverse participation forms, we obtain an evaluation of the key factors with which to judge the adequacy of the different public participation models to the goals set and to the existing context. Clearly, not all models are incompatible among themselves, and several mix cases are also explored.

It must be stressed that both the decision process as put forward by this work, as well as the factors taken into consideration when doing so are open for discussion. Both are the product of an observation of real cases as well as of a thorough analysis of the legal, social and economic constraints that influence municipal participation in networking projects in Europe and the USA in recent years. However, there is always room for further evidence and for further analysis, which may shed additional light upon the matter. Furthermore, there is not, and there can not be, a unique adequate model of municipal participation in wireless initiatives. The legal and socioeconomic constraints of every municipality will conduct and inform such decisions, but beyond that, the political philosophy of every community, as well as their political will, shall ultimately dictate which form of engagement, if any, is *the* right one for that concrete municipality. The role of the public sector in the economy and in the provision of services has historically been one of the most controversial matters in politics at all levels. There are broad differences in the degree and sort of engagement in public enterprises that is deemed adequate even in today's European landscape, otherwise characterized by a rough consensus on a "state-provisioned, welfare state"-centered social model.

The outcome of this analysis is hence the elaboration of a tentative workflow that structures the decision process to be followed by any city council, under the light of their special goals and context, to choose how to best implicate itself in promoting the establishment of a wireless municipal network.

1 Why a municipal network?

Nowadays the feasibility in the provision of a wide set of services using wireless technologies, mainly WiFi/WiMAX, as well as their impact on the local environment allow the municipalities to use those services as a powerful tool to increment their internal efficiency, and to increase the social and economical development among the citizenship.

The objectives established by local administrations in the definition and use of wireless technologies are really wide and rely on several variables. Municipal networks are built to achieve a set of objectives that often are mutually reinforced. In this section we expose the most common objectives established by local authorities when deciding to promote the use of wireless technologies, which can be classified into three main groups:

- **Expansion of the information society among the citizenship.** Part of the existing initiatives push on the offer of telecommunication services to extend and expand the use of Information and Communication Technologies (ICT) among the citizenship. Local governments look into ICT as a basic tool to increase the economical and cultural development in the society (see, for example, the case for Lake County in Florida (US) described in [Ford et al., 05]), promoting its use and extending and adapting current e-government services, some of them already offered through Internet, to encourage ICT usage among the citizenship.
- **Improvement of Municipal services.** In other cases, the municipalities deploy broadband wireless networks to support their own internal services. The reasons behind this objective are mainly to reduce the cost of existing services and develop new specific services for the local administration that run on networks owned by traditional telecom operators at high expenses especially for the wireless services. Examples of internal services are itinerant access to databases for police and fire departments, local internal telephony services, SCADA systems, cameras for traffic control, etc.
- **Increase the value of the territory.** The municipal government wants also to make more attractive the city itself for business and tourist visitors, or companies that want to establish their headquarters inside the municipal area. Municipalities intend to attract more visitors offering better and personalized local services such as tourist information, hotels and accommodation, sightseeing, meteorology, etc. They also offer interesting conditions to get more companies installed in the city which may consist on telecommunication wireless facilities along the city. In general, this motivation is addressed to increment the economic activity via broadband wireless deployment, as the empirical evidence shows (see for example, [Gillet et al., 06])

These three main objectives can be reinforced by sharing the use of common municipal wireless networks to further several simultaneous goals. For example, a WiFi/WiMAX municipal network can be mainly designed and exploited for internal services, such as sensors and traffic cameras, and at the same time offer extra capacity for free open Internet access services using advertisement models or to complement the Internet offer in areas where there is scarce broadband offer from private providers, in order to cover at the same time the previous main objectives.

More specific objectives and their implications in municipal wireless networks are analyzed in the following sections.

Availability of Broadband infrastructure

Rural areas with no broadband offer at all due to the lack of economical viability from the private telecom operators' point of view show a great handicap to integrate their citizens into the information society. In these cases, the local governments can play an important role in correcting this unfair situation and offer the same opportunities to all citizens, promoting the economical and social development through ICT.

The use of wireless technologies, deploying municipal networks is an important tool to be considered in these situations. The lower initial investment required in comparison to fixed technologies, allows a rapid deployment with reasonable costs to be afforded. However, it is very important to have in mind several factors before making the decision whether to deploy their own wireless municipal networks, with respect to broadband infrastructure:

- *Are there any future plans from other (regional or state/national) administrations or private telecom operators to deploy broadband networks in the area?* After starting the decision process it is important to check if there are external plans to cover these needs in the city, and to know the detail and coverage for those plans in order to complement or expand the offer. For example, in Catalonia (Spain) there have been several programs to deploy a broadband transport network in rural and semirural areas using WiMax technologies promoted by the regional government [Gencat, 06]. When there are existing regional or national plans oriented to supply broadband services in areas with no commercial offer, the municipal involvement can overlap the pretended goals and perhaps complementary actions in the demand side can render more benefits.
- *Wireless technologies offer less capacity and quality than fixed networks.* WiFi/WiMax offer an interesting solution at reasonable costs, but wired technologies offer more capacity and better quality of service than the wireless ones. Hence, wireless can be a complementary solution to wired technologies but not a long-term substitute of them. It is important, in the deployment of municipal wireless networks, to foresee wired investments trying to make as much complementary as possible both networks avoiding direct competition between wireless and wired.
- *High costs for backhaul and transport networks if no local offer is available.* Wireless networks rely on backhaul and transport networks, even in the case of mesh networks, to provide most of the communication services¹. In areas where there is a lack of telecom infrastructure, to reach Internet services may be only possible through expensive and high latency satellite technologies. In some deployments, this satellite hops can represent a very important part of the whole investment reaching three quarters of the initial investments and operational costs.

Nevertheless, in many scenarios where there is a lack of telecommunications infrastructure and there is a low probability of future deployments by third parties, the use of municipal wireless networks seems the best opportunity to offer ICT services and allow the full development of the information society in rural and semi-rural areas.

¹ WiMax networks are less dependent on backhaul fixed infrastructures, as the coverage for each base station is wider than for WiFi cells, but both need transport connectivity that is usually based on fixed infrastructure or dedicated high-capacity radiolinks.

Increase of competition in the broadband market

In most locations the broadband market is composed by one or maybe two operators which promote the use of monopolistic or oligopoly practices without a real performance of the offer/demand market rules with a direct impact on the price for the broadband services. These higher prices reduce the penetration of services and may be a serious barrier for economical and social development. This is the case in most European countries, where the incumbent companies cover more than one half of the market, and less than one quarter are only covered by alternative operators with own telecom infrastructure [CEC, 07].

- Within this specific objective, municipalities look for an increase of the alternative offer in the local broadband market using separated telecommunication infrastructures. This objective can be achieved by the promotion of new local operators with private, public or mixed funds to establish effective competition in such markets. To succeed in the increase of the effective competition in the broadband market, the business model used should offer substitutive services, on top of the municipal wireless network, at lower prices rather than the existing services, without resorting to disloyal competition practices, based on the local government special legal situation and/or applying subsidies, when applied in a transparent and open way to all actors. Otherwise, the specific objective should be hardly satisfied.

It is not straightforward to find suitable business models that accomplish these conditions in a sustainable way. In this direction, the wireless technologies and their low barriers in terms of deployment cost can be crucial in the definition of strategies to achieve this target. In the same way, the use of shared infrastructures among incoming operators can also be a good strategy to really increment the competition in this market. Sharing infrastructure facilitates the commercialization of services under different models like wholesale or for internal municipal services, which introduces new variables to make feasible the economical sustainability of the network deployment. In this sense, the municipality may align different interests from other actors in order to build a common business model where private companies are in competition for services sharing the infrastructure investments.

Reduction of the digital divide

Arguments related to reducing the digital divide are claimed very often by the municipal administrations in their municipal networks deployment plans. In these scenarios, the efforts dedicated to implement municipal wireless networks can be an interesting complement to achieve these social objectives. Rarely this specific objective is the only one that leads to the deployment of networking infrastructures due to:

- Not always the digital divide is because the lack of broadband services or its higher prices. In most situations, the lack of digital culture has a greater impact on the digital divide than the availability of infrastructures at a cheap price.
- When the problem seems to be related to the higher prices, specific programs based on subsidies for citizens with lower income per capita, or the availability of free centers with Internet access and computer can become a more cost-effective policy than deploying municipal networks only to solve this problem.

However, this specific social objective can be targeted additionally in the deployment of wireless municipal networks offering these services at reduced rates for some collectives. For example, the WiFi deployment in Philadelphia includes this type of actions in the commercialization of services [Wireless Philadelphia, 05]. The availability of broadband to reduce the digital divide is only a first

step which impacts the commercialization model explained below. Usually the digital divide reduction is a quite complex task, and requires specific programs based in combining teaching introductory ICT courses, subsidize equipment, build specific places where to offer free access, etc. Although the digital divide is not a major driven in building municipal networks, additional actions complementing the municipal network deployment complete the local government actuation framework.

Promotion of itinerant services for citizens

We understand by itinerant services those used commonly by citizens when they are moving around the city, specifically in public spaces. To cover this objective it is required a critical mass of potential users owning wireless terminal (mainly WiFi) equipment which means a reasonable income per capita among the citizenship.

Moreover, the selection of zones where the service is offered is also crucial for the success of these itinerant services. Places with a high density of potential users should be targeted such as parks, malls and shopping areas in general, transportation hubs, etc.

Although the most common service used are the traditional web browsing as well as email and instant messaging, the municipality can develop adaptations of current services for being adapted to mobile networks and terminals with reduced capabilities in display and processing. The municipalities may improve the utility of itinerant services, implementing more specific municipal. Location based services may offer geoinformation applications of the city with graphics and maps, availability in parking zones, etc. These services can be part of other ICT programs and actions from the local administration which easily matches and add value to the current wireless infrastructure.

Specific services for visitors

Specific services for visitors are oriented to cover needs for both professional and tourist users that stay for a short period of time in the city. Their use may be somewhat different from the one addressed to citizens, and the zones to be covered may also differ. In this context, places for exhibitions and conference centers are places highly interesting to be covered. Together with the general services such as web browsing and email, the development of specific tourist services as location-aware guides with specific information of the city located at the most visited tourist places and exhibition venues, can fulfill this objective.

As well as in the case of itinerant services for citizens, in this case the access technology will be based on WiFi in order to adapt the network to the terminals (PDA, smart phones, laptops) and to the existing user communication capabilities.

Savings in Telecommunications expenses

Reducing the costs of the telecommunication services used by the municipalities is also an interesting objective that motivates the promotion of public wireless networks in the city. The use of wireless technologies such as WiFi/WiMax offers the possibility of replacing some municipal internal services that are supported using expensive 2G/3G wireless networks. In this context, the possibility of being able to use a municipal network can reduce drastically the cost of municipal services, obtaining important savings in the telecommunication expenses.

This specific objective is possible whenever the amortization of the initial investment of the wireless network plus the operational cost is under the cost of telecommunication services

contracted to third parties, especially mobile telecom operators. This situation heavily depends on several factors like the existing use of commercial wireless services, the density of users and zones to be covered, the cost of 2G/3G services itself, etc. which requires a particular study for each situation. In any case, to better evaluate the interest and real savings to achieve this objective, it is important to take in mind:

- Cellular technologies, and more specifically 3G services, are relatively recent and mostly oriented to users that are less sensible to the cost variable. It is expected a progressive reduction in cost and a change in tariffs models trending to flat rates or similar billing structures, that will lower the telecommunication expenses for the municipality in the medium and long term.
- The increasing needs from municipalities for mobile broadband services will be more stressing in the next future, which will be taken in mind when the economically viability of municipal networks is assessed.

The quantification of both factors is difficult and prone to estimation errors, especially in the long term plans, but they both will impact in the medium and long term, and at least a sensibility analysis on these issues should be performed in order to evaluate telecommunication savings along the expected life of the municipal network.

An important issue to be included is the availability of voice IP services running on such networks. Nowadays the conversational services used by the different departments of the council for itinerant officers represent an important part of the telecommunication expenses. To plan the migration of some of such services using voice over IP technologies to the municipal network is also an important aspect to be considered.

Improvement of the efficiency of municipal internal services

Even when the savings introduced when promoting a municipal wireless network is not enough, the use of local infrastructures allows a better performance of internal services in terms of quality of service and deployment time. Specific services that require a certain bandwidth in places where there is not any wired infrastructure to connect can represent an important restriction in cost and time. For example, a wireless network can facilitate some internal municipal services that require the use of cameras for security, traffic control or special events in the city. Some of these services may not be run on top of 3G networks due to bandwidth technical limitations and cost reasons, and it is not economically feasible to contract a fixed service either.

WiFi/WiMax technologies combined with application layer mechanisms, offer now security solutions in terms of confidentiality to build robust and secure networks for sensible internal uses like police and fire department services.

A recent study [Muniwireless, 06] shows the public security, productivity of itinerant public workers and savings in telecommunications are the more important motivations stated by USA municipalities when promoting the use of such networks. In many cases, the deployment of municipal self services are the main objectives that motivate and justify the use of municipal wireless networks, rather than offering public services to the citizenship, avoiding regulatory barriers and commercialization concerns.

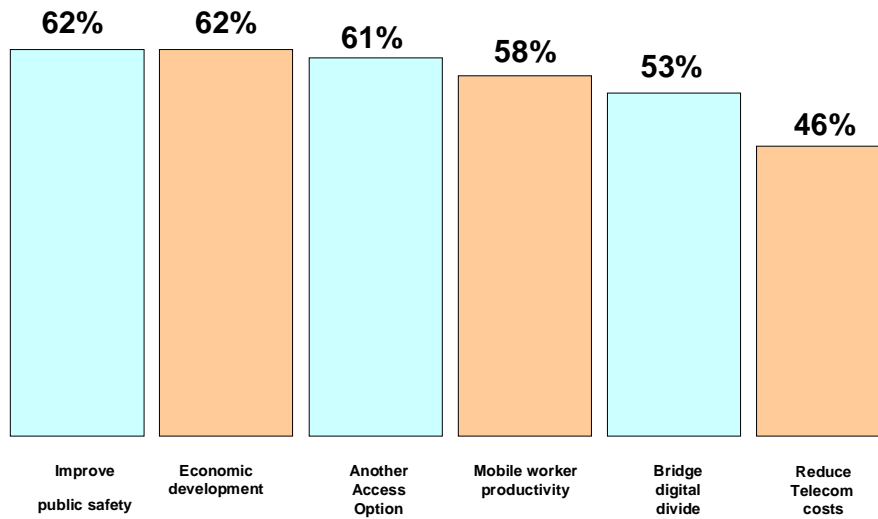


Figure 2-1: Motivations for wireless municipal networks in USA

Source: [Muniwireless, 06]

2. Context for the municipal participation

Municipal participation in the deployment of networking infrastructures has been always a controversial topic to which different authors have devoted much effort in the last years from different viewpoints (see for example [Gillet et al., 06], [Bar et al., 06], [Balhoff et al., 05]). On the other hand, the deployment of public electronic services, such as e-government, informational services or other tools to promote the use of information and communication services and technologies among the citizenship has been positively seen and actively promoted by municipalities. In this context and from an strategic point of view, the difference between infrastructure and services investments is clear: while the first one requires a meditate vision and a selection of models for its exploitation and development, a complex framework of actors cooperating offering services and applications on top of it, and a more general long-term strategic plan for the use and sustainability of such an infrastructure, the services by themselves do not show this level of complexity, and even do not require such a detailed previous work of planning in the mid and long-term by public administrations including municipalities.

In this section we analyze the context to establish different variables or constraints that allow the successful deployment of wireless networking public initiatives in a municipal framework. In this paper, we concentrate our research on 'wireless infrastructures' because they are considered as a 'low-cost' telecommunications model, requiring less deployment investments than fixed fiber-based deployments. The access part of the network infrastructure always consumes an important part of these resources, and the local governments see in wireless technologies a very interesting approach that optimizes cost and services. In contrast, the transport or backhaul part of the network may use either fixed or wireless infrastructures in a more flexible way.

Although the economical resources required for deploying public network infrastructures play a key role, they are not the only variable to be taken into account in order to decide the viability of the project or to choose the best model to follow. Within this context we analyze the different variables or constraints that recommend the use of one model in front of others.

The municipalities have a wide range of visions and they have different levels of implication in this kind of projects. Regardless of the policy decision process, there are a more or less standard set of participation models to follow, depending on the context, which can be described as a set of variables. A key variable is the availability and adequacy of existing resources to support and assist a particular project. Not only networking resources, but also personnel with the adequate know-how are very important in order to successfully follow one specific model. Regulatory and legal frameworks are also crucial constraints to keep in mind. In most countries, specific regulations establish the different grades of freedom in choosing some models. Market maturity in a broad sense, going from the digital divide features to broadband penetration figures including the degree of competition and existing offerings in the area, are also variables to take into account in choosing the model. Finally, the investments and possibility of getting funds from other administrations at the regional or national level is also very important to study the economical viability and sustainability of such a network.

In the following subsections we analyze these constraints or variables, as inputs required to set up a decision procedure presented in this work in order to establish the most feasible models to adopt in every case.

Demand profile constraint

The demand profile issues takes into account aspects related to the existing needs of broadband services in the area. Some municipalities have broadband offer from private wireless/wired companies in specific areas, such as the city center or dense populated neighborhoods, but a lack of connectivity in other areas such as residential areas far from the urban zone, semi-rural or rural areas. In terms of market development, the key aspects that directly affect whether to deploy municipal wireless networks are the following:

- Population distribution within the municipality. Private investments traditionally prioritize areas where there is a high or medium population density to optimize the investments. The population spread in the municipal geography is a variable that requires more investments to cover the same market volume in contrast to densely populated cities.
- Demand patterns and its evolution. Usually, in cities the broadband demand is higher than in rural areas, but in order to get a reasonable market share, the municipal network must offer competitive quality, coverage and prices compared with the evolving market offer. In dispersed rural areas, where there is no availability of broadband offer, it is important to make a realistic estimation of the demand to better match the network coverage and costs with the existing needs. In these scenarios user-driven deployments are usually more effective than others that aim to maximize the coverage. These two possibilities, depending on the type of demand, establish two main models for deploying such networks: the hotspot model, with partial coverage in selected places where the demand is concentrated; and the whole area or citywide deployment. Each deployment model implies different constraints when deciding the local government participation model.
- Residential/business markets. The type of user also should be taken into account in order to fix the model. Business users are more sensitive to the service agreement in terms of availability, bandwidth and delay. If the forecasted users are mostly residential, then the infrastructure can be slightly different, more oriented to maximizing coverage and less oriented to strict QoS guarantees. Some municipalities plan special areas for the establishment of businesses and companies, generally outside the city center, with no networking infrastructure available especially at the very beginning. This scenario requires the intervention of local administrations to first invest in telecommunications infrastructure to promote the demand in such places. SMEs can become a key part of the business market for such networks, as the QoS and bandwidth requirements are usually lower than the ones of the big companies where the fixed networks are more adequate.

- **Market maturity.** According to several parameters such as broadband penetration, growth and demand, it is important to assess the level of maturity of the market to plan the infrastructures and their evolution according to it. Immature markets where coverage is the only main variable will evolve, as the users become more experienced, introducing new aspects to be considered, as promoting competition in services, digital divide issues, etc.

Competition and existing infrastructures

Existing and planned broadband infrastructures are a key issue to be considered in choosing the model for investing in public networking infrastructures. Wireless technologies stimulate the demand for broadband services and can help waking up the demand for ordinary fixed broadband infrastructures. In this context, municipalities may use this kind of deployments to foster demand but also to set up a new market and attract private investments. It is important to quantify some of the variables related to broadband offer:

- **Broadband offer map in the municipality.** Sometimes, and especially in rural areas, there is not a uniform and homogeneous offer of connectivity in all of the area. The urban area, and specially the city center, where most of the population is concentrated, is where private operators concentrate their investments in access networks. But in industrial zones, or other urban areas far from the city center, lack of broadband offer is common and only dial up connections are possible.
- **Competition in broadband offer.** Only in medium and big cities the broadband is usually offered by more than one service provider. Incoming operators concentrate their efforts in providing alternative services in densely populated areas (“white areas”), where the demand is very high and the investment in access network may provide benefits sooner. This desirable situation, with a healthy competition in services and infrastructures, is not feasible in all municipalities, where most of them have only one provider in the area (“grey areas”).

Regulatory and legal constraints

Some state and/or national regulations allow municipalities to deploy and promote telecommunication infrastructures in general, provided the competition issues are addressed, while others are very strict and establish a complex framework to involve public administrations in it.

This constraint may be classified into two main points:

- **Competition regulations.** Legal constraints mainly focus on the unfairness of public funding to compete or promote the use of services that are also offered by private providers. In most countries, the national regulatory authorities (NRAs) and the general competition authorities have started to suspiciously look at public endeavors in telecommunications, which may provoke disturbances from the public sector in terms of investments that may alter the classical market rules. There are general exceptions in places where there is no infrastructure at all or very unequal broadband offer.
- **Technical regulations.** The creation of public telecom operators implies following the regulations established for any actor in the sector. This implies not only the competition regulations but also the technical regulations for ensuring the availability of the service supervise and report the quality, bill the customers, guarantee the privacy of the communications and keep records for public safety. It is important to know this framework to offer the service according to the laws established for each area, which may differ greatly.

Internal know-how and experience

Not all the municipalities have enough experience and resources to start and run a networking project by themselves. Depending on the size of the municipality, and its internal structure, there may be technical departments or municipal utilities with enough experience in deploying such projects. The total amount of required funds can be more or less easily estimated, but the availability of internal leadership and experts to supervise the execution and operations of the project is not always straightforward.

This constraint, especially for small-medium municipalities is important, where the lack of internal resources may recommend to hire services from engineering and consulting companies with enough experience in it.

External resources and funding

In most of the developed countries there are regional, national and suprastate plans to provide funds for some specific areas and projects to promote wireless networks. These programs may help considerably in having part or all the funds required like in depressed areas where development funds try to establish recycle societies towards new industrial sector specially ICT. The city of Avilés, in the north of Spain is an example of wireless municipal network funded using European Community subsidies (European Regional Development Fund, ERDF program) for special areas [Ayto. Avilés, 06]. In these situations it is important to identify the constraints established by the regional, national and European funding plans and see if the local objectives and constraints match with the conditions established by those plans.

External funds are interesting for the initial phases and set up of wireless municipal networks but it is important to foresee the future needs for funding and, in general, medium and long term economic viability and their possible sources, being internal or external ones. Otherwise, the infrastructure may become collapsed or underused if there are no plans for operating and following a continuous users and infrastructure growth to achieve the initial objectives.

Presence of other actors interested in deploying the infrastructure

There are some examples of networks deployed by collectives, which are not part of the municipal government that deploy wireless networks in the ISM band with several objectives. These collectives comes from associations that usually react in front of a lack of broadband offer in rural areas, as the case of Guifi in Spain (<http://guifi.net/en>), or just want to build an alternative bottom-up network. [Middleton et al., 06] identifies the principles embodied in cooperative and community-based technological innovation that include collaboration, participation, consultation, open access, transparency, democracy and regard for the public interest. Some municipalities cooperate with this kind of movement around building networks to promote the use of ICT and offering internal resources such as locations or part of their internal network to expand such initiatives.

If there are some organizations, citizenship associations or movements around free networks, it is important to have it in mind and try to build collaboration in order to coordinate efforts in the deployment of the networks. Besides the Community Wireless Networks, other organizations like chambers of commerce, universities, etc., can also help to catalyze and facilitate the deployment of municipal networks and, as analyzed in next section, sometimes a consortium can be constituted in order to agglutinate interests and efforts.

3. Alternatives for municipal involvement and selection criteria

Prior to selecting a participation model, the first question to be answered is if the municipality should be involved in the setup of a wireless network at all. Assuming that one or several of the objectives addressed in section 1 have been selected by the local administration as action lines that

can be pursued by promoting a wireless municipal network, these objectives must be quantified in monetary terms, in order to be able to compare the total cost for the presumed life of the network with the benefits to be obtained. Only by reducing the decision factors to comparable magnitudes (money, in this case) is it possible to arrive at rational decisions about which resource allocation procedure maximizes the overall utility of the municipality.

Some of the benefits to be obtained are more or less simple to quantify: short and medium term savings obtained by using the municipal network for the provision of existing municipal services instead of the commercial services (for example, the use of data cellular services to gather data from sensors or actuate on electronic infrastructure), or income to be obtained from the commercialization of fixed and itinerant services, provided that a market analysis has been performed.

Other benefits, as the ones to be obtained in terms of economic development of the municipality, actuations on the digital divide, or the increment of the competition in the telecommunications market are more difficult to evaluate in monetary terms, and some indirect indicators should be used, such as the cost of other kind of actuations with similar targets (for example, subsidies for contracting broadband for disadvantaged collectives in the case of remedies for the digital divide), economical evaluation of the benefits obtained for the whole community on a tariff reduction derived from the competition increase, empirical evidence from similar experiences on the economic development increment (see for example, [Osorio, 06]), etc..

The quantification of benefits and, moreover, its translation to monetary terms is not a simple task, and in most cases there are factors that are very difficult to estimate, measure and anticipate. In the particular case of wireless networks, the evolution on penetration and prices of the 3G markets for the itinerant services and DSL, cable and FTTX for the residential market play a key role for estimating the market share, incomes and savings to be derived from implementing a municipal network. A good practice is to define several scenarios considering different market evolutions in order to quantify the risks and sensibility to each aspect.

The social benefits many times can only be estimated deciding political priorities and assigning budgets to each objective. Even considering the uncertainties implied in the benefits evaluation, it is important to make the exercise in detail in order to compare the benefits with the costs incurred, in order to be able to take informed decisions on the risks to be assumed and consequently tune the objectives and the corresponding deployment of network and services and long-term maintenance and evolution. In fact, this is one of the key tasks that the private sector performs before launching any network or service, evaluating also risks and uncertainty for the current and future scenario. The differences with the private sector are just that the community benefits pursued by the public initiatives should also be translated to monetary terms in order to be able to compare the whole benefits with the costs.

In this step, special care must be taken on the estimation of residential demand, which is sometimes overestimated (e.g. optimistic estimations in rural areas, underestimation of the packaged offerings from cable and incumbents in metropolitan areas), and on the response of the competition to municipal initiatives with aggressive offers. Among other factors, the deployment of a municipal network may provoke a tariff reduction by the existing private providers, which may achieve the result expected from a competition increase. However, in this case, the market share and hence the income obtained by the municipal network will probably be lower than expected, which could endanger the viability and sustainability of the municipal project.

Once the social benefits and incomes are quantified, a comparison with the full cost of the actuation must be carried out. The full cost comprises all the items involved in the deployment, operation and maintenance of the network and services, including direct and indirect costs, and depreciation. In wireless networks the depreciation is stronger than in other areas of networking, due to the rapid technical evolution of the equipment, which in this case accounts for a much more important part of the total costs than in the fixed networks. The costs of O&M and amortization are many a time

underestimated, and realistic analyses should be performed in order to unveil and consider all the hidden costs.

The comparison between the incomes and social benefits and costs should be established for the presumed life of the network or, at least, for the initial five or ten years, and parameters as the Net Present Value (NPV) or the Internal Rate of Return (IRR) should be obtained in order to evaluate the suitability of the business plan. In this regard, the critical situations that the municipality can face are the following:

- The IRR obtained computing savings, incomes and the quantification of social benefits is negative or very small. In that case, probably, alternative investments or actuations can render more benefits and the municipality should not be involved in the network deployment. Sometimes, a review of the objectives reducing expectatives and network coverage or including other objectives can raise the IRR and turn the involvement of the municipality viable. It is important to note that this consideration applies regardless of the regulatory issues. Even when the regulation allows the municipal involvement in low IRR cases, it does not seem wise to spend more money and effort in the project than the estimated benefits to be obtained.
- When the expected IRR excluding the quantification of social benefits (i.e., computing monetary savings and incomes from customers, but not the value of digital divide reduction, increment of competition or economic development or economic growth objectives) is under the range of the usual IRR used in the telecommunication sector, it can be considered that the administration is incurring in disloyal competition with the private sector and the legal issues can be a serious impediment for the public involvement. In fact, the European regulation uses this criterion as the key factor to discern the legality of public ownership and investment on municipal networks when there is a broadband offering available in the territory (sometimes, as is the case in France, there are exceptions when there is offering from only one operator, but in other cases, as in Spain, even the presence of only the incumbent is considered to be a competitive situation).

Although there is not a exact algorithm to compute the total estimated costs and incomes and the IRR varies depending on the assumptions and scenarios considered, making optimistic assumptions supposes taking not only economic, but also regulatory risks. When the municipality is in a scenario with no competition (no broadband offering, or in some countries limited to one for residential services, or there is no 3G offering for mobile data), the local government –provided that the state or country regulation allows it, as is the case in most European countries can and should be involved in the network and services deployment, in one of several forms and with varying intensity, depending on the objectives, market context, and stakeholders interested in participating in the effort. In the cases where there is competition (existing, or potential competition in the short term), and where the business plan is not viable, instead of launching a municipal network, the public intervention probably should concentrate on other lines, such as facilitating the use of municipal infrastructure to private operators, stimulating the use of services by the citizens or subsidizing actuations to solve specific market failure issues.

Summarizing, prior to selecting the participation model, a careful analysis of the total costs, incomes, savings and quantification of social benefits, as well as the constraints and opportunities for the public participation, should be carried out in order to decide if the municipality should get involved in the deployment of a wireless network ([Balhoff et al., 05] provides detailed guides on issues to be considered).

Relevant business factors for the municipality

As stated before, and as will be analyzed in more detail below, there are many forms in which the municipality can get involved in promoting and supporting the deployment of municipal wireless networks. But the wireless network is only a mean to an end, which can be any of those presented in section 1. Hence, if abstraction is made of how the network comes into being, and who manages the

network and its services, it is interesting to evaluate which aspects of the wireless network as a business project should be controlled by the municipality in order to best serve those goals. These aspects can be grouped in three categories:

- The municipal participation model
- The exploitation model
- The commercialization model

In this chapter, most detail will be devoted to the first category, for it embodies the main goal of this work. However, a brief review of the other two is of some importance and will be performed next.

As has been seen, the goals of the municipality are generally related to the citizenship welfare, and hence are only indirectly related to the exploitation of the wireless network itself. However, the exploitation model chosen can affect the short and long term chances of success for the objectives set. As a consequence, the municipality may have an interest in being involved in deciding which exploitation model best serves those interests. As way of example, if the goal set by the municipality was to increase the degree of effective competition in the territory, the degree of openness of the network infrastructure to alternative providers may be paramount. In a situation of doubtful commercial viability for a private network provider, for example, the existence of, and competitive access to an existing network can make all the difference in convincing an additional provider to enter the market. Should the municipality have favored the deployment of a municipal network by a private operator supported by a public subsidy, the entrance of an additional provider depends entirely on the access clauses set by the municipality in exchange for the subsidy.

Two broad exploitation models can be considered, irrespective of the ownership of the network infrastructure, and the municipality should carefully balance their pros and cons when taking a decision on which kind of municipal network they wish to have. They will be analyzed in more detail in a subsequent section, but a few introductory words are necessary here:

- Retail provision: This is surely the most common exploitation form of a network infrastructure. In it, a single service provider makes use of the network infrastructure to offer retail services. This does not imply necessarily that a vertical operator is in place, for the infrastructure could be of public ownership, while the exploitation could be in private hands (more on this later in this section)². But it indeed precludes that a competitor makes use of the infrastructure to introduce a measure of competition. Especially in this case it is paramount that, for attaining most typical objectives set in section 1, the conditions set by the municipality relative to prices, communities served, quality of service or other, be very precisely and unambiguously stated, for competition is thereby relinquished as an indirect means to attain the common good.
- Wholesale provision: The sharing of telecommunications infrastructures has become common practice. Especially in the mobile sector in Europe, which suffered a severe punishment after the 3G auction cost and deployment delay, it has been pushed as a way of reducing costs for 3G deployments. Subsequently, initiatives have emerged to also share infrastructures to reduce especially the costs in civil engineering. Analogously, the sharing of a wireless platform in an otherwise unattractive location can greatly reduce the investment necessary and hence bring competition to the sector. However, this option also brings with it the necessity to provide for the technical means to share the infrastructure without disturbing the provision of the service by any provider. Quite often, the management of the network falls on the hands of a private operator, which can also be a service provider in the retail market. A conflict of interests can quickly arise, and strict supervision measures, which frequently fall outside of the capabilities of a municipality, for lack of resources or know-how, are to be put in place.

In a similar way, analyzing the consequences of the commercialization model is also important.

² This model has recently been used in several European countries for the exploitation of the railroad system, e.g. in Spain.

Different models can be considered:

- Prepaid cards to access the network for a fixed amount of time.
- Premium SMS for shorter periods.
- Captive portals with web registration and billing.
- On-the-spot charging, like in cybercafés.
- Indirectly through packaging with other services, like the rental of a hotel room.
- Through exposure to publicity, like in a recently launched initiative by Google.
- Free access to some or all services.

The type of commercialization models to be applied must be selected considering the target market and other issues such as the patterns of service usage. Hence, if the closing of the digital divide for less well-off citizens is of importance, the usage of a commercialization model that necessitates additional (expensive) electronic devices, like mobile phones for SMS micropayment or near-by kiosks to sell prepaid cards in remote rural areas may not be the best choice. Since the interests of the service operator and those of the municipality are not always fully aligned, a certain commercialization model can make perfect economic sense for the latter, and negate the social goals of the former.

The commercialization model also affects the audience targeted through the complexity of the payment method (burdensome activation procedures via SMS for the elderly?), the necessary additional infrastructure (the aforementioned kiosks in remote rural areas), or the tariffs (premium SMS are necessarily very expensive). In this last regard, there is a clear conflict of interest between some municipalities, which of lately have pushed forward initiatives to offer “free wireless” to their electorates and commercial entrepreneurship. Under which special conditions a private operator would be interested in providing and exploiting a municipal network, for which it can not charge its customers? Will the publicity-supported business models be economically sustainable? This alone would justify paying attention to the commercialization model chosen prior to granting any licenses, or setting conditions thereto.

The tool of trade in order to set a priori that kind of clause is the public tender and its associated Request for Proposals (RFP). It is in the RFP that the different clauses are included, and consequently it is of paramount importance that any municipality considering participating in a municipal network in any way invest the necessary resources and pay due attention to a careful elaboration of the RFP, under the light of the current and foreseeable objectives set for the establishment of a municipal wireless network. It must be remembered that such licenses as are given as a result of a RFP are generally multi-year, and hence a careless RFP design can endanger the goals set for years to come.

Besides setting purely technical requirements, the RFP clauses can involve matters such as:

- Upper and/or lower limits for prices, as well as permitted price increments, or special tariffs for certain social groups.
- Access conditions to the network infrastructure for alternative service providers.
- Roaming agreements to other technologies or networks, or closed user groups agreements for certain collectives (like municipal workers, for example)
- Special conditions for the usage of the infrastructure for the provision of municipal services.
- Agreements on guaranteed network coverage, being it in geographical, demographical or socioeconomic terms.
- Exploitation and commercialization conditions.

- Penalties to be paid if the previous conditions are not met.
- Etc.

Obviously, the set and kind of clauses included in the RFP depends strongly on the chosen participation model for the municipality on the setting up of a wireless network. Next, consequently, the different forms of municipal participation will be analyzed, as well as trying to identify the critical factors driving the adequacy of a given participation model for a given situation.

Granting use of municipal infrastructure

When implementing wireless networks based on the ISM bands, as is the case for the WiFi networks, it is necessary to deploy access points and antennas in numerous locations³. Furthermore, additional facilities are mandatory in every location, like at least electrical supply and an easy way to attach the equipment to the chosen location. Besides, unless a mesh network is used, it will also be necessary to have access to the fixed network at every location, in order to connect each AP to the network, and even for mesh networks, part of the APs must also be connected to a transport network. The municipal assets (streetlights, traffic lights, lighted marquees, etc.) and the control networks based on copper or fiber for the management of municipal equipment (e.g. street lights remote controlled in some cities) are a key facility to facilitate a fast and cheap deployment and connection of the equipment that constitutes the access network.

The municipality *owns* this essential element in any WiFi network. If an operator is not granted the use of this infrastructure, the cost of deploying a wide WiFi network is very high⁴. So high, indeed, that nowadays, in most cases the expected income does not cover the deployment cost when no municipal assets are available for equipment deployment. Although in the European and American context the rights of way are regulated, and any operator can claim the use of the public space to deploy lines and equipment, this does not cover the traffic lights, poles, and the electric supply available in these municipal assets. In a sense, the municipality has the key to the economical feasibility of metropolitan WiFi networks.

As a consequence, the municipality must and will be somewhat involved in most, if not all, the municipal network initiatives. Even when the network is financed and owned by a private operator, an arrangement on the use of this urban furniture must be made. Considering the importance of this infrastructure for the viability of the network and that many actors can be interested in its use, but only a limited amount of equipment can be attached to each piece of furniture, it is important to take account of these recommendations:

- Excepting the case where the municipality is the owner of the wireless network, a public tender should be carried out to grant the use of the urban furniture, in order to open to all potential actors the possibility of participating in the deployment of the municipal network.
- Among the conditions for the adjudicatory it is very convenient to consider an “openness” clause stating the obligation to provide wholesale service to any service provider under cost-oriented prices. Although the network may be operated in the short term under a retail model, with a single service provider (usually the network owner), it facilitates future competition in the service layer based on a unique network deployment.
- Of course, the clauses for granting access to the urban furniture should consider a compensation for the electricity consumed and any other expense incurred by the municipality for granting access to the furniture. Operation and maintenance costs should also be calculated and shared, and procedures to perform O&M by the service operators should be defined.

³ This is not the case for WiMax networks on licensed bands (the more usual WiMax spectrum use), where less civil infrastructure is needed, as the coverage for each base station is much larger.

⁴ This is not the case for hotspots located in privileged spaces, where an extensive deployment has taken place, in which the incumbent operators have taken a leading role.

When the local government limits its participation to granting access to the infrastructure, neither owning the network, nor participating in the commercial exploitation, the objectives must be pursued through the clauses establishing conditions on the coverage, services offered, prices or commercialization models and openness of the network to service operators searching an equilibrium between the municipal objectives and the economical attractiveness for the private sector.

The use of existing municipal networks designed for other purposes (e.g. traffic surveillance, pollution measurement, etc.) to serve as backhaul for the wireless network deserve special attention, especially in major cities: many of these cities own extensive control networks for traffic lights, sensors and cameras supported by copper and that are gradually being substituted by fiber. In this case, under municipal ownership of the access network, unused capacity on those municipal internal networks can be used as backhaul, at least in part of the city, lowering significantly the cost of this item, which accounts for an important part of the overall deployment cost. In other cases, when the access wireless network is owned by other organization (mainly, a private operator), it is not easy to articulate the joint usage of the municipal telecommunications infrastructure due to the following reasons:

- The priorities of the municipality for deploying and extending the network are not always the same as for the wireless operator, and it is complicated to establish a procedure to reconcile both objectives in the internal municipal network evolution.
- A more strict separation between the municipal use and the private use must be made. In fact, the municipality turns itself into a wholesale operator, being obliged to fulfill all the legal conditions established for telecommunication operators (registration, confidentiality and record of communications, etc.), plus account separation from other municipal activities and cost-oriented provision, due to its condition of public administrations and for the prevention on disloyal competition.

Due to these limitations, in most of the actual initiatives based on granting use of municipal infrastructure for third parties, the cooperation is limited to placement space in street lamps, semaphores and other assets and electrical supply obtained from these equipments.

The municipality as an anchor tenant

The use of wireless municipal networks for internal use has been reported as one of the most cited advantages of this kind of network. Those cities that own a municipal utility can use it to monitor equipment, acquire usage data, etc, [Osorio, 06] establishing synergies and important savings. Although in general that is not the case in the European context, where the utilities' market is more concentrated at national or regional level, there are many internal local government services, as seen in section 1, that can be provided using the wireless municipal network in a more effective and economical way than the services provided by fixed and cellular operators.

Taking into account the important savings that can be obtained from using these networks for such purposes, an important part of the economic viability in many initiatives derives from these savings. When the municipality owns the network, it is clear that the synergy can be obtained using the wireless infrastructure for internal use in the same way as any other corporate network or equipment owned by the municipality, and sharing the costs between the internal use and the public use.

When the owner of the network is not the local government, the municipality can act as an anchor tenant contracting the wireless network provider for such municipal services taking advantage of quasi-ubiquitous telecommunication services availability. Considering that many of the services more fitted to this kind of network are difficult to replicate in other networks at a competitive price (wireless security cameras, broadband itinerant data services, etc.), the involvement of the municipality as an anchor tenant is a good alternative for both, the municipality and the network owner, which benefits from predictable incomes in the short and medium terms.

This situation is common in all major cities where, as told, there is a progressive increment of the use of itinerant access to information systems by municipal officers, equipment remote control, sensor data gathering and security cameras. Simultaneously, in major cities there exists fixed residential broadband offer, which eliminates it as a possible source of main income to guarantee the sustainability of the wireless network, except in very peculiar situations. In most small villages, the municipality, due to the small scale and number of its data services, will encounter difficulties in becoming an anchor tenant providing important savings, and it must be the residential market, the one that will probably sustain the economic viability, for there is usually less (or no) competition from fixed network operators providing broadband and Internet access.

Subsidize network deployment

In those situations where either there is a market failure, or the IRR is not high enough to justify the private investment and the local government does not want or cannot be involved in the ownership of the network, the subsidies can be a solution to solve those market failures. This is the case on rural broadband extension programs promoted by the central and regional (and sometimes, municipal) administrations applied in many countries in Europe. The administration pays for the deployment of infrastructure (DSL extensions in some cases, WiMax for low-density areas or satellite for remote regions) and establishes the price to be paid by the users according usually more to social cohesion objectives than cost-oriented.

The subsidy is an adequate tool when a private fixed or wireless access network already exists and it is necessary to extend the coverage in order to grant services to locations where there is no broadband offering, or there is a small gap between the expected income and the income needed to build a viable business plan. It should be noticed, however, that in that case, the municipality relinquishes all control over the future evolution of the network, as well as over its exploitation and commercialization, except if clearly stated otherwise in the conditions of the subsidy, which rarely is the case. It is important to note that in order not to enter in disloyal competition, subsidies should fulfill several conditions:

In a competition situation (i.e., there already exists a commercial offering for similar or substitutive telecommunication services), the subsidy from the administration probably will be considered by the companies not favored by it as disloyal competition, which can represent legal problems both for the administration and for the subsidized company. This condition implies that subsidies should be only oriented to correct situations where there is no equivalent commercial offering to the one that will receive the subsidy, hence making this mechanism more amendable to fostering broadband availability objectives, and not in competition promotion.

- Any subsidy should be awarded via public tender and following a technologically neutral approach (i.e. requiring services without fixing the technical solution to be adopted), in order not to discriminate any potential actor interested in participating.

The subsidies can be a total subsidy covering all costs involved in the network deployment or the costs may be shared between the municipality and the operator receiving the subsidy. In general, a 100% subsidy for a whole wireless network does not make sense, because in that case, the municipal ownership of the infrastructure is a better strategy in order to retain control of the future evolution of the network and its use for municipal objectives, that are not necessarily the same as those of the subsidized operator [Daggett, 07]. In any case, when there is an existing private network and the municipal objectives are to be fulfilled with an extension of this existing network (for example, deploying network infrastructure in low-income areas), a full subsidy covering the deployment costs can be a fast and clear-cut solution to obtain broadband availability in areas not covered by the existing offer.

When, on the contrary, there is a private commercial interest in deploying the network to the areas of municipal interest, but the foreseen revenue generated is somewhat short of guaranteeing an adequate ROI, then a partial subsidy can simultaneously lower the barrier to the deployment for the

private operator and the cost of fulfilling the municipal objectives.

It should be emphasized once more, that in order to dimension the municipal subsidies, it is important to perform a careful quantification of the benefits to be obtained and the associated cost. The economical evaluation will supply a guide to establish how much the municipality can invest and to check if there is a viable way to fulfill the objectives by supporting a private deployment via a subsidy.

Constitution of a consortium

In many cases the municipality is not the only actor interested in the availability of the network and the services provided on it. Organizations like the chambers of commerce, regional administrations, education institutions, tourism promotion consortia, and even companies interested in using the network for their own purposes are the most usual actors that are interested in promoting this kind of network.

In those cases, a possible approach to launch a municipal network is to constitute a consortium where each actor contributes with resources oriented to fulfill its own objectives. In this case the ownership of the network corresponds to the consortium and the members steer the strategy driving the deployment, network and services operation through their oversight of a third party (usually a wireless specialized operator), who performs the day-to-day technical management functions on behalf of the consortium.

The rationale to opt for this participation model should include the following considerations:

- The objectives for all the participants in the consortium should be complementary, or at least compatible in the short and medium term. It is also important to detect additional candidate anchor tenants that could increment the economical viability of the network.
- All the participants should acquire a compromise to contribute with resources. Sometimes the resources are just money, but in other occasions some partners can contribute with network segments (for example, WiFi hotspots already deployed), access point locations, providing hosting or housing facilities for equipment, electric supply or backhaul networks or technical or business model assessment and support.
- The decision making process should be well defined, agile and the intensity of the participation of each actor should be taken into account when establishing the weight of each actor in the strategy definition.
- There should be clear rules and compromises for entering and leaving the consortium, especially when the resources granted by the participants are key elements for the network operation.

Although the consortium among interested actors is a suitable mechanism to involve the civil society in the network definition and evolution, it is not always the optimum way to articulate the participation of several actors. When there are several actors participating, the decision making process gets more complicated and slow, and the uncertainties on future evolution grow. A careful assessment on the advantages obtained in terms of contribution and additional anchor tenants involvement compared to the mentioned disadvantages should be performed. The scenarios where this participation model is more adequate takes usually place in large networks with important associated investments and several organizations coordinating their efforts and objectives. The case of the Boston initiative [Boston, 06] is a paradigmatic case of this participation, where the municipality contributes with assets to locate the access points and will act as an anchor tenant for the network.

The participation of telecom operators in the municipal consortium places special concerns, as some of the usual objectives for the large municipal networks, as incrementing the broadband offer and competence via opening the network to all ISPs, and broadband extension for underserved areas are not always compatible with the private operators view, who prefer to concentrate network coverage

in richer areas and use the network under exclusivity models. In these cases, the consortium can be advised by the operator that operates the network on behalf the consortium in order to assure technical and economical soundness, but no necessarily must be part of the consortium that takes the decision.

The municipality as network owner

When the municipality finances all or most of the network deployment, and the regulation allows for the municipal involvement (as is the case in Europe, provided that account separation is accomplished and no disloyal competition is performed), the network ownership is the natural way to articulate the municipal participation, that should be medium-long term oriented, as the investment will not be returned in the short term.

Municipal Network ownership implies a number of legal obligations. Some of them are associated with the condition of being a public administration, as the aforementioned cost account separation or abiding by the competition rules for public intervention, and others are derived from the condition of telecommunications operator that is associated with the services provision to the public, such as maintaining connection logs for security reasons, warranting confidentiality of the communications and users' data, and the like. Although none of them are difficult to be accomplished, these issues suppose additional tasks for the local government that should be balanced with the benefits to be obtained.

The main advantage on municipal ownership is that the local government can exert a total control on the network coverage and technology evolution. This is important when the objectives are oriented to social issues not compatible with market monetary motivations, as digital divide amelioration and also when it is of paramount interest to warrant in the long-term network openness [Daggett, 07]. Also, when the network backhaul is built in a great part using the municipal corporative network, it is simpler to manage and evolve all the network (the access and the backhaul) as a whole, conciliating both the internal corporative services needs and the external network use, and so, in this case is also advantageous the municipality ownership of the access network. Of course, when the local government funds the whole network, usually it does not make sense to transfer the ownership to third parties.

In general, the local government ownership is fitted to efforts where most of the resources (monetary or network facilities) are coming from the municipality, due to a lack of private interest in invest on network deployment or due to shared use of network facilities with other municipal activities, as is the case of the municipal electric utilities in the USA, or the use of modern fiber-based traffic lights control networks as backhaul.

Although local government ownership does not automatically implies municipal network management and deployment, nor services commercialization, it is important to note that this model supposes a long-term municipal involvement, contrary to the subsidies or the provision of civil infrastructure for private networks models. A more detailed analysis than the one to be performed for one-time subsidies should be devoted to the strategies, threats (as the evolution of fixed broadband and 3G offer), risks, economical issues and possible disloyal competence considerations. A good reference for “things that can go bad” and usually undervalued issues in the medium and long term when planning municipal networks deployments can be found in [Balhoff et al., 05].

Before considering getting involved in funding a whole network, it is important to check if the pretended objectives can be achieved granting use of municipal assets, subsidizing existing networks or via other mechanisms that lower the long-term risk for the municipality. As seen this last years, there are private companies as The Cloud or Google that are eager to deploy and exploit this kind of networks, and the municipality can lean on them in some cases. Anyway, sometimes there are not private parties interested in funding and exploit the network (Earthlink, an important USA player in this field in has stated their intention not to cover more cities by now and concentrate in their existing contracts [Reardon, 07b]) or the deployment characteristics advise the municipal

ownership, and in the case where an important part of the network facilities are based on municipal corporative networks.

Should the municipality manage the network?

The ownership of the network does not imply that it should be directly deployed and managed by the municipality. In fact, the deployment, operation and maintenance of networks are specialized tasks that require a profound know-how of the associated techniques, processes, tools and issues, being also subject to scale economies. Since municipality officers working on the IT departments are generally specialized in managing private networks, but not in public networks⁵, and it is not possible to apply economies of scale to a single municipal network, these activities are usually outsourced to specialized companies.

When the network and/or the services management is outsourced to a third party, the municipality should define Service Level Agreements (SLAs) stating the expected availability, number of incidents and resolution time, service provisioning parameters (average and standard deviation values for each type of service, etc.), performance, and any other parameter affecting the service and network quality. It is important to define SLAs in measurable and verifiable terms, in order to be able to check their fulfillment. These SLAs should be included in the outsourcing contract, stating penalties for SLAs non-fulfillment. Once the outsourcing contract is running, the municipality must be involved (directly or through a third party different from the outsourcer) in controlling this SLA fulfillment and network and services evolution.

Although the most common scheme is, as stated, to outsource the network management activities to a specialized company, in small deployments (e.g. isolated hotspots) and wireless networks strictly for internal use that are part of the corporate network, and if the IT department have the tools and knowledge to manage the network, it is possible to keep such operations internalized. Nevertheless, most municipal wireless networks correspond to the outsourcing scenario, where the municipal involvement is centered on stating requirements for the evolution of the networks and services.

Wholesale and retail commercialization

As told before, there exists essentially two ways of commercialization of the services provided by a municipal wireless networks: the wholesale and the retail model. The retail model is based on a direct service commercialization in the residential and business market. Under the wholesale model, the services provided by the network owner are used by service providers that are the ones that sell services to the public in general. The service provider contract minutes, connections or bandwidth in the network stating SLAs based in general in availability parameters, and paying a fixed or variable amount depending on the terms established for granted the services offered by the network, and sell in the retail market the final services to the users. Wholesale and retail commercialization can coexists on the same network, as is the case for telecommunications incumbents that supply retail services and sell (in many situations obliged by the law) to other operators.

When a local government finances or deploys a network, or grant access to traffic lights and poles to build a network that will provide public service it must choose the commercialization model/s that will be used by the network owner for accessing the market. In general, it can be said that the wholesale model is a clean way to enforce network openness and promote competition in the services market. Under the wholesale model, municipal owned wireless network is seen as a public infrastructure that is used by the private sector to deliver services to the public, lowering the role of the local government as a supplier for the companies, that takes the leading role in managing the services portfolio, marketing, billing and in general services and clients management ([Infante et al., 05]). This is consistent with common views of the public organizations as infrastructure providers

5 Even in that case, outsourcing is the more usual management model used by the IT department of municipalities.

for basic services, but not as value-added services providers, where the private sector shows a more dynamic behavior.

In the case that the network is deployed by a private company using the public infrastructure, some clauses for wholesale offer can be included in the public tender or agreement in order to warrant that other ISPs can use the network and increment the present or future services offer. [Lehr et al, 04] describes issues to be considered when establishing clauses for this wholesale model. Considering that is limited the number of equipments that can be mounted on the poles and that the municipality in order to avoid maintenance troubles will prefer to allow the deployment of just one network, the company that is granted with the use of this kind of infrastructure will enjoy a de facto monopoly on the citywide WiFi network. That is another reason to include clauses stating the obligation to open the use of the network to other ISPs in order not to sustain a private monopoly on wireless broadband services.

The canonical wholesale model does not allow the private network owner or provider to commercialize retail services, in order to avoid interest conflicts among the retail business and the wholesale business. In that way, for example, the Boston initiatives establish this condition for the consortium that will own the network [Boston, 06]. However, companies that are usually interested in tendering for these network deployments are reluctant to apply this rule, and claim that there are much more risks for them when they can't commercialize services directly in the retail market. A balanced compromise is many times needed to allow retail commercialization while supplying wholesale service, stating clearly and with as much detail as possible the wholesale obligations for the private network operator including provision timescale, rules to obtain the wholesale price and technical conditions.

The wholesale model present, however, some disadvantages over the direct retail commercialization. The main one is that it is technically more difficult to implement (the architecture must consider several ISPs connections and the captive portal must show and redirect to the different ISPs) and there are more actors implied supposing a more complicate organizational structure. For small municipalities where there are only one interested ISP in operating the network and selling services, the direct retail model (with a clause stating the future openness of the network if any other ISP is interested in providing services over the network) and a simple architecture oriented to this retail model is usually the optimum solution.

Participation in wireless commons efforts

The wireless commons models are based on infrastructure sharing among several participants granting an open and free access to the whole network to each of the participants (many times, but not always, also to all the citizens). Each participant contributes with resources, usually fixed broadband Internet service and/or access points, and adheres to a set of rules governing this infrastructure sharing.

Most of the wireless commons initiatives are boosted by citizen non-profit communities constituted by technology enthusiastic sharing a common view based on the hacker ethics sustaining the free software models [Himanen, 01]. Their interest is focused on technology experimentation, altruistic service for the community and development of bottom-up network development steered by the users and not the telecom operators [Sandvig, 04]. Although many of these community wireless networks (CWNs) are small, lack of organization and are not merged with the rest of the citizen community not keen on technology, part of them as Urbana-Champaign, Austin Wireless or Guifi comprises an important number of participants, interesting projects and have established relations with other civil society organizations as SMEs, universities, cultural associations and municipalities.

In the case that one of these well-organized and active CWNs is located in the municipality, some of the possible local government objectives can be covered through collaboration with the CWN. It should be considered, however, that CWNs are not Internet Service Providers, meaning that no QoS

guarantees, nor customer care facilities, nor top-down deployments can be achieved by leaning on these organizations. This weakness generally excludes the use of this model for deploying broadband service in competition with commercial ISPs, for internal municipal services, and any other network deployment in need of intense planning. Nevertheless, there are situations where the collaboration with a CWN can render profit for the municipal objectives:

- In the case of “grey” zones where the commercial broadband offer is scattered covering some parts of the municipality, but not others, CWN can play a key role in extending the coverage and sharing the existing broadband connections in greater areas using of WiFi radio links and nodes shared by wireless commons rules. This is the case of guifi (<http://guifi.net/en>), a Spanish CWN located in Osona, a rural area from the autonomous region of Catalonia. In August, 2007 Guifi accounted for 2.545 adhered access points configuring one of the most extensive wireless commons network initiatives in Europe. The wireless commons rules applied in this CWN consist on open access to the equipments of each participant (usually, to be used as relay node for connecting some location) and freedom to offer Internet service to the public or use the network for internal services. Small municipalities or isolated SMEs where there is no broadband commercial offer, and residential users in the same situation or not concerned with strict QoS guarantees are the main participants in guifi, collaborating in deploying network and in the operation and maintenance. The municipalities in the area of Osona are actively collaborating, financing nodes for the mesh network in order to get service where there is not offer and facilitate broadband spreading among the community.

- In the case of well-connected locations where there is existing commercial broadband offer, the municipal collaboration with a CWN maybe useful to boost public and private hotspots offer in the city. This is the case with Austin Wireless City Project (AWCP, www.austinwirelesscity.org) described in detail in [Fuentes-Bautista et al., 05]. AWCP is composed of user groups, startups, nonprofits and advocacy groups and provides common user interface across different hotspots, network monitoring and support tools for statistics and access control. The Austin municipality deploys hotspots in parks, public buildings and nonprofit facilities that are jointly managed by the city and the AWCP. The collaboration between AWCP and the municipality benefits both parts, as the local government participates in the support of AWCP in order to get technical support and advice, and facilitate the deployment of private venues hotspots that are mainly based on a free access model. The data provided for the AWCP initiative shows that the users are a select group placed among the youngest, more educated and more affluent Internet users and that most of the hotspots adhered to AWCP are located in the wealthiest part of the city, indicating that the digital divide reduction objectives are not covered by the model adopted in Austin. In any case, objectives oriented to increment the free wireless coverage in public access areas as parks and retail commerce venues oriented to services and good consumption seems to be well fitted with this kind of collaboration.

Most of the CWN rely on sharing fixed broadband access among users (under free or paid models) that break the clauses established by the fixed ISPs that restrict the use of the service to just internal use of the organization or residential user contracting the service. Although this is not the case in Austin, where Time-Warner agrees on the use of the fixed broadband service for the hotspot service to the public, this is the case for most of the ISP broadband offer and the municipality should be careful when opening to the public the use of fixed broadband internet connection through a hotspot, in order not to get in trouble with the ISP. Till now, there has been few legal problems when sharing broadband connectivity, but it is expected that the ISPs will define their position as active persecutors of contract infringements (when the service competes with broadband fixed services or even with 3G services in the case of integral operators), or –as in the case of Time Warner in Austin-, granting the use of the service for hotspots, considering that the hotspots will act as a incentive for fixed broadband demand. Anyway, the municipality should try to reach an agreement with the fixed ISP (as for example, the case of the Cincinnati a mixed municipal-nonprofit-cable company initiative ([TWC, 06]) or at least, evaluate the incurred risks when sharing

fixed broadband connections.

An special case of wireless commons models are those that are based not in voluntary and non-profit participation, but in a commercial business model where a company supplies service supported by mainly residential fixed broadband connections shared by the user contracting the service and the company providing service to public. In this case, the adhered users get free access to the whole hotspots network forming a wireless commons organization and share the incomes with the service provider when external users connect their hotspots. This is the case for FON, a Spanish startup funded among others by Google and Skype and operating worldwide and as stated by the company (www.fon.com/en). FON claimed to have 100.000 access points and 250.000 users in its first anniversary in February 2007 (while the jiwire hotspots finder announced 153.409 hotspots as August, 2007, *worldwide for the rest of hotspots operators*).

Some municipalities in Europe as Lleida and Malaga in Spain, Oslo in Norway, Lund in Sweden and Blanquefort in France (www.fon.com/es/news) has made arrangements with FON incorporating their municipal hotspots to the FON network. In exchange for the municipal collaboration, FON donates wireless routers for the residential users in order to incentive the spreading of FON hotspots, and configures the initial portal for the municipal hotspot with location aware information (for example, in the municipal swimming pool, the user sees information about courses, activities, fees, etc.).

FON share with the non-profit CWNs the main weaknesses, i.e., participant contract infringement for most of the ISPs (once again, Time Warner is the exception, [Reardon, 07a]) and sparse hotspot distribution mainly based in residential access points. In our point of view, in this case what the municipality obtains from the municipal participation is short for most of the scenarios. In the case that the municipality owns a limited number of hotspots in public spaces, the agreement with FON can provide a for-fee service to citizens and visitors without devoting resources to users access and payment management, issue that can be solved also with the collaboration of a local start-up employing the FON share for that means. In the case that the municipality deploys a wide wireless network covering whole zones, if the service is provided by FON, in fact FON will act as a commercial for-fee ISP (except for other participants in FON, being free the service for them) and the adequacy of the agreement with FON should be analyzed using the rational explained in the proceeding paragraphs for the collaboration with the commercial ISPs. Probably, most of the municipal involvement with FON has considered the collaboration with this company as a mean to boost in a simple way the residential and commercial venues involvement along the city in deploying hotspots, acting as examples to be follow for the citizens in order to increase the city wireless commons. It is still early to evaluate if this strategy gets the pretended objectives.

So, in short, when there is an existing active and well-organized CWN, it could be interested to collaborate with its participants in order to extend broadband service in areas where there is no commercial offer through mesh networks architectures. Also, in well commercial served locations, the collaboration with a CWN can be a useful tool to promote the hotspots deployment in public access venues. The collaboration with a hotspots aggregator comprising wireless commons agreements for the participants will help to increase the size of the wireless broadband sharing among the citizens. Objectives related with internal municipal services mobility, citywide covertures, commercial reliable and quality service, and digital divide reduction cannot generally be met using this participation model.

Participation model decision workflow

The diagrams shown in the following figures summarize the rationale described in the preceding paragraphs, suggesting a set of decision criteria in order to establish the municipal participation model. Figure 2-2 shows how, once the municipal objectives are set depending on the local conditions (existing broadband offer, regulatory issues, economic development situation, etc.), a comparison of the deployment and O&M costs versus the supposed benefits should be done. If the project is economically viable in strict monetary terms (incomes and savings) considering the short and long term, the network will clearly arise enough interest to be deployed, under municipal ownership in the case that the corporate network is to be used as backhaul or if there is an existing synergy with other municipal activities (the case for example of municipal electric utilities), and as a privately owned initiative in other cases. In the latter case, a public tender will be performed in order to grant access to municipal assets, including clauses ensuring the accomplishment of the objectives that are not clearly addressed by the private sector (wholesale clauses, digital divide actions, commercialization conditions, etc.), but are compatible with the private initiative project economic feasibility.

When the direct incomes obtained by the commercial operation do not suffice to attain economic sustainability, perhaps guaranteeing reliable revenue by acting as an anchor tenant can raise the income for the private sector enough to encourage the private network deployment using the municipal civil infrastructure. Otherwise, an assessment should be done on the whole municipal economic feasibility of the project, considering the existing budget for social objectives as “the value” for reaching these non-commercial objectives. When the sum of incomes, savings and the budget for social objectives does not allow economic feasibility, a reassessment of the municipal objectives should be done in order to equilibrate costs with the expected benefits along the expected life of the network. If this reassessment, probably reducing the municipal objectives, coverage and services does not allow economic feasibility, it is not worth it to promote a wireless network and the project should be abandoned in favor of other kind of municipal actuations.

Supposing that the social objectives mixed with the economical ones allow the economic sustainability, a municipal involvement is advisable. Different forms of involvement are possible, from the development of a complete network, through the granting of subsidies for an existing one, to the deployment of municipal hotspots in collaboration (or not) with other actors.

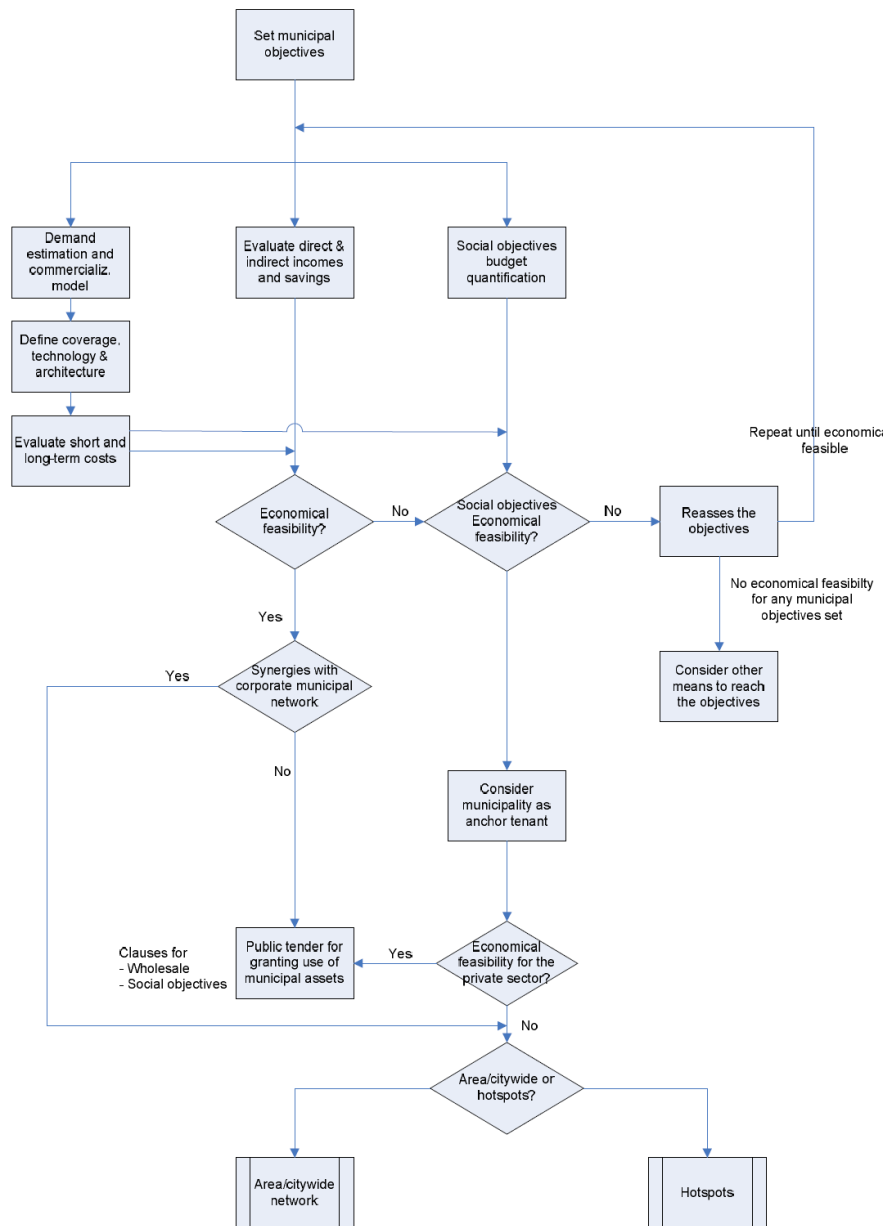


Figure 2-2: Decision process for launching a municipal network

For the large and dense networks covering whole areas or city-wide zones, in the case that there already exist broadband networks providing service for most of the municipal area, a subsidy to cover the gap between the costs and incomes can provide an incentive big enough for the existing operators, or a collaboration with a CWN can be sought to cover the underserved areas through mesh citizen collaborative networks. Otherwise, a new network should be deployed. Depending on the capabilities and interests of other actors interested in network deployment, a consortium to fund and own the network can be formed or the local government can act as a unique owner and financier.

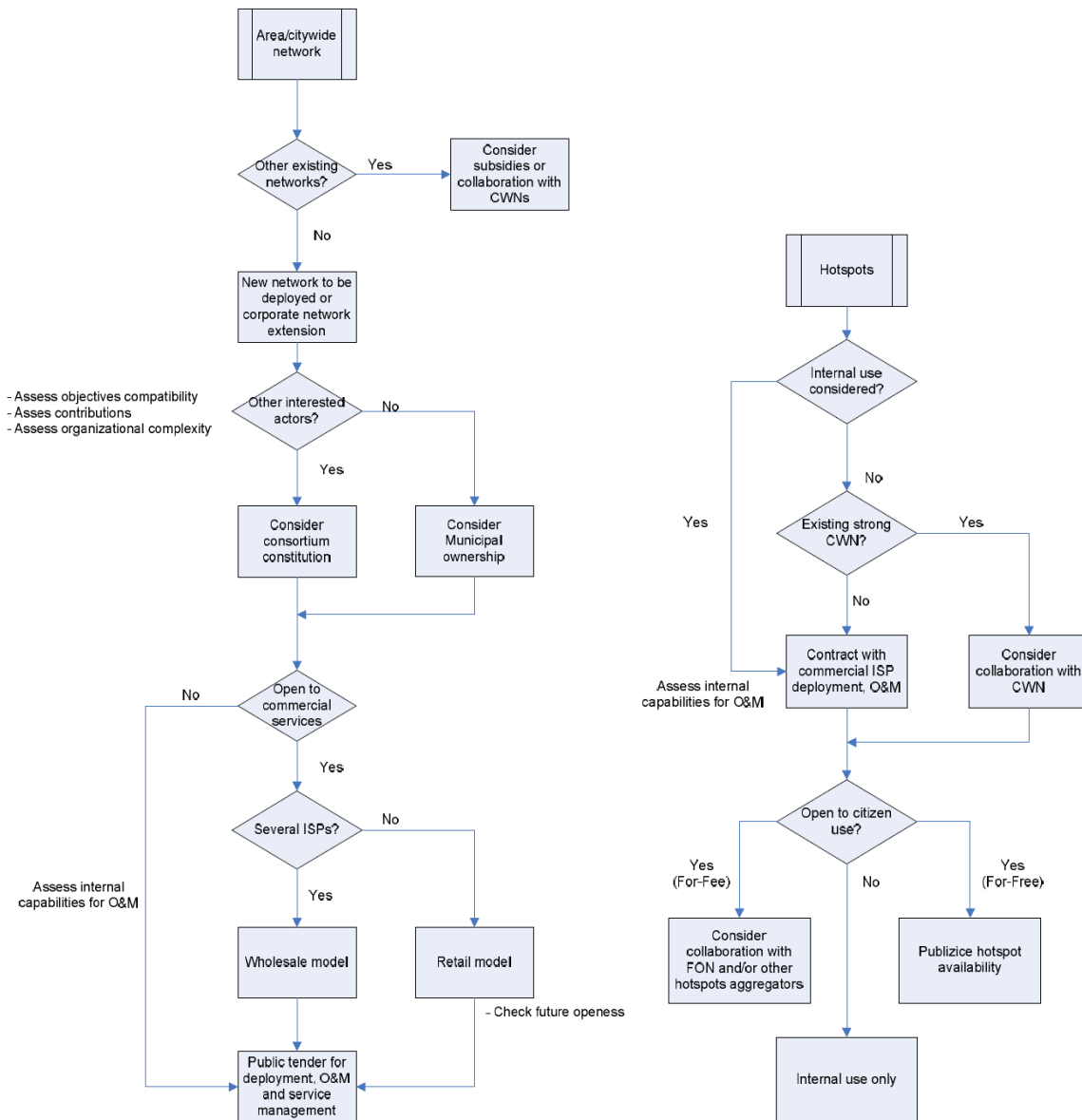


Figure 2-3: Decision process for launching a municipal network

Depending on the municipal objectives and the market context, the network will be closed to commercial ISPs (municipal internal services and only e-government services or free service for the citizens), open to all interested ISPs (wholesale model) or operated by just one ISP (usually the one that deployed and maintains the network), establishing in that last case conditions to open the network in the future for other ISPs. In most cases, the wide areas network deployment, operation and maintenance will be performed by a private specialized company that will be selected by a public tender.

Wireless wide area networks are usually oriented to cover objectives that imply a high degree of QoS guarantees and coverage targets that are difficult to meet by collaborating with CWNs, which usually are less QoS oriented and follow a bottom-up growth model not oriented to cover whole areas. On the other hand, when the municipal objectives are covered via hotspots deployment, collaboration with this kind of actors can render benefits, as shown in Figure 2-3. The CWNs can help extend wireless hotspots in retail commerce and residential venues, integrating the municipal deployed hotspots in a more extensive and dynamic network. In the case that the municipal hotspots

are to be operated under for-fee commercialization schemes, joining a hotspot aggregator network with wireless commons agreements for the participants can also foster the citizen hotspots deployment. When the hotspots are to be used for municipal internal services, probably special security and QoS concerns will arise and the network deployment and, in most cases, a specialized private company will provide operation and maintenance.

Of course, the alternatives and decision flows shown are subjected to the existing legal framework, different in each country (and even in every state in the USA), to the market and socioeconomical situation, local government sensitivity to each possible objective, possible participant actors and budget issues. All these conditions will enable or disable a different set of branches.

4. Conclusions

In recent years, a broad interest has arisen in public circles for the deployment of municipal networks based on wireless technologies, as well as for the direct participation of city councils in such projects. The goal of this paper has been to first *identify* and then *assess* the key forms that public participation in wireless municipal networks can take, under the light of the different goals put forward by city councils in pursuing such projects, as well as their diverse socioeconomic, legal and strategic contexts. The ultimate result has been the elaboration of a set of decision processes that can guide the municipal representatives in choosing the most adequate form of involvement, if any, for their specific situation.

One of the main conclusions of this work, beyond the chosen form of involvement, is that adequate care must be put in elaborating the levers that the municipality keeps to influence the exploitation and future evolution of the wireless network, especially if it the network itself or its management and exploitation do not remain in public hands. To set up adequate clauses in the public contracts to supervise and influence the network operation are paramount to ensure the attainment of the public objectives, which will be rarely fully aligned with those of the private entrepreneur.

A second remarkable concern is that due attention has to be paid to the sustainability of the project, in the short and in the medium term. As a guide, economic feasibility can serve to decide which form of municipal involvement (public infrastructure deployment, subsidy, and anchor tenant) is the more adequate. In general, in areas with no broadband service (or, in some special cases, limited to the presence of the incumbent), and locations where the network will rely heavily on existing municipal communication facilities or where the network will be devoted to corporate use, it may be adequate that the municipality is directly involved in funding the deployment of the network, and hence it should keep its ownership. Otherwise, less intense involvement looks more promising.

When considering municipal networks funded by private companies, two are the key roles of the municipality in most potential scenarios: As anchor tenant, and granting access to urban furniture. The first, because by guaranteeing a stable flux of income, it can ensure the economic viability of private projects, at the same time as the costs of providing public services can diminish. This is certainly true of big enough municipalities, and less so for small villages, where such public services as need telecom support are fewer. Second, granting use of municipal assets is important since the usage of public infrastructure as location of equipment and sources of electricity for ubiquitous coverage are critical, and advantageous access to them can greatly reduce the deployment costs for private operators in all cases.

What has also emerged as a clear idea is that municipalities rarely possess the adequate know-how and human resources to directly manage the network, and that in most cases that should be outsourced to professional companies⁶.

⁶ An exception are municipalities which, for different reasons, dispose of a related know-how, such as the municipal electric utilities existing in some locations in the USA.

Public-private partnerships are a powerful weapon to embark other interested actors and civil society into such a project, but the complexity of managing the resulting consortium should not be ignored. The interests and capabilities of the different participants should be aligned and complementary. Clear decision rules, where the degree of involvement in the project also results in higher decision power should be put in place to avoid stalemates and misalignment of objectives.

Subsidies are a good alternative when small network extensions or a small increase in IRR are all that is necessary to achieve the municipal objectives, but they can easily be rendered ineffective or counterproductive. In certain circumstances it is possible to create a reliance or even dependency of subsidies to pay for the network extension, even if the extension is economically profitable for the company receiving the subsidy.

In general, guaranteeing access to the network infrastructure for more than one service provider (wholesale service), irrespective of who keeps the ownership of the infrastructure, and even a company is simultaneously the owner of it and one of the service providers, allows for the smooth present or future introduction of competition in services. Since effective competition is the tool of choice to increase the welfare of consumers, monopoly exploitation rights should be discouraged in most situations.

Lastly, the participation in wireless commons efforts is adequate in special situations, provided that all legal and technical guarantees are fulfilled. Mainly, where broadband coverage is patchy (in remote rural areas), collaboration with CWNs can bring about the connection of those small villages or locations, which are not commercially viable for private operators, and where a small set of APs will serve to cover the area. Certainly, connectivity is here more important than quality. Alternatively, CWNs can also be used in well covered cities to boost the creation of hotspots in public spaces and shopping centers, acting simultaneously as catalysts of broadband demand and offer.

Municipal involvement in wireless network efforts is a reality. The technological evolution of public service provision is also an unstoppable matter in this ever more mobile, ever more networked society. This work has tried to shed some light on how best take advantage of these trends to the furtherance of the public good. To that end, adequately choosing the model according to which the municipality will involve itself in municipal networking is paramount. As it is, at present the experience with real deployments is still short, and hence it is not an easy task to foresee which models will eventually succeed. Furthermore, the amount of variables to be taken into account, as evidenced by the diagrams and analysis presented here and in other related works, is large and consequently all forecasts must be taken with the proverbial pinch of salt. Only time will tell.

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