OPAALS PROJECT

Contract n° IST-034824

WP12: Socio-Economic Models for Digital Ecosystems

Del12.7 – Sustainability and Business Models for Digital Community Ecosystems

Information Society Technologies

Project funded by the European Community under the "Information Society Technology" Programme

Contract Number: IST-034824

Project Acronym: OPAALS

Deliverable N°: 12.7

Due date: November 2008

Delivery Date: 26 January 2009

Short Description:

In Phase 1 we analysed Community Networks and Digital Ecosystems relationships. Two important issues we learned are that under the Community Network label we can consider many different phenomena mainly based at local level and that with the term Digital Ecosystem we may consider more than business communities. Therefore we refer here to Digital Community Ecosystems (DCEs) as the heterogeneous way to adopt the DE principles by a wide range of communities at the local level. In fact, DE services could be adopted at the business, at the grassroots and at the government levels. To understand DCEs means to identify business and sustainability models by underlining, for example, how DCEs innovation could create a virtuous circle between social, infrastructures and services innovation. This innovation dynamics is related to many actors involved at the local and global level. The main objective of this deliverable is to explain the possible business model of DCEs in terms of creation, sustainability, return of investment (ROI) and risk.

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Partners contributed:

Made available to: Public

Versioning

Version	Date	Name, organization
1.0	30/12/2008	Csaba Szabo and Francesco Botto (CN)
2.0	20/1/2009	Csaba Szabo and Francesco Botto (CN)
3.0	26/1/2009	Csaba Szabo and Francesco Botto (CN)

Quality check

Internal Reviewers: Antonella Passani (T6 ECO), Ossi Nykänen (TUT)

Dependences:

Achievements*	In the reported period it has be developed: • the Digital Community Ecosystems idea; • the theoretical and conceptual reflection concerning the Trentino DCEs experimentation; • the identification and explanation of a first level of issues for DCEs business and sustainability models; • the identification of an alternative model of DEs regional introduction out of the Trentino case innovation strategy. In the reported period we did not develop a set of exhaustive and coherent business and sustainability models for DCEs.
Work Packages	The following WPs could benefit of this deliverable: • All WPs: Chapter 4 on participation and the complementary approach for DE development can enrich the "user level" understanding. • WP11: Chapter 1 on DCE definition and Chapter 4. • WP12: all the deliverable should interest the WP12.
Partners	LSE, T6 ECO, UniKassel, UL, IITK, IPTI, UNIS, SUAS, WIT.
Domains	Social science domain.
Targets	All
Publications*	Actually we did not publish the reported work.
PhD Students*	
Outstanding features*	With the conceptualization of Digital Community Ecosystems we are introducing the novel idea that DEs innovation could be applied in a wide range of ways at the regional level. The idea to move from DEs business clusters to the ecosystemic regional innovation is new. Also the strategy to follow and facilitate the regional innovation by working on different bottom-up/top-down project layers is new.
Disciplinary domains of authors*	Csaba Szabo: computer science and business planning/modelling domains Francesco Botto: social science and information systems research domains

The information marked with an asterisk (*) is provided in order to address Recommendation n. 4 from the Year 2 review report

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Introduction

In Phase 1 we analysed the relationships between Community Networks and Digital Ecosystems. As we emphasized in our earlier report (D7.2), Community Networks (CNs) provide ubiquitous access, full coverage of the respective territory, and access from a multiplicity of user devices and platforms. On the other hand, a broadband infrastructure is a fundamental requirement for a digital ecosystem. Digital Ecosystems (DEs) are advanced services enhanced by new software infrastructures that hardly require broadband connectivity. We aimed to show how CNs can help the adoption of DEs in regional settings and we illustrated it by using the early steps of our regional case study: the development of a regional community network in the Provence of Trento, Italy. When applied to regional community networks, digital ecosystems can generate a broad range of positive externalities and interact constructively with the network effects that the community network "kick-starts" but that the digital ecosystem continues to feed.

This deliverable plays a strategic role between the Phase 1 work and the upcoming case-study analysis. Deliverable 7.1 defined and analysed the relationship between CNs and DEs from a conceptual and theoretical point of view. It suggested the adoption of the socio-technical perspective on infrastructures in order to consider (a) the complex relationships that are usually invisible when reflecting on DEs implementation, and (b) the relevance of the participative-based and longitudinal qualitative analysis for any meaningful and sustainable DE concrete development. Deliverable 7.2 started introducing the very first steps of DE innovation in the Provence of Trento. The forthcoming deliverable 12.8 will present the current steps of the Trentino – the commonly used name of the Province of Trento - case in terms of Digital Community Ecosystem. The future local research will follow the same framework.

Our current objective is to introduce and analyze business and sustainability models for Digital Community Ecosystems. We refer here to Digital Community Ecosystems (DCEs) as the heterogeneous way to adopt the DE principles by a wide range of communities at the local level. In fact, DE services could be adopted at the business, at the grassroots and at the government levels. In order to understand the value of this approach we should then consider all the main dimensions of DEs under a “glocal” framework. It goes from a local level, where local communities create and re-create themselves with services and infrastructures, to a global one, where those many communities engage in global relationships. To understand DCEs means to identify business and sustainability models by underlining, for example, how DCEs innovation could create a virtuous circle between social, infrastructures and services innovation. This innovation dynamic is related to many actors involved at the local and global level. We will consider also the potential vicious circle that is connected to the bad dynamics between the same actors and innovations. Therefore, the main objective of this task is to explain the possible business model of DCEs in terms of creation, sustainability, return of investment (ROI) and risk.

In this report we are not providing a set of exhaustive and coherent business and sustainability models for DCEs. DEs are still under an early experimentation phase, the empirical relationship between DEs and CNs is at its first stage, and the idea to start experimenting DEs for the open local society is new and challenging. More formal models

will probably follow the results of the first experimentations. At this stage the only perspective we can suggest is to understand those models as an imperfect set of ideas and points of attention for DCE development. In particular, we refer here to business models as a set of assumptions regarding the sources and amounts of expenditures and revenues. About sustainability, we suggest the development of DCEs by adopting the participated methodologies that will facilitate local stakeholders choices about DEs innovation (Chapter 4). Those ideas and dimensions are part of our regional case research outcomes.

This report may be considered as somewhat imbalanced in favour of telecommunication infrastructures issues. The reason of this is that it is the only place in OPAALS where to consider CNs in relation to DEs. Therefore, we are focusing on basic infrastructures and economic assumptions, plus suggestions on the strategies and processes to develop sustainable DCEs.

In Chapter 1 we define Digital Community Ecosystems (DCEs) in order to empower the Digital Ecosystem (DE) vision with other aspects of the broadband-based innovation like Community Networks. This section will finally underline some issues for DCEs business and sustainability models discussion.

Chapter 2 starts with a brief summary of business aspects of state-of-the-art wireless technologies. We consider the “business aspects” of these technologies: availability in terms of standardization, maturity etc. Main business models are dealt with in Sub-section 2.3. We point out that the anchor tenant model has been successful in the USA and worldwide. Therefore in Sub-section 2.4 we present the anchor tenant model implemented in Trentino, Italy. At the time of writing this report, it was not possible to collect enough data for building business models. At this point we only would like to demonstrate, with some high level and preliminary data, how the anchor tenant model is being implemented in Trentino.

The approach that can be called capillary development of access networks is dealt with in Sub-section 2.5. Close to 100% broadband coverage of the territory is the main challenge for local governments that intend to develop a community network (CN). Local government may decide to reach this objective in many ways.

Having analysed the business models for infrastructure development, we address the issues of the deployment of services in Chapter 3. First we point out to an important point of choosing the right business structure for the infrastructure creation, operation and for provision of services to public institutions and in the marketplace. In Sub-section 3.2 we briefly present the business structure implemented in the Province of Trento, Italy. In 3.3 we summarize the planned services in Trentino and point out to the expected benefits. Section 3.4 is dedicated to “service delivery platforms” or service platforms or SDP.

Finally, in Chapter 4, “Participation”, we first criticize the earlier DE introduction model in favour of a more locally-based process, second we explain the participated methodology that would allow a regional DCE-inspired innovation out of our strategy.

CHAPTER 1: Digital Community Ecosystems

In this chapter we will define Digital Community Ecosystems (DCEs) in order to empower the Digital Ecosystem (DE) vision with other aspects of the broadband-based innovation like CNs. It is possible to approach the DE-CN relationship by analysing how DEs could meet the sustainable deployment of ICT for development in a specific setting (see: Sarkar and Rajagopalan, 2008), providing interesting information for DE applications for local communities. We will follow the CNs and DEs conceptual framework that has been developed within WP7 of OPAALS 1st phase, and we will drive ideas to DCEs business models to be considered in local settings (in Deliverable D12.8).

We will consider both the conceptual interpolation between DEs and Community Networks (CNs) – provided by the OPAALS D7.1 (Botto and Passani, 2008) - and the technologies involved in the regional broadband-based innovation – provided by the OPAALS D7.2 (Szabo et al, 2008) -. Therefore we will first summarize the dimensions that DCEs collects from DEs and CNs, secondly we will define DCEs by using the CISG framework that has been developed in D7.1, thirdly we will focus on DCEs services for participated local innovation, and finally we will underline some issues for DCEs business and sustainability models discussion.

1.1 DCEs between DEs and CNs

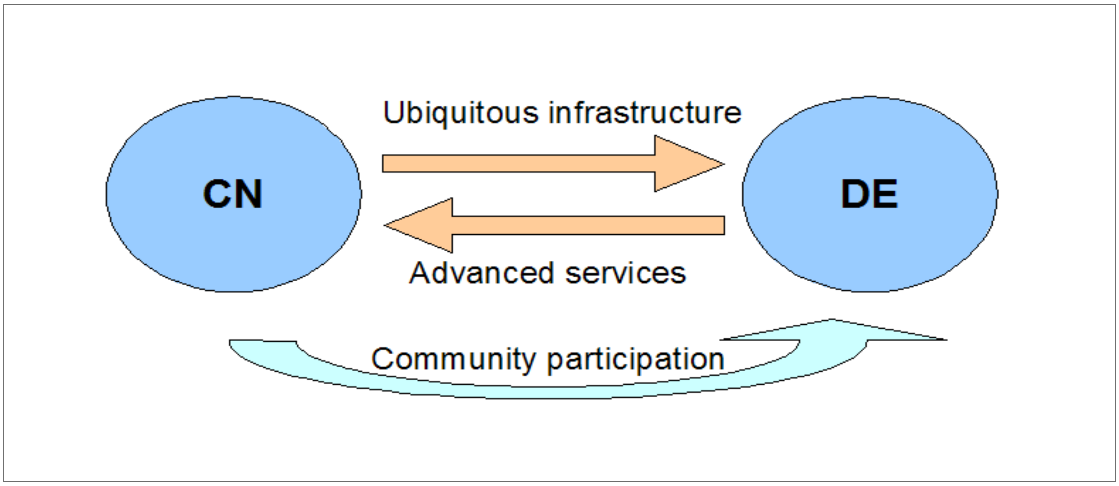
We define Digital Community Ecosystems (DCEs) as a phenomenon that stands on the line of two possible DE and CN intersections. Therefore DCEs could be considered between (a) DEs empowered by considering the most important broadband-based local phenomenon that is CNs, and (b) CNs with some kind of DE services. Since DEs are not yet a reality[1], we can simply theorize - and experiment (see the forthcoming D12.8) – their application outside the business world and connected to local communities. In fact the business-oriented DE services could produce virtuous circles if based on the more broader local communities needs and on technologies and collaborative socio-technical environment in general. The OPAALS report D7.1 (Botto and Passani, 2008) describes what CNs are and how CNs and DEs could help each other.

CNs have been described as off-line local communities that also meet on-line (Kavanaugh et al, 2005), then D7.1 defined two main tendencies. On one side there is the grassroots bottom-up tradition (Schuler, 1996) that underlines the participated construction of democratic technology. On the other side there is the government top-down new tendency to consider CNs as public broadband infrastructures (Chlamtac et al, 2005). Since the wireless infrastructures are actually offering useful and relatively cheap infrastructure

1 DE is a novel concept that can be defined in many ways. We are here referring to the European Commission understanding of it. In this report we consider DEs as a sort of ideal that should be re-designed and tailored to develop and fit the regional needs. What still does not exist is a solid concrete and sustainable experience of regional Digital Ecosystem innovation.

solutions, it has been noticed that the grassroot tradition is nowadays involving the construction of infrastructure technology and not only software.

On the DE side the tendency is mainly top-down and considering an already given broadband infrastructure. The innovation is promoted by the local government or a public agency, the role of the Service Oriented Infrastructure (SOI) is stressed that should be self-managed by the users, and that will support the creation of services in an automatic way. With an high degree of reduction it is possible to say that CN traditions can offer ubiquitous infrastructures and a model of community participation to DE services (Figure 1).



Quoting the D7.1 (Botto and Passani, 2008:53):

"It can be said that once a mature 'Government CN' and an efficient DE emerge with a full technological development, it will be populated by a cloud of services and players. Once this happens, three possible synergies between CN and DE will emerge (...):

a) CN and DE as a synergistic regional development strategy that implements both a government CN and a DE, providing communities affected by the digital divide with ICT access and advanced services simultaneously.

b) DE and CN as sources of different but possible complementary services. As it was developed, DE can be interpreted as an instrument for providing users with advanced services; by providing the possibility to make already existing B2B services interoperable, and by providing SMEs with an effective path for ICT uptake and collaboration boosting. Besides this, DE can be interpreted as an important knowledge provider. (...). CN, as 'government CN', could provide, through the DE, those services now available through the web, related to fostering citizens and SMEs participation to the Information society (i.e. eGovernment, eProcurement, eHealth and eInclusion services). Merging CN and DE services would also lead to the enlargement of the number and the typologies of communities, and thus augmenting the possibility of populating the ecosystems. This would then reduce one of the gaps that now separate the DE and the CN.

c) CN as a source of well-tested experience related to community participatory practices. Starting from the history of the development of Italian civic networks, an action-research could start by taking into account the possible dialectics between grass-roots CNs' pattern of participation (commonly replicated in communities of practice) and government governance. This can guide the DE research community

in developing further a participatory process for defining models of governance applicable to the DE at the local and global levels.”

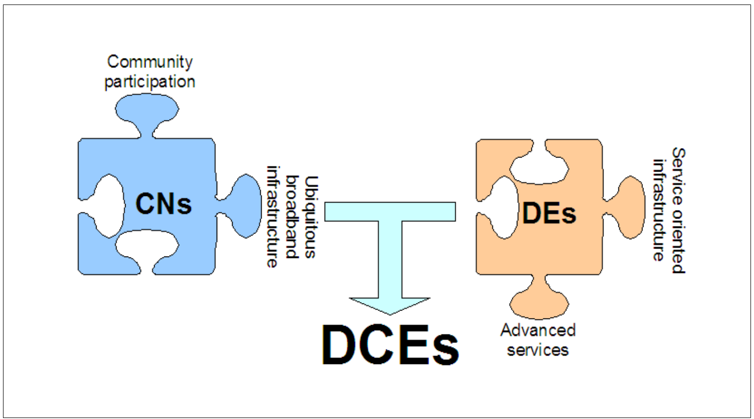


Figure 2: DCEs as an interpolation between CNs and DEs

This means that the emerging DCE idea (Figure 2) could be possible if we consider:

- *a synergistic regional development strategy*;
- *different but possible complementary services;*
- *community participatory practices.*

Those issues will be used in the following sections. If “...*Merging CN and DE services would also lead to the enlargement of the number and the typologies of communities, and thus augmenting the possibility of populating the ecosystems...”,* we need to go back to the conceptual framework adopted in the 1st phase to consider the many dimensions that could interact in a DCE.

1.2 DCEs in the CISG framework

In the OPAALS D7.1 and D7.2 deliverable we used the C.I.S.G. framework to better understand both CNs and DEs. The same framework will be used now to reach a first abstract definition of DCEs.

1.2.1 The CISG framework

It is important to remind that the C.I.S.G. framework is a way to reach a multi-dimensional, relational and ecological definition of broadband-based local innovations. It is built up on the suggestions of the socio-technical infrastructures theory (Star and Ruhleder, 1996) and considers four dimensions (Botto and Passani, 2008:17):

- *Communities*: stakeholders, like initiators and users, that contribute to an innovative socio-technical infrastructure. Sub-categories[2]: grassroots, businesses and government institutions.
- *Infrastructures*: the core technological part of a STI composed by networked infrastructures and the web of hardware and software that enhance it.

2 Sub-categories are only indicative and could be enriched or modified in a specific analysis if more informative dimensions emerge.

Subcategories: hardware and software infrastructures.

- *Services*: the different services that are provided and enabled within the STI. Sub-categories: on-line and off-line services.
- *Governance*: the regulation activities of communities that control and/or coordinate the use of infrastructures and services. Sub-categories: grassroots, corporate and government governance.

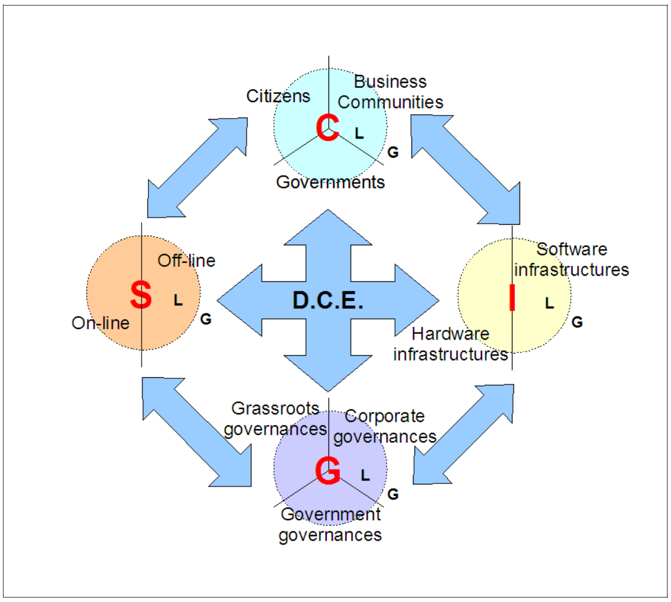


Figure 3: The relational character of C.I.S.G.

CISG is more related to a *when* than to a *what* because of its relational and ecological character. It is "relational" (Figure 3) because it suggests to consider the other dimensions when defining them. Therefore the goal is not simply to enlist the four elements, but to find relationships between agencies, technologies, services and policies. It is "ecological" because, like the socio-technical infrastructure theory, it considers innovations as artefacts emerging from practice, directly connected to human activities and material structures (Star and Ruhleder, 1996).

It is possible to say that the CISG framework is:

- an evolution of the Socio-Technical Infrastructures theory;
- a tool to remind and pursue the relational and multidimensional understanding of innovation phenomena in different ways:
  - describe and compare different STIs types (CNs, DEs, CDEs): it is the aim of the current deliverable and of D7.1;
  - analyse specific case studies: it is the aim of D7.1 and D12.8.

When the framework is used to analyse specific cases, the ethnographic analysis could be enriched by the details like the different actors narratives, the invisible work and the paradoxes that keeps the infrastructure alive (Star, 1999, 2002). In this situation the CISG framework could better support the adoption of what Star and Ruhleder (1996) and Star (1999) suggest as the core dimensions of large-scale technologies: embeddedness, transparency, reach or scope; learned as part of membership, links with conventions of practice, embodiment of standards, built on an installed base, becomes visible upon breakdown, and is fixed in modular increments.

1.2.2 When is a DCE? Through the relational and ecologic approach.

In the D7.1 we suggested a table in order to start combining the CNs and DEs concepts (Table 1).

	Government CN	**DE**
C	*Citizens, Public Administration, Research Centres, Universities, Science Parks, Enterprises*	*SMEs tourist sector, other enterprises of the tourist value chain, software house and other service providers*
I	Top-down ***Infrastructures*** *Ubiquitous infrastructure*	Top-down ***Infrastructures*** *Service oriented infrastructures adjusted to local needs*
S	Top-down services *Online access, user support, information*	***Top-down high level services*** *Connectivity, advanced market place functionalities, interoperability related services* **Bottom-up services** *Several advanced services for users: from security management to CSM, from communication services to marketing services*
G	***Government regulation***	*To be developed*

Table 1: Government CNs and DEs into the CISG

More recently, the DEs governance has been studied in the Deliverable 12.2 (Darling, 2008) and the Work Package 11 is actually keeping governance as a core issue for DEs regional development. In this study we refer to the “governance and regulation” perspective on DEs governance described in Deliverable 12.2, since we are considering the multi-stakeholder policy practice of placing restrictions and enable innovation by using rules, actions and technologies.

Communities:

When thinking about DEs for extended local communities the list of stakeholders implied in the development and consumption of services is expanding. To the business sector we should add users as public administrations, citizens, research centres and universities, and all the grassroots sector that is composed by specific communities of interests and citizens. The highly heterogeneous group of possible stakeholders suggests that we are considering many different interests, needs, participation styles, communication languages and technology skills. Those elements have the potential to increase the complexity of the others (I, S, G) dimensions.

Infrastructures:

DCE infrastructures are first of all broadband infrastructures provided by

telecommunication companies and/or local governments. When the territory is covered by those networks it is possible to imagine the set of software that will allow services. It is important to notice that the DE service delivery infrastructure is only one possibility of the many and that the local decision makers should sustain innovations that have some chance to be concretely used in the future from their point of view.

Services:

This means that DCEs services should try to follow the DE idea but it is difficult to imagine the massive presence of DEs services at this stage of DE research. In fact the many communities and institutions involved in a DCE innovation increase the complexity of initial needs and therefore increase also the innovation constrains. It is therefore important to sustain the DE vision inside of a set of needed and possibly implementable services.

Governances:

The local government is obviously the crucial actor for policies related to DCEs. First of all there are policies for the reduction of the digital divide. Secondly, there are policies for the management of the local community network. Thirdly, there are policies for the DE vision at the local level, that should start defining the core idea, objectives, stakeholders and organizational/technological principles. Then there are policies for the management of the creation, development and sustainability of the DCE. Other stakeholders governances could nonetheless play a relevant role in the DCE since every group should negotiate its degree of autonomy inside a regional innovation. In general, the principle is that the more a community participates in an innovation, the more are the chances to negotiate and obtain autonomy.

This understanding underlines the importance of the three main characteristics – introduced in Section 1.1 – also for a DCE:

1. *A synergistic regional development strategy.* Local decision makers should therefore produce a vision and follow a development strategy where communities, infrastructures, services and governances are considered;
2. *Different but possible complementary services.* Given the stakeholders interests and the networked infrastructure, DCEs should be built in order to enable local communities services. DEs services are one of the many possibilities and could interact with the other ones;
3. *Community participatory practices.* The regional development strategy needs to be sustained by local actors. Communities should be engaged at some level in the creation of Infrastructures and Services.

From the ecological point of view (Star and Ruhleder, 1996), the DCE is: (a) a concept that tends to sustain the DEs idea on the many communities and possible services of a regional setting; (b) an opportunity that should be developed accordingly with local needs, interests and sense making processes. In fact, apart of the needed principles and ideas that define the DE vision, a DCE is something that should grow up between individuals, organizations, institutions, services, infrastructures and policies at the local level. Therefore we will continue this report by avoiding the taken from granted assumptions of DEs as units of innovation. Instead we will continue the work done in the D7.1 and 7.2 by underlining the socio-constructivistic and ecological idea on DEs. This idea is that specific

DEs are the result of situated (Suchman, 1987) innovation trajectories that only partially fit what is planned and are deeply related – if not inextricably coupled – with other innovations like the broadband infrastructures one.

DE research case studies (Val, 2007; Konda, Bayon and Shelton, 2007; English and Dory, 2007) tend to follow the implementation of DEs in regions by previously defining the value, the meaning and the adoption degree of DEs technology involved. In this way it is possible to approach DEs for specific business sectors, whether a core community-oriented ecosystem should pay attention to more variables and possibilities. Therefore the only perspective we could have when studying the business and sustainability models of DEs for heterogeneous stakeholders at the regional level is:

a. to define in general the characteristics of such innovation – this paragraph -;
b. to underline the core issues to consider when starting the development of a DCE – this research from here -; and
c. to be aware of the fact that ideas, models and possibilities are elements that should find specific meanings and understandings in situated innovation trajectories.

1.3 Issues for the business and sustainability models discussion

We started reflecting on possible DCEs from an ecological and multidimensional perspective. It is important to notice that CREATE-NET's participation in a regional innovation introduction concerning DCEs (see Szabo et al, 2008; and the forthcoming Deliverable 12.8) is helping us in considering some relevant dimensions. At this point of the empirical research and by examining the Community Networks and Digital Ecosystems experiences (Botto, Passani, 2008) we identify some issues that will play a crucial role in the business and sustainability models discussions:

1. **broadband infrastructure:**
   a. *available wireless technologies;*
   b. *commercial and government initiatives to introduce mobile broadband;*
   c. *business models for public participation in infrastructures creation;*
   d. *models based on sharing wireless access;*
   e. *policies for capillary development of access networks;*
2. **advanced services:**
   a. *business structures/relationships of creating and operating CN infrastructures;*
   b. *service delivery platforms;*
3. **participation:**
   a. *strategies for a sustainable DCEs introduction;*
   b. *methodology of participation.*

CHAPTER 2: Broadband infrastructure

This chapter starts with a brief summary of business aspects of state-of-the-art wireless technologies. We consider the “business aspects” of these technologies: availability in terms of standardization, maturity etc. Main business models are dealt with in the following Sub-section 2.3. We point out that the anchor tenant model has been successful in the USA and worldwide. Therefore we present the anchor tenant model implemented in Trentino, Italy.

The approach that can be called capillary development of access networks is dealt with in Sub-section 2.5. Close to 100% broadband coverage of the territory is the main challenge for local governments that intend to develop a community network (CN). Local government may decide to reach this objective in many ways.

2.1 Business aspects of wireless technologies: available technologies and trends

2.1.1 Available wireless technologies

Below we overview three wireless technological alternatives such as Wi-Fi mesh, WiMAX and 3G cellular mobile, based on (Farkas, Szabó and Horváth, 2009). For further information interested readers should refer to any of the several technical books, e.g. (Webb, 2007), on wireless technologies.

Wi-Fi Mesh

Wi-Fi (Wireless-Fidelity) mesh networks are peer-to-peer multi-hop networks based on the IEEE 802.11 standard family (IEEE 802.11, 2008), where the nodes cooperate with each other to route information packets through the network (see Figure 4). They present an alternative solution to “infrastructure based” networks like ADSL (Asymmetric Digital Subscriber Line). Mesh networks have some attractive features. Thus, they are “organic”; nodes may be added and deleted freely; the mesh principle means also fault tolerance, thus nodes may fail and packets will still be routed; mesh networks are manageable in a distributed manner.

However, mesh networks also pose challenges. If there are too many nodes, the need for routing other nodes’ traffic decreases the access throughput of a given node. On the other hand, if there are too few nodes then routing could be a problem. Security is also an issue. A practical problem is that today there are no interoperable products as the WLAN (Wireless Local Area Network) mesh standard (IEEE 802.11s) has not been approved yet. As of November 2008, it is in Draft stage and the next ballot within the standardization group is expected to be held in January 2009. Already a number of industry players support it, but of course the first certified products will appear in the market only after the 802.11s standard will have been approved.

In spite of the aforementioned shortcomings, the majority of wireless CNs is Wi-Fi mesh and it is the most likely option to consider when someone is planning to create such an infrastructure. Current products feature dual/multiple radios (separate radio(s) for the access and backbone parts) to significantly compensate the throughput decrease when traffic is routed through a chain of nodes. Most recently combined devices have been also developed that implement both the Wi-Fi mesh and WiMAX capabilities using the latter technology for backbone purposes.

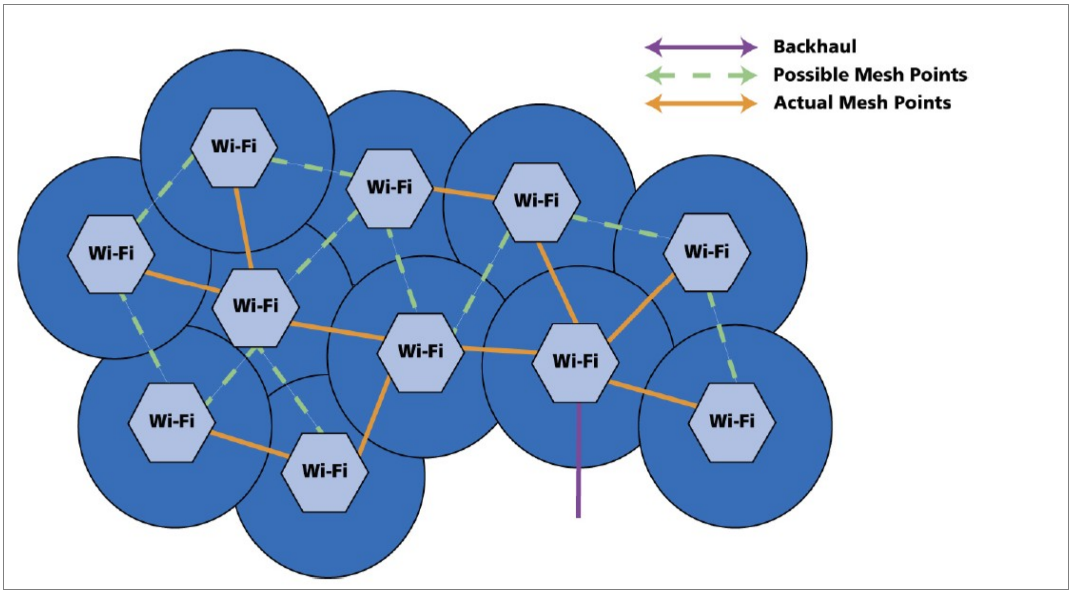


Figure 4: Wi-Fi Mesh Network Example.

WiMAX

WiMAX (Worldwide Interoperability for Microwave Access) is an emerging wireless technology and a flexible telecommunication architecture based on the family of IEEE 802.16 standards (IEEE 802.16, 2008). It is often considered as the next generation of Wi-Fi networks, though the two technologies represent two different design and development lines from technical perspectives. The WiMAX technology provides a big step ahead evolution as the offered capacity and the communication range are approximately an order of magnitude higher compared to Wi-Fi. The topology of a WiMAX network can be point-to-point, point-to-multipoint or mesh. The area coverage is up to tens of km in LOS (Line Of Sight) environment at limited data rates. An attractive feature is operation under NLOS (Non Line Of Sight) conditions. Spanning only short distances high capacity and data rates up to 100 Mbps can be achieved which make WiMAX a viable option for backbone and distribution network segments. It provides a high level of security due to the 3DES (Data Encryption Standard) and the AES (Advanced Encryption Standard) encryption standards. Quality of service is an inherent feature of WiMAX. It has several service classes including support for real-time data streams.

Figure 5 illustrates a typical fixed WiMAX network architecture consisting of base stations, subscriber stations and different communication link types. To support mobile or nomadic users – implementing seamless handover of the user between the base stations – the mobile version of WiMAX based on the IEEE 802.16e standard was approved at the end of 2005, and products built on this standard have already been available. To deploy a WiMAX network is easy, quick and relatively inexpensive. Different spectrum allocation

possibilities exist in licensed and license-free frequency bands, see the next sub-section. However, implementers of wireless CN infrastructures are cautious regarding WiMAX, mainly due to the currently high costs of WiMAX subscriber stations. Though, as we mentioned above, the combination of a WiMAX based backbone for Wi-Fi mesh networks seems to be an attractive option. Moreover, mobile WiMAX will be definitely the solution when mobility is of key importance.

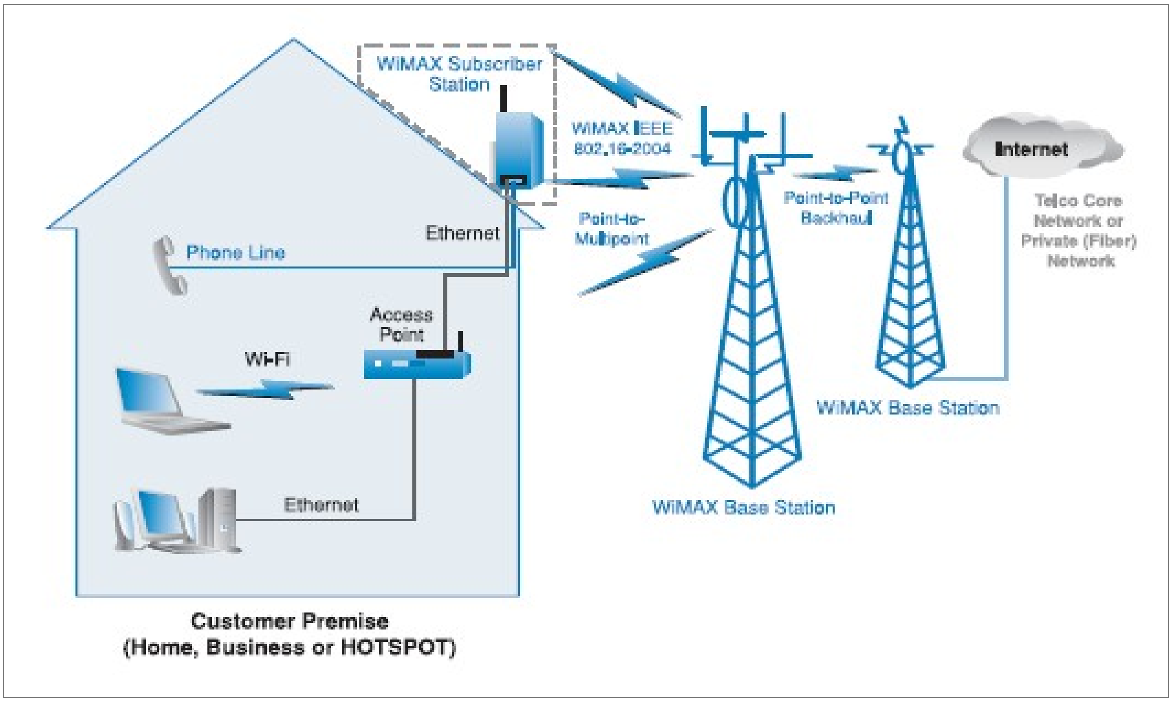


Figure 5: Fix WiMAX Network Example.

A comparison of main features of fixed and mobile WiMAX is shown in Table 2 from (Szabo, 2008). In this table, four application types are identified that have different degrees of mobility from one extreme of fixed acccess to full mobility. For these applications the corresponding customer devices, speed of movement and handoff requirements are listed. Finally the last two columns indicate whether fixed and mobile WiMAX satisfy to the requirements of these applications.

Application	Customer devices	Speed	Handoff	Fixed WiMAX	Mobile WiMAX
Fixed access	Outdoor and indoor CPEs	Stationary	No	Yes	Yes
Nomadic access	Indoor CPEs, PCMCIA cards	Stationary	No	Yes	Yes
Portable access	Laptop PCMCIA cards	Walking speed	Hard handoff	No	Yes
Mobile access	Laptops, PDAs, smart phones	Low to high vehicular speed	Hard or soft handoff	No	Yes

Table 2: Comparison of key features of fixed and mobile WiMAX

3G/4G cellular mobile for community networks?

3G cellular systems together with enhancements like HSDPA/HSUPA (High-Speed Downlink Packet Access/High-Speed Uplink Packet Access) (ITU, 2008) also, due to the smaller cell size, offer per-customer data rates that would satisfy the requirements of most of today's mobile applications. Nevertheless, it is hard to find community networks that are based on cellular mobile service. The reason might be a simple one: municipalities did not take this option into account. On the other hand, cellular operators might be also reluctant to work out individual offers for cities with very special pricing, and specific solutions in addition to cellular coverage, e.g. a combination with WiMAX, to support large institutional users. Thus, we include this option here for completeness only.

Let us conclude this section with a brief comparison between Wi-Fi/WiMAX, collectively called BWA - Broadband Wireless Access, and 3G/4G cellular mobile technologies.

IEEE 802.16/WIMAX AND 3G

IEEE 802.16/WiMAX is a complementary rather than a replacement technology for 3G wireless systems. While 3G systems are designed primarily for mobile voice and data users, IEEE 802.16/WiMAX systems are optimized to provide high-rate wireless connectivity for a large set of services and applications (e.g., with multimedia traffic) that require QoS guarantees. In addition, IEEE 802.16/WiMAX systems can be used along with 3G wireless systems to provide QoS to the wireless Internet users in a cost-effective manner. WiMAX networks can also serve as backhauls for 3G networks [6]. Since such a network can provide high bandwidth with large coverage area, 3G BSs can be deployed easily and flexibly to extend the cellular coverage area.

IEEE 802.16/WiMAX AND 4G (more correctly B3G - beyond 3G)

In future-generation wireless systems (e.g., fourth-generation, 4G, systems), different wireless technologies (e.g., cellular, WLAN, and BWA technologies) are expected to coexist and collaborate with each other to provide Internet services to mobile users in a seamless manner [7]. While WLANs are more suitable for stationary/quasi-stationary users requiring high throughput connections, cellular networks are more efficient for voice-oriented and limited throughput mobile data services. On the other hand, IEEE 802.16/WiMAX networks can provide very-high-speed wireless connectivity in presence of mobility. However, since the coverage area of an IEEE 802.16/WiMAX BS is larger than that of a WLAN access point (AP) or cellular BS, the bandwidth per area becomes limited. Therefore, an efficient load balancing mechanism among these three different wireless systems will provide an optimal solution for 4G wireless services.

2.1.2 Commercial and government supported intitiatives to introduce mobile broadband infrastructures and services

The first commercial mobile WiMAX-based service was launched by Sprint in Baltimore, USA, in October 2008. Sprint is planning to expand the service to other cities. Clearwire will launch its "Clear" service in Portland, Oregon in January 2009 (WiMax.com, 2008). In

Europe, the first service will be most likely offered by WorldMAX, a Dutch operator currently providing service for nomadic users based on fixed WiMAX in the Netherlands. As WiMAX in general, mobile WiMAX is expected to play a very important role in introducing mobile broadband services in developing countries and regions. In many cases the governments launch specific programs to help the introduction of mobile WiMAX deployment and services. Below we cite a few recent examples.

Mobile WiMAX in India (WiMax.com, 2008)

On December 12, 2008, semiconductor giant Intel has announced an alliance with the the WiMAX Forum India that will see it develop and introduce low cost WiMAX devices for the Indian market. Intel would work with the WiMAX Forum, service providers and device manufacturers to launch WiMAX-enabled notebooks and netbooks for the Indian market by 2009. The WiMAX Forum says India would have over 27.5 million broadband internet users by 2012.The alliance is focused on delivering "affordable" devices to Indians that will leverage the upcoming 4G WiMAX networks, with the initial focus being on 2.3 and 2.5 GHz devices. Other ecosystem members would help determine device needs, time lines, testing and interoperability plans. C. S. Rao, chairman of the WiMAX Forum's India office said that the WiMAX ecosystem has grown significantly over the past five years, and WiMAX is viewed as the best wireless broadband technology for India, as a diverse and complete ecosystem ready to deliver affordable, lightning-fast wireless Internet.

WiMAX in Africa (www.alvarion.com)

One of the largest WiMAX equipment vendors in Africa, Alvarion, estimates that there are just over 100 installed WiMAX systems in Africa; over 45 of these are operating in unlicensed spectrum and over 55 in 2.X or 3.X spectrum. Increasingly new systems are being licensed in the 2.X spectrum. Alvarion claims to have more 50% of the market and out of the 40 key major operators (many with Pan-African operations), it claims to have sold to 26 of them.

M-Taiwan Program: a WiMAX Ecosystem (WiMAX 2007a)

The M-Taiwan program will create several city-wide broadband wireless networks for providing integrated mobile services. These networks will form a big test-bed for the trials of new technology development and application services. To achieve these goals the following strategies are adopted for the technology development of the M-Taiwan program and WiMAX related projects:

- Form a complete WiMAX ecosystem that includes chipset, CPE, base station, network elements, system integration, applications and commercial operation.
- Develop differentiated applications, e.g., IPTV broadcasting over WiMAX.
- Design a coupled WiMAX/Wi-Fi network to leverage strength of Taiwan Wi-Fi industry.
- Leverage government sponsored research & development projects for core technologies, e.g., the WiMAX acceleration project.

For an extensive coverage wireless technology like WiMAX, the most essential element is undoubtedly a dedicated frequency spectrum. For opening up spectra, the Taiwan government announced on February 13, 2007 a two-phased spectrum release plan for broadband wireless access services, the first phase being the issue of three regional licenses and the second is one nationwide license.

2.2 Regulatory aspects of the deployment of wireless infrastructures

2.2.1 General considerations

In our opinion the role of the regulatory environment for building network infrastructures by public participation is twofold. Firstly, it has to define what can and what cannot be done in terms of provisioning of network and application services by a local government. Secondly, and more importantly, the regulators, in particular those responsible for frequency allocation for wireless networks, have to offer the maximum possible freedom and flexibility of using wireless frequencies for publicly operated infrastructures so that important objectives such as supporting new entrants in the telecommunication market or solving the digital divide problem can be achieved. The two roles are of course interrelated.

At governmental and inter-governmental level we can observe the right strategies: main programs like “Broadband services for all” in EU or similar initiatives in the USA clearly set objectives for the road to broadband for all and closing the digital divide.

As for the specific regulatory areas, first the telecommunication regulation has to be taken into account. In countries where the telecom market has been liberalized, the telecom law of a given country itself usually does not contain specific permissions or limitations for a public entity to provide telecom services; for example a permissive clause can be found in the telecom Act of USA, such as “any entity can provide telecommunication service…”). However, there have been many lawsuits between municipalities and telecom service providers with varying decisions. In EU, as usual, the “directives” set directions, and the specific ruling is left to the national regulatory bodies.

Building and selling fibre optic infrastructure on equal basis for all market players is mostly allowed (maybe not directly by the public entity, a public enterprise such as a utility company can be a solution, in many European countries). From regulatory point of view this is the preferred form (physical level or infrastructure-based „unbundling”). Providing service to end-users is not advisable even if it is allowed (conflict with market players which the public entity wants to help entering the market). Providing connectivity and even telephony (VoIP) service to public administration institutions instead of leasing lines and using services from telcos is usually allowed and actually this is one of the clear cases when a public administration wants to be an “anchor tenant” of the network (see Sub-section 2.1.3.4).

2.2.2 The role of regulation for current and emerging wireless and mobile broadband services (WiMAX, 2007b)

The role of the regulator is likely to become more complex and wide-ranging in the current environment characterized by a fast-paced technological innovation. Regulators will increasingly need to define broad spectrum usage rights that allow network operators the freedom to adopt the most advanced and cost-effective technologies as they become available instead of defining specific technology-based licensing conditions and spectrum allocations.

There is also a trend towards subscriber equipment that supports multiple wireless interfaces. They will enable users to automatically connect to the best network available, depending on location, device, bandwidth required and application used. To make this possible, network operators need to have the flexibility to roll out different technologies when and where appropriate. "A *technology-neutral approach* is required from the regulators that allows operators to decide which technology to adopt and brings the necessary flexibility to the market, facilitating the deployment of cost-effective, advanced technologies. Mandating a specific technology discourages technological innovation, and in many cases it limits the ability for new entrants to compete in the marketplace. Allowing a choice of technology, operators can extend competition to technology. Furthermore, increased competition at the technology level will give users more choice: multiple technologies will increase the variety of services available, their pricing and the applications they support…."

As proposed in (WiMAX, 2007b), the main strategic goals are as follows:

"a) Permit mobile broadband services in other bands that have common global allocations. The 2.3-2.4 GHz band is emerging as a band that is widely available. In other markets, additional bands may be or become available for mobile broadband such as the 3.3-3.4 GHz band in India and in other markets, and the 700 MHz band over the next few years. While these bands are not yet available worldwide, their availability is a precious resource to operators, either to expand their mobile broadband services into the new bands for increased capacity or to develop services for specific market segments. For instance, they may reserve spectrum in the 700 MHz band for rural deployments.

b) Let operators decide which services to offer within their spectrum holdings. In addition to choosing which technology to deploy, operators should have control over the level of mobility they want to offer. For instance, in many markets operators can only roll out fixed services in the 3.3-3.8 GHz bands. This approach not only limits the overall availability of services in the market and the ability of operators to gain revenues from the infrastructure they have deployed, but increasingly the distinction between fixed and mobile access ceases to be meaningful and difficult to define and enforce.

c) Introduce trading in rights of use in the secondary market. This regulatory component keeps technology ecosystems healthy and improves efficient use of spectrum. As business entities compete to provide the best services to end users, enabling shifts in geographic partitioning of spectrum, band disaggregation, ownership and leasing is likely to lead to more targeted services and better coverage for both business and consumer

subscribers.”

2.2.3 Suitable frequency bands for Wi-Fi and WiMAX and the regulatory situation

The 2.496-2.69 GHz band (also referred to as the 2.5 GHz band in the U.S. or the 2.6 GHz band in Europe) is currently the best candidate for mobile broadband deployments as it has been widely reserved for mobile services, but it has not yet been assigned for these services in many countries. Signal propagation in this band enables the deployment of mobile services in a cost-effective way. Higher frequencies (3.4-3.6 GHz or 5.7-5.8 GHz) are at present well suited for fixed and nomadic services and in many countries are available for deployment. The propagation properties in higher bands are less favourable to mobile access, with the exception of areas with high demand, as they reduce base station range and thus increase the deployment costs. In the 3.4-3.6 GHz band, nomadicity and limited mobility can be supported in areas where demand is high (e.g. in urban areas) and a high density of base stations is required to meet the capacity requirements. Spectrum allocations below 2 GHz offer better propagation characteristics, but the spectrum in those bands is typically already allocated and is in use, and as yet there is no band that could become available in a majority of geographic regions, with the possible exception of the 700 MHz band, though in most markets this is not available in the short term. In some countries this may not be possible as regulation prohibits roll out of mobile services in the 3.4-3.6 GHz band.

2.2.4 A novel regulatory approach for WiMAX in the USA

The 2.5 GHz band is available for WiMAX in the US, but the allocation possibilities are limited as this band is largely controlled by large operators such as Clearwire, Sprint, and AT&T.

The Federal Communications Commission (FCC) has recently recognized the spectrum limitations that US operators faced, and introduced an innovative licensing scheme in the 3.65 GHz band (Paolini, 2008) with the objective of promoting the availability of broadband to areas that are currently underserved in different parts of the country. The newly available spectrum is allocated according to the scheme called “light licensing”. It means that it is easy and inexpensive to obtain these licenses, but the granted licenses are not exclusive. In many ways, the 3.65 GHz band promises to combine most of the advantages of unlicensed bands with substantially lower, manageable levels of interference.

“The FCC’s goal was to create a band with low entry costs and minimal regulatory delays to enable multiple wireless operators to roll out services, while keeping interference at a minimum. In trying to find a compromise between expensive, difficult-to-obtain licensed spectrum and interference-prone unlicensed spectrum, the FCC decided to adopt a *nonexclusive licensing scheme* with a *contention protocol* requirement” (Paolini, M., 2008). Obtaining the license in the 3.65 GHz band is easy and the costs are in the order of a mere USD 200.

Under this licensing scheme the number of operators that can obtain a nationwide license is not limited. This is at a first glance surprising since then overlaps of frequency usage and consequently interferences among operators are unavoidable but this situation seems to be manageable. First of all, since, according to the regulatory approach exercised in the US in general, licensees are expected to co-operate with each other and co-ordinate the usage of the frequencies, and the FCC intervenes only in case of necessity. In this particular case it is expected that each operator will focus on selected geographical areas and that this will prevent spectrum overcrowding. Licensees are explicitly required to “make any effort” necessary to minimize harmful interference. All operators with a license are required to register their base station locations with the ULS (Universal Licensing System) prior to deployment, and to appropriately coordinate operations to minimize interference. Operators that deploy first in a given area do not enjoy any first-to-market advantage over operators coming on later. They are all required to collaborate to find a solution that enables multiple operators to coexist. To further manage interferences, the FCC also uses a contention protocol.

2.2.5 Current situation for WiMAX in Europe

As mentioned above, the potentially available frequencies for fixed and mobile WiMAX are the licensed 3.5 GHz and 2.6 GHz bands and the unlicensed 5.7 GHz band.

Despite of the efforts made by WiMAX Forum, a non-profit industrial association that came to life to promote WiMAX services worldwide, the regulatory situation in Europe is far from being satisfactory and in this respect Europe is lagging behind the USA (where the regulatory approach has been traditionally different from Europe, being more customer-oriented) or from Asia where in some developing countries the governments push the usage of WiMAX both for telecom service providers and for other entities in order to quicker penetrate broadband access, close the digital divide and foster economy.

The associated technical issues are solvable. Re-allocation of these frequencies, used for a long time by military purposes is usually not a big problem, as these bands have been unused for some time by their owners), maybe just the administrative process of freeing them up could take time. What slows down the process is mostly a economical-political issue. Governments have sold GSM and 3G licenses for huge amounts of money and operators having paid these sums naturally want to see their investments returned. They consider WiMAX as a competing technology, not as much from technical but from business point of view, since those who would operate a mobile WiMAX network and provide services based on it would in fact directly compete with them.

While on one hand the concerns of mobile operators are valid and all their lobbying activity is understandable, the reaction of governments should not be to imply serious restrictions on the use of WiMAX but decide on a clever strategy and also distinguish between commercial service providers and public administrations. For the formers, the regulatory bodies should consider carefully the situation in the market (for example there are countries where there are only two or three mobile operators which is an oligopoly and not a free competition). And for local public administrations, they should issue regional licenses so that they can implement WiMAX infrastructures in their respective territories. Regulators should also open up, as quickly as possible, the unlicensed bands of 5.7 GHz for WiMAX.

The current situation in Europe differs from country to country:

- WiMAX frequency licensing is not yet regulated;
- a few licences are granted (sometimes just one, an exclusive one);
- several licenses have been granted;
- country-wide and regional licenses are granted.

2.3 Main business models for public participation in infrastructure creation

2.3.1 Introduction

In our earlier report (Szabo, Botto, Danzi, Salvadori and Passani, 2008) we summarized the possibilities for the involvement of the public sector in infrastructure creation. For completeness we include a figure from that report (Figure 6) where it can be seen that, according to the level the public administration wants to invest and the management complexity it can commit to, there are different possibilities of public-private partnerships.

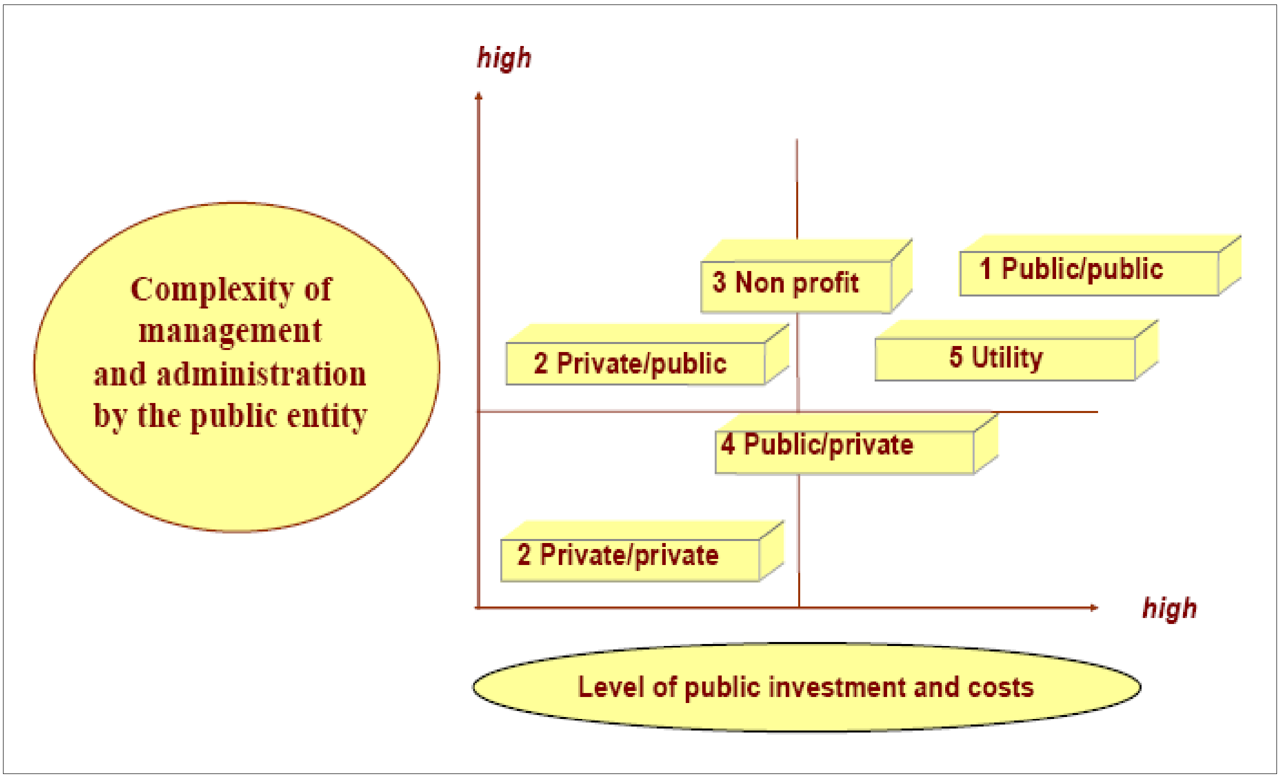


Figure 6: Comparison of PPP models.

There might be a series of reasons for choosing one or the other PPP form. According to a recent research by Muniwireless.com (Muniwireless, 2007), the main reasons why public administrations choose not to invest and/or operate the broadband infrastructure, are indicated in Figure 7. (In this research, statistical data were collected from 232 survey responses.)

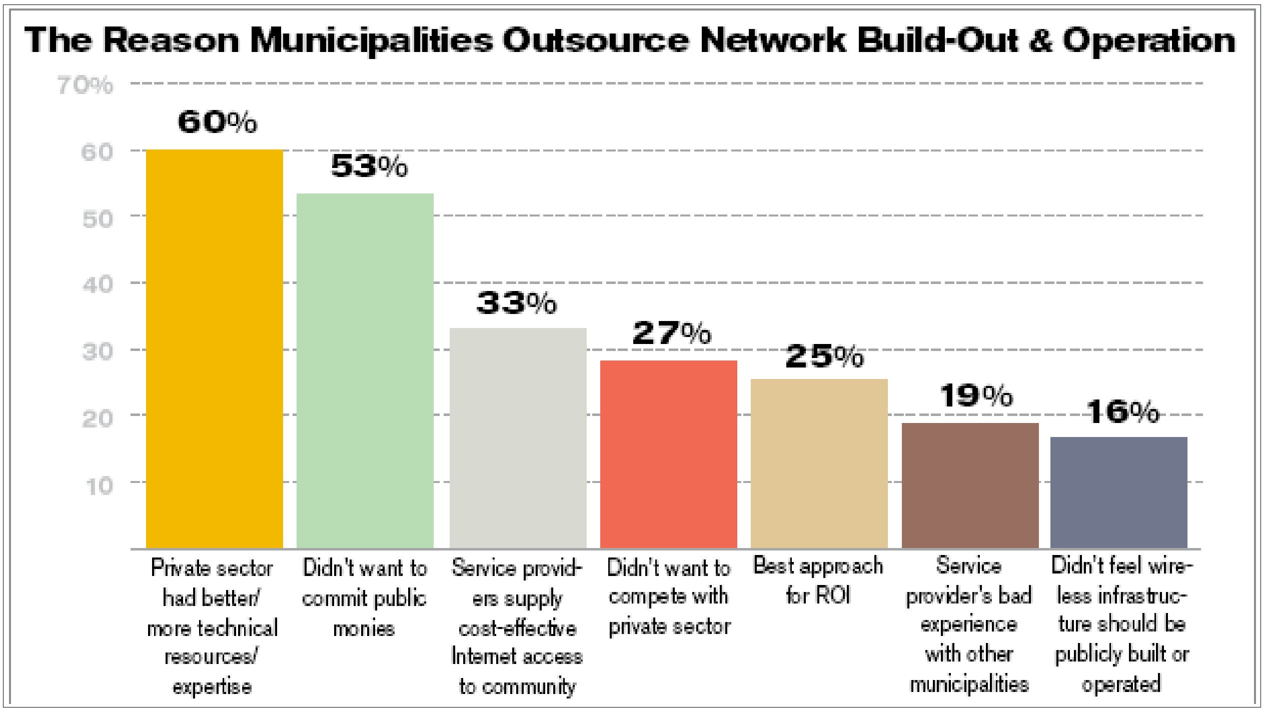


Figure 7: Reasons for outsourcing wireless network deployment & operation (Muniwireless, 2007).

On the other hand, there are also good reasons for being involved in creation and operation of the infrastructure, as illustrated in Figure 8.

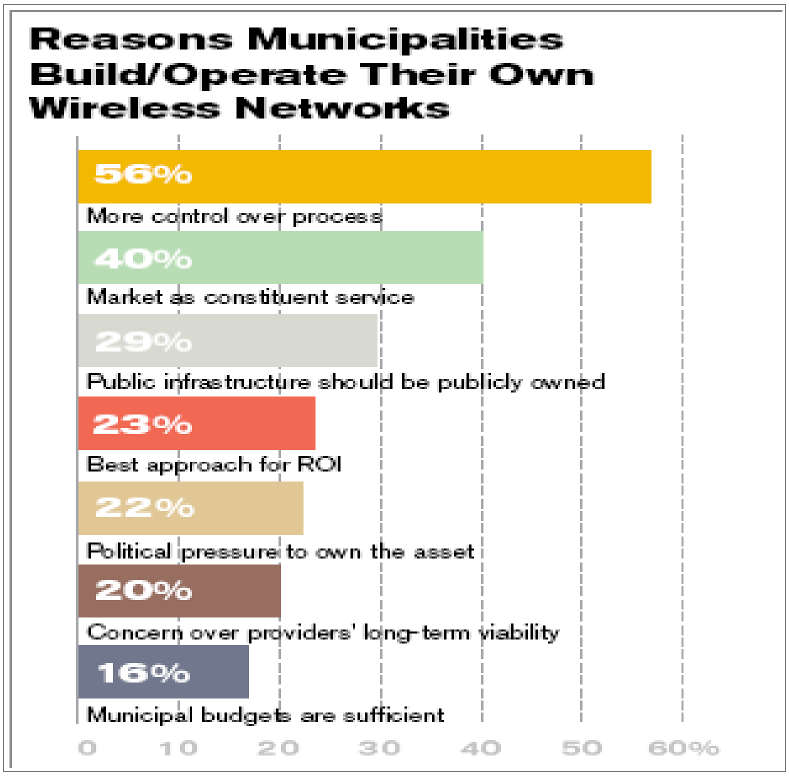


Figure 8: Why municipalities want to deploy and/or operate their networks (Muniwireless, 2007).

According to this market research, the summary of municipalities' involvement in deployment and operation of municipal wireless networks is shown in Table 3.

Network Build-Out & Operation

	Total	Deployed Networks	Planned Networks
Municipal Built	24%	30%	17%
Private Built	76%	70%	83%
Municipal Operated	28%	33%	22%
Private Operated	72%	67%	78%

Table 3: Statistics of municipalities' involvement in building and operating wireless community networks (Muniwireless, 2007)

2.3.2 Main business model types

Coming back to our Figure 6, the problem with PPPs is first of all the term: public-private partnership is more confusing than enlightening, moreover it only tell us about the ownership structure and not about the most interesting question: what makes the investment by the public and private sectors viable. After analysing many existing networks and projects we have come to the conclusion that two models can be distinguished:

- *Type 1 model, also called the franchise model* or “private corporate franchise model” (Josgrilberg, 2008), meaning the same thing. Here the public administration grants the private company the use of public facilities. The important point is that the latter does not commit to be a major customer. In terms of our PPP classification, this is a private/private model where the private company pays for these assets to the public administration.

- *Type 2 model, also called the “anchor tenant” model.* Here the public administration or one of the organizations under public control or another business entity commits to become a major customer of the wireless infrastructure. The latter can be implemented and/or operated either by a private company or by the public administration itself. Thus this model corresponds to several PPP models as the emphasis here is on the question “who is paying for the network usage?”

Note that in (Daggett, 2007) and in (Josgrilberg, 2008) this model is defined in a restrictive way in two respects: “A *privately owned* network, with the *city* agreeing to become *the* anchor tenant” (emphasized by us). Firstly, while it is desirable that the municipality becomes an anchor tenant, even the first one, there can be anchor tenants others than the

municipality, for example an ISP or a large business that buys connectivity from the network operator. Secondly, the network can be privately owned, but not necessarily, the public administration may decide to invest itself or choose an appropriate PPP model.

Let us note that there is a third model which can be called “community-based” or “new grassroot”. Since it is not consistent with the first two as it can only be a supplementary solution to them, we will discuss it in Sub-section 2.1.5.

Type 1: the franchise model

The most cited example of this model is the “Wireless Philadelphia” project. This initiative started with a pilot, covering the central districts and was expanded to cover the entire metropolitan area with a total 20 million USD investment. The project was financed and implemented by Earthlink, a major US internet service provider, specialized in offering services based on wireless networks. Earthlink has been partnering with many US cities. The business model was based on providing Internet access in the city, as the level of broadband penetration was very low (below 25%) and was mainly dial-up access. Earthlink was also planning to sell bandwidth both to retail and wholesale customers. The city was planning to subsidize Internet access for low-income residents. The model essentially failed, and, after a long period of uncertainty about the future of Wireless Philadelphia, Earthlink withdrew from it in 2008.

This model is characterized by the following objectives of and assumptions made by the two main stakeholders:

- *Public administration.* Its objective is to provide free or low cost internet access to its citizens. It does not want to invest in creation of the network, nor does it want to operate it, and, perhaps most importantly, the public administration does not want to commit either to paying for the usage of the infrastructure to be created by a third party. The maximum it offers is right of use of public buildings, poles, towers, ducts, for free or even for payment.

- *Third party service provider.* Its objective is to earn money from providing internet service to customers, based on the assumption that the existing low penetration of internet access will significantly grow when the (wireless) infrastructure will be on place. It also expects that the local government will also become its customer in spite of the lack of commitment from the latter as mentioned above. The service provider also thinks that advertisements will be a significant revenue source.

Many Type a) projects have failed or are in trouble in the USA, mainly because of the lack of commitment by the city to the service provider, and also because of false assumptions, e.g. that free internet access can be financed by advertisements. The bottom line is that internet access is not enough, key applications for the public and for businesses are needed. As it was stated in The Economist, “…the future of the municipal broadband rests on making cities safer, saner and simpler to manage…”, meaning that public safety, health care and municipal administration are the areas where key applications and services should be created. And by these applications the cities are supposed to save costs thus making their networks economically viable. A significant part of the public administration

employees are mobile workforce, e.g. building inspectors, employees of public safety organizations, health inspectors, social workers etc. Their effectiveness in the field can be greatly enhanced by the availability of a wireless network so that they can save paper-based work, react and make decisions immediately by accessing remotely their respective databases. These considerations lead us to the Type b) model, in the next sub-section.

In spite of the well-publicized failure of several Type 1 models, some local governments still continue looking for companies that would invest in the infrastructure without any commitment explicitly made by the municipality or regional government. A recent example is the Expression of Interest for Wireless Broadband, issued by the Government of New South Wales, Australia in 2007, according to which respondents were asked to state the "services" they want to offer and "technologies" they want to use, together with specifying what government resources e.g. ducts, towers etc. they require. (According to informal information from a government official, the project has been suspended.) Another example is a recent Request for Proposals for municipal wireless issued by the City of Fresno, California, which states that "the preferred network model would be a privately owned Wi-Fi or WiMAX network, designed, deployed, operated, supported and upgraded *at no cost* to the City of Fresno" (emphasis by the authors). Answering the – totally rightful – questions of some of the potential bidders as to whether the city can make some commitment to be anchor tenant the vague answer was that they can consider that option, too.

Note that it would be a superficial conclusion that advertisements cannot finance municipal Wi-Fi deployment and operation in general. In (Farkas, 2008), some good examples are presented where a well chosen, usually location-based service can be the subject of advertising. For example, Microsoft recently unveiled its MSN Sideguide as a means of providing location-based advertising to MSN users using their XP and Vista platforms. This sidebar displays content from MSN channels and enables easy Live Search. A main reason behind MSN Sideguide is to fund the deployment of free Wi-Fi networks. MSN Sideguide is a key element of MetroFi's municipal wireless deployments in Concord, California and Portland, Oregon. The launch of Google Maps is a key example of how Google aims to provide targeted advertising to Internet users based on their location. In New York City, Google users accessing the Internet via their cell phone are provided location-based advertising based on their position which is determined via the triangulation of cell towers. These and other advertisement-based models for community wireless networks are analyzed in (Farkas, 2008).

Type 2: the anchor tenant model

Probably the most cited example of this model is the municipal wireless network in Corpus Christi, Texas, USA. This city, which has about 250,000 inhabitants and an area of about 150 sq. miles, has decided to implement an Automated Meter Reading (AMR) system for water and gas customers.

"Meter readers often have difficulty accessing a property because of fences or dogs," explained Leonard Scott, MIS unit manager and program manager for the Wi-Fi project. "We average several complaints per day, every day, from customers who believe their utility statements are incorrect. If someone wants to buy a house, there is no easy way to

check gas and water usage history." With automated data collection, gas and water customers can check meter data online and view a property's gas and water consumption history. Instead of monthly meter readings, meters could be read daily, or even more frequently in the case of commercial customers and other large users. Close monitoring of consumption would allow the city to match daily gas usage with gas price fluctuations and better control water flow to reduce system breaks (Scott, 2007).

Overall, the city spent $20 M on the AMR system and on the wireless network, which yields a saving of $30 M over the estimated $50 M costs within the next 20 years without AMR. In addition to savings, the project resulted in higher level of customer service and support to citizens. After the roll-out of the project, it was realized that the AMR application uses only a fraction of the bandwidth of the wireless network, therefore the city is planning to implement other applications including the support for public safety, health inspection, animal control, public works and utilities personnel, see (Tropos Networks, 2007), (Pronto Networks, 2007), (Scott, 2007).

When the city presented a demo and conducted a brainstorming with the different stakeholders and market players, the result was 20+ new application ideas, some of which have been subsequently implemented:

- building inspection (implemented);
- fixing faults such as broken pipes;
- health care: electronic health records made available at the site when a person got ill or injured;
- video surveillance: instead of permanent transmission of videos the central site polls the individual video surveillance systems e.g. of a bank.
- city portal (implemented).

The city then extended the network to cover a territory of 147 sq. miles. The wireless technology was supplied by Tropos Networks and the service management software by Pronto. Existing fiber is used as a backhaul and Alvarion's pre-WiMAX is used as a backup to the fiber. Access point density is 60-70 per sq. miles in the center and as low as one AP per sq. mile in suburbs.

As for the business model, the city first invested capex in building the network. After three years from the beginning, the city sold the infrastructure to Earthlink which now owns and operates it and provides services both to the city and the inhabitants.

The city is paying $500k a year to Earthlink for using the network for the city's applications such as AMR, building inspection and portal. The savings (from the AMR) are $300k a year thus the other services for the public cost only $200k for the city. Earthlink is also paying to the city 5% from its profit. Earthlink is making money from providing Internet access for a fee and for hosting applications for the city.

There is a place for an important comment. Although the main benefits from the aforementioned applications are increased effectiveness, savings of energy, materials and time, there is another important aspect. Namely, the introduction of this type of services have implications on the current workforce of the public administration and on the job opportunities in general. For example, the building inspection application supported by the wireless network in Corpus Christi allowed for savings of the cost of two FTE employees. The human resource aspects of this type of digital ecosystem could be an interesting

further research issue.

A larger scale project of this type is T.Net, a community network infrastructure project under implementation in Trentino, a province in Northern Italy. Here the anchor tenant is the public administration itself, but also wholesale customers such as alternative telecom companies and ISPs are anticipated. Its management model involves publicly controlled companies for the implementation and management of the broadband infrastructure, supplying of transport services, connectivity and IT services for public administration and renting infrastructure to wholesale customers under fair and non-discriminatory conditions. The network consists of a fiber optic backbone and a pre-WiMAX-based (HiperLAN-2) wireless access network. The number of backbone nodes will be 78 with the total length of optical cable over 750 km. The network will connect in total 223 municipalities. Until the deployment of fiber infrastructure will be completed, the province is leasing Gbit Ethernet facilities from Telecom Italia, the Italian incumbent telecom service provider. Wireless access is already being provided for many municipalities (Longano, 2007). We are going to be more specific about the business models used in T.Net in the next section.

This model is based on the existence of at least one key application and its user, the so called anchor tenant which is ideally the public administration itself. In Corpus Christi, the key application was the AMR service, and the anchor tenant was indeed the city administration itself, as it was responsible for collecting electricity bills from the citizens. In Trentino, the key application is the transmission of voice and data traffic among public institutions in the province, and the anchor tenants are the province and city administrations as well as the public sector institutions.

An anchor tenant which can justify the investment at least to a greater part, can help generating additional applications and bring additional “tenants”. It is much easier to bring in additional customers when we can tell them that the infrastructure will be on place to serve the requirements of the already existing anchor tenants and they only have to check if it is suitable for their own purposes.

2.4 Example: the anchor tenant model in Trentino

(Sources: Longano, 2008; Lazzaris, 2008)

In this section, we give a brief overview of the infrastructure under deployment in the Province of Trento (also called Trentino). At the time of writing this report, it was not possible to collect enough data for building business models because the public administration is still working on pricing of network services. We are planning to collect more data during the coming months and include the business model in our next deliverable. At this point we only would like to demonstrate, with some high level and preliminary data, how the anchor tenant model is being implemented in Trentino.

2.4.1 Current situation

Informatica Trentina, a company fully owned by the Province administration, has been operating TELPAT, the province’s network for providing IT services to public

administrations. For TELPAT, Telecom Italia leased lines, later their fibre optic cables were used.

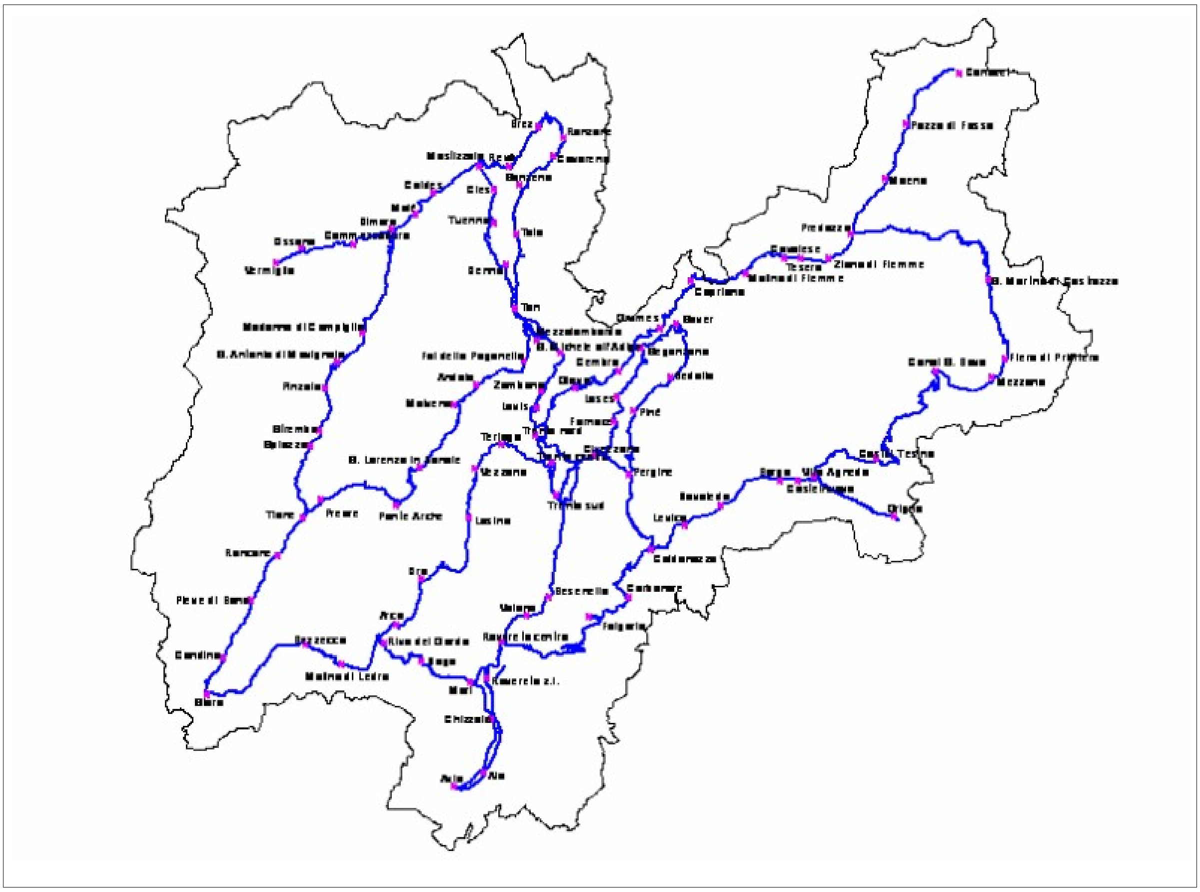
Current rental fees for Telecom Italia connections are as follows: 100 Mbps: EUR 6500/year, 1 Gbps: 15k EUR/year, 3 Gbps: 25k EUR/year.

The services provided by Informatica Trentina to the public sector institutions based on TELPAT will be fully based on the new infrastructure of Trentino Network's optical backbone as soon as the latter will have been deployed, presumably by end 2009. This way the whole rental costs currently paid to Telecom Italia will fall out.

Informatica Trentina will pay rental fees to Trentino Network for using the new infrastructure on a cost basis. Fees have not been determined by the time of writing this report.

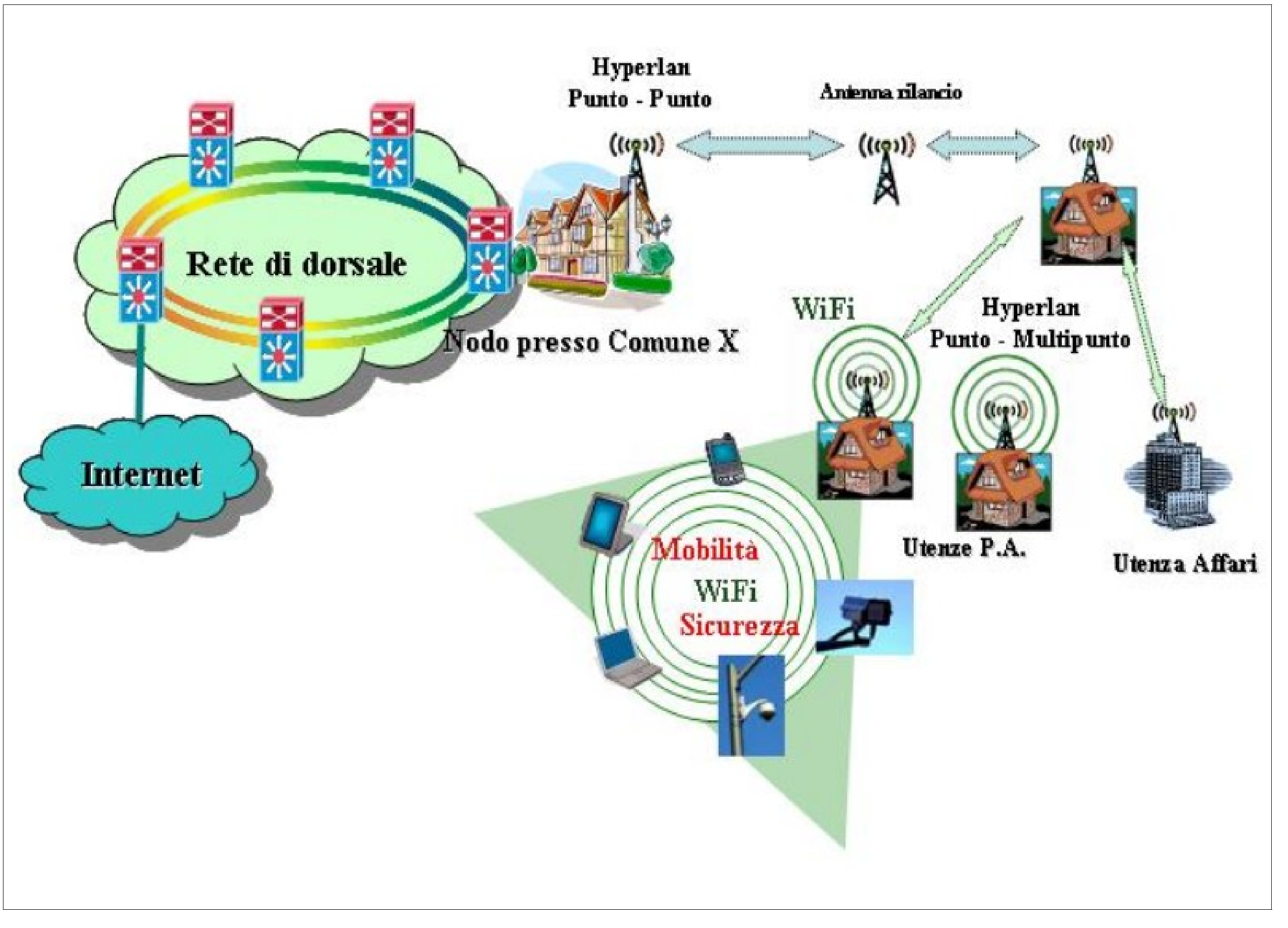
2.4.2 The new infrastructure and investment

T.Net will consist of a fibre optic backbone network and a wireless distribution/access network. FTTH is another access possibility under consideration. The fiber network is currently under construction. It consists of 92 nodes that serve as starting points for distribution/access networks. The topology is shown in Figure 9.



As a temporary solution for the backbone network, the Province is leasing cable connections from Telecom Italia, based on a 5-year contract, which expires in 2010, but is extendable for one more year. TI cable network, called CABLA consists of two rings, the western ring and the eastern ring. The 13 primary nodes (installed in the cities where there are hospitals) are interconnected via 8 Gbps links, while the 53 secondary nodes have 1 Gbps access links.

The wireless network, called WiNet, is based on point-to-point microwave links that extend the fiber backbone (CABLA) and a point-to-multipoint HyperLAN equipment used for distribution. Access is based on Wi-Fi to residential users and HyperLAN to SMEs. For WiNet, see Figure 10 (Note: HyperLAN can be considered as a pre-WiMAX technology).



Total cost of the backbone network is 110 M €, consisting of the following parts:

- ducts and fiber: 45 M
- node equipment: 45 M
- access network for public administrations: 10 M
- equipment: 10 M

Financing is provided by Cassa Trentina, a bank owned by the Province. It is expected that 70% of the costs will be financed by the Province through this bank and 30% should be covered by Trentino Network by revenues from services.

2.4.3 Savings and revenues

The public administration as an anchor tenant will use the network to replace TELPAT, that is for all kinds of data communication among the public institutions. Moreover, the new infrastructure will be used to form a network of PBXs (private branch exchanges) operated in public administration's buildings. Since the network was under deployment at the time of writing this report, we can provide only figures for cost savings only for the fraction of the infrastructure that was already in operation, namely in the city of Trento. Thus, the cost savings resulted from moving the PBX interconnection network from Telecom Italia connections to the new fibre optic backbone are as follows. Before moving to T.Net, the Province was paying 200 k € yearly. The cost of interconnections on T.Net is only 50 k thus the saving is 150 k € yearly!

Several other applications are being planned or are already in the implementation phase. We will overview some applications, in particular an e-health system, in Section 2.2, and will give estimates for the costs saving where possible.

Revenues are expected from wholesale customers. Again, since the network is up and running only in the city of Trento and between Trento and the major provincial towns, currently there are such customers only in Trento (4 operators). Revenue data were not available.

2.5 Models based on sharing wireless access

This type of models which can also be called "new grassroot model" is based on sharing internet connections among the members of the community. It is also called community Wi-Fi (or municipal Wi-Fi) because of the wireless networking technology used. Probably the most well-known example is FON which claims to be "the largest Wi-Fi community in the world" (www.fon.com). Technically, FON distributes a special router called La Fonera to the members of its community called Foneros, who agree that their internet access will be shared with other Foneros (for them it is a free service) and non-Fonero users (who are supposed to pay a small fee for the usage). FON tries to co-operate with service providers (e.g. British Telecom). Its community is growing, they can be found e. g. in Geneva, Oslo, Munich, Tokyo, New York, San Francisco. FON-type models are of interest for at least two reasons: (i) failure of type 1) models in many cities in the USA and (ii) lack of public money and/or lack of interest from commercial operators to build CN infrastructures.

FON is only about making a "normal" internet access point such as a residential DSL or cable access available for additional users within the coverage area of the FON router. This shared access can be extended to a larger neighbourhood by combining the open access with the mesh principle. This means that additional members of the community operate specific mesh nodes that not only serve as access points but also do forwarding of traffic from other access points. This way the coverage area can be extended by several hops (typically at most 4), thus achieving distances in the order of one km. FON does not seem to like the option of extending Foneros by mesh nodes, apparently because FON's

large telco partners such as British Telecom would not be happy with it.

A company called Meraki, supported by Google, on the other hand, encourages users to form a mesh network by using Meraki's mesh routers. By this approach they claim to have built a network in the city of San Francisco which provides Internet access to 165,000 users (www.meraki.com).

Sparknet and OpenSparknet was implemented in Finland in a university campus of the Turku University and the neighbouring science park environment where the entities participating in maintaining Sparknet do have a (wired, ADSL) Internet connection and just extend that to a number of additional users using bridges. In a science park environment, the reliability is less of an issue as here we deal with "professional" users who can keep on their routers all the time.

CUWiN (the Champaign-Urbana Community Wireless Network) is a coalition of wireless developers and community volunteers committed to providing low-cost, do-it-yourself, community-controlled alternatives to contemporary broadband models. CUWiN's mission is to develop decentralized, community owned networks that foster democratic cultures and local content. The organization supports organic networks that grow to meet the needs of their communities through advocacy and a commitment to open source technology. To achieve its mission, CUWiN relies on international and domestic partnerships with dozens of research institutions, not-for-profit organizations, community groups, businesses, universities, and government institutions. Solutions of CUWiN include a free open source, open architecture software for mesh wireless networking (Farkas, P., 2008).

An interesting question is if FON-type networks can serve as CN infrastructures? The answer is yes and no. Yes, in cases when only plain internet access is needed and applications do not demand high bandwidth and quality of service (QoS). For QoS-demanding applications and services the answer is no. There is also a general availability issue for this model: there is no assurance whatsoever that the nodes that are supposed to be shared will be up and running 24 hours. Availability can be increased by involving special professional user groups such as restaurants, tourist offices or other small businesses, see later in this sub-section.

Even if internet access is the only service required from the shared infrastructure, the area coverage is still an issue. Since the community based solutions extend the internet access to a neighbourhood, typically just by a Wi-Fi access point accessible for the members of that community, or a slightly larger area using mesh nodes, we can have only small or slightly larger "islands" around a fixed Internet access point such as ADSL. Thus the area coverage depends on the density and distribution of fixed access points within the given geographic area.

Therefore, we can conclude that while Type 1 and 2 models aim at fully covering a certain geographic area, either to be able to offer internet access to the whole population of the city (Type 1 models) or because the anchor customer's application requires it, Type 3 model can be used as a supplementary method. In cases where the public administration cannot be an anchor tenant nor can or wants to invest in the infrastructure, Type 3 model can serve as an introductory step, a kind of pilot project, covering for example the tourist area of the city with some specific applications for tourists.

The last concern related to the "new grassroot" model is sustainability. The community consists of households and changes permanently, some participants move out of the city, some lose their interest in operating a shared access node, and in an extreme case the whole community network can fail.

An interesting variant of the FON-type model could be to involve certain groups of businesses, SMEs that can be considered as "semi-professional" users, meaning that they are still not Telecom or internet service providers but on the other hand they could behave in a more professional way thus ensuring a higher degree of availability and sustainability. Examples are a network of Internet cafes, tourist offices, hotels. They would easier agree on operating a shared access node than an ordinary citizen, and they hopefully would operate the node with more care.

FON, for example, also works through so-called Bills. Bills are business owners (restaurants, hotels, stores, etc.) who invest in FON routers in the interest of selling access to the connection. There are even Super Bills who are entrepreneurs who want to invest in routers and place them in public places and then share their revenue with FON and the owners of these public places so that the latter don't have to buy routers themselves (Farkas, 2008).

2.6 Policies for capillary development of access networks

The previous section explains business models and technology solutions for access sharing, while this one deals with specific development policies that use those models and technologies, among others.

Close to 100% broadband coverage of the territory is the main challenge for local governments that intend to develop a community network (CN). The reduction of the digital divide is relevant for both the citizen accessibility to standard and advanced internet services and the support of innovation in the business sector. Depending on the territory and the policy makers strategy, there are two main directions that could be followed.

The first choice is to exercise direct control of the whole CN. The public direct coverage of the territory is the most expensive solution both for planning, implementation and management issues. It should be noticed that it is hard to cover a whole regional territory, especially in presence of a mountain area and scattered population presence. Therefore in these cases cities usually do not prefer this strategy.

The second choice is to directly cover a certain percentage of areas by the public broadband infrastructures, and facilitate the deployment of further access infrastructures. Two complementary sub-strategies are: (a) facilitation of capillary infrastructures and access networks, and (b) the enhancement of sharing wireless access models.

The facilitation of mesh networks is an example of the enhancement of further capillary infrastructures. The local government can act as a Telecom operator and foster the development of infrastructures to expand the bandwidth. The new operators will therefore acquire public connectivity and cover new areas of the territory.

When a capillary network is working on the territory, the new challenge could be to expand the possibility for people to get connectivity from multiple access networks as a unique service. The FON and Spark-Net service (see section 2.1.5) are intended to create an open access connectivity in presence of multiple closed wireless networks. In this way a citizen will be connected at home or equally outside, via the private wireless signals coming from a customer of the same shared service.

The role of the public in enhancing the connectivity sharing services is relevant. For example, due to a restrictive anti-terrorism policy, the Italian laws do not permit this service and the many FON customers are in fact illegal. The local policy makers should therefore create a better legal environment if interested in the development of sharing wireless services on their own territory.

CHAPTER 3: Advanced services

Having analysed the business models for infrastructure development, we address the issues of the deployment of services in this chapter. First we point out to an important point of choosing the right business structure for the infrastructure creation, operation and for provision of services to public institutions and in the marketplace. In Sub-section 3.2 we briefly present the business structure implemented in the Province of Trento, Italy. In 3.3 we summarize the planned services in Trentino and point out to the expected benefits. Section 3.4 is dedicated to “service delivery platforms” or service platforms or SDP.

3.1 Business structures/relationships of creating and operating CN infrastructures

As it was mentioned in Subsection 2.3, when quoting Muniwireless research results for North American municipal wireless projects, local governments prefer various forms of public-private partnerships, and only about a quarter of them want to invest and operate the infrastructure and services. In Europe the situation is probably a reversed one: local governments often decide to invest or at least co-invest themselves, for the reasons outlined in 2.3.

In this case an important point to consider is the right business structure for the infrastructure creation, operation and for provision of services to public institutions and in the marketplace. Here the public administration has to comply with the relevant Telecom and competition laws (see our Subsection 2.2) and its own strategic objectives (of fostering the Telecom market and economy development) have to be taken into account.

Let us note here that business structures and business models should be distinguished. A business model is a set of assumptions, in particular regarding the sources and amounts of expenditures and revenues. A business structure is the definition of business entities, their ownership structures and the relationships among them.

Figure 11 shows a possible business structure (Szabó, Chlamtac and Bedő, 2004). Here two business entities are created in which the public administration has a (majority) shares, directly, or indirectly. The “Infrastructure company” is majority owned by the local government (LG) with other minority shareholders. The public administration may decide not to be the owner directly but through one of its utility companies. (It is often the case, in particular in Europe, that the local government owns and operates some utility companies, such as the water company.) By having a separate infrastructure entity, the local government can offer and sell network services in the market to all businesses on an equal basis, as a wholesale service provider. At the same time, this company is selling network services (generally referred to as “connectivity services”) to its own service provider company (which can be co-owned by other entities), and this company would be in business of providing services to the public administration itself and to other publicly operated organizations. Having co-owners in both the infrastructure and services companies could be important from the investment point of view, but also advantageous because this way the public administration can bring in the necessary operation and

service provisioning experience it does not have.

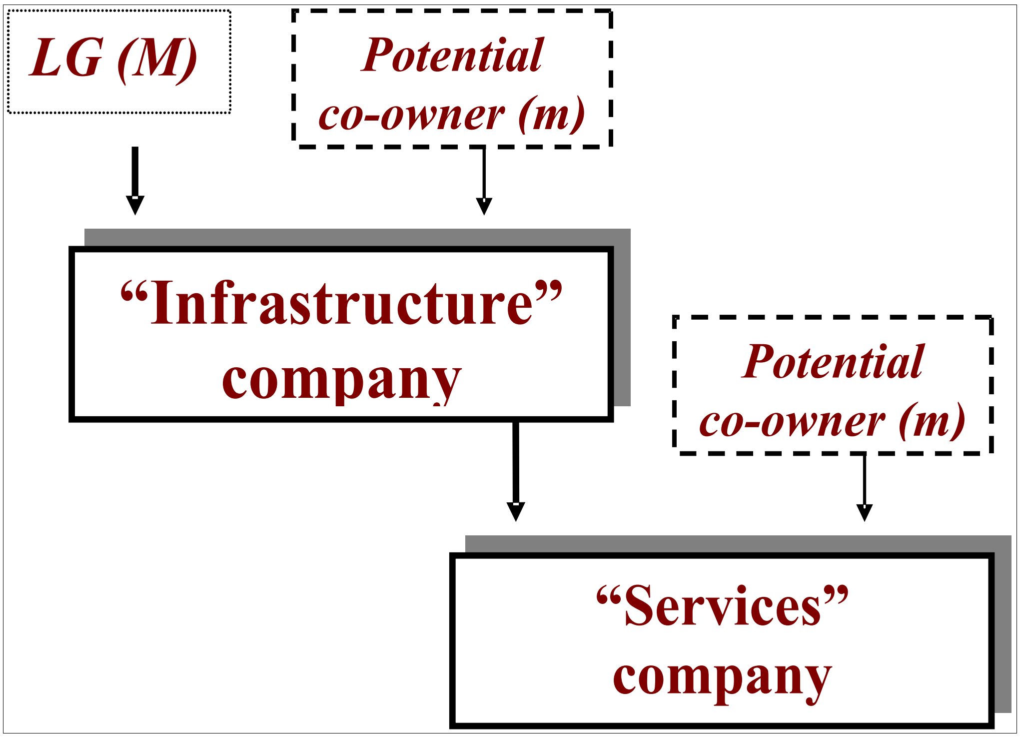


Figure 11: Potential business structure for the case when the public administration wants to be part of investment and service provisioning.

In the next sub-section we will briefly present the business structure implemented in the Province of Trento, Italy.

The business structure is in practice more complicated as it may include the "anchor tenants" of the community network. As we demonstrated in 2.3, at least one anchor tenant is needed for a healthy business case for the infrastructure investment. The public administration itself can be the anchor tenant, but often there are other stakeholders that can serve as "anchor tenants", either from the beginning, or they may join at a later stage when the infrastructure is in place. This happened in the example of the city of Corpus Christi, where the municipality, interested in the implementation of the automated meter reading service for the utility services they are managing, was the first anchor tenant, and organizations in charge for public safety and health care joined at a later stage.

A related issue is the business aspects of the development and implementation of applications and services. They are being implemented as separate efforts from the infrastructure project and although they are interrelated and inter-dependent, it is important not to mix them. In the two cases, the investors or sponsoring agencies are different. As for the infrastructure, the investor or co-investor is the local government. Financing of the services can come from different sources: the anchor tenant's own resources, the public administration (especially when the company is a public sector entity) and local, national and international sponsoring agencies. In fact, the last is probably the most important, as there are many calls for proposals in different application areas e. g. in health care, or in transport control. Note that these primary funding sources are indeed application-oriented and the funding agencies expect that the necessary telecommunication infrastructure is

available for the proposers (Szabo et al, 2008).

Application projects are highly inter-related with the infrastructure: Planning of infrastructure should be based on the identification of requirements of key applications and services immediately to be implemented, and the estimated requirements for future applications. Requirements include the basic ones such as coverage, bandwidth and quality of service parameters. The capabilities of the infrastructure have to be taken into account when planning new services, and the infrastructure should be extended both in quantitative and qualitative terms, taking into account the requirements of new applications. Some planning guidelines were introduced in our previous deliverable D7.2.

3.2 The business structure for infrastructure and services in Trentino

The participants of the business structure in Trentino are *Trentino Network, Informatica Trentina* and *telecom operators and ISPs.*

Trentino Network (T.N. in this document) is a corporation (S.p.A.) currently 100% owned by the Province Administration. There is a plan to include *municipalities* as shareholders which is required by the Italian law in order to enable T.N. to provide services for them.

T.N. is responsible for building the network infrastructure, for its operation and maintenance and for providing transport services and IP telephony to the Province and to municipalities. It acts as a neutral network provider for telecom companies and other potential wholesale customers.

Services to end users will be provided exclusively by *telecom operators and ISPs*.

Informatica Trentina (I.T. in this document) is a corporation (S.p.A.) currently 100% owned by the Province Administration. Its role is to provide services to public administrations all over the Province. Services are IT services and telephony (VoIP), except the connectivity service which is provided by Trentino Network.

There are plans to modify this business structure by further clarifying the roles or T.N. and I.T.. Another possible change is that additional participants such as municipalities are expected to become shareholders. We are going to come back to this structure in our next report.

3.3 Planned services in Trentino and expected benefits

As we demonstrated in 2.1.4, the public administration is an “anchor tenant” for the Trentino community network infrastructure. Data communication and internet services, that were provided in the past fully and at present partly on a network infrastructure leased from Telecom Italia, the country's incumbent telecom operator, will be implemented soon on the new fibre optic and wireless network covering the whole Province of Trento. In this section we will be a little more specific about the services to be provided to the public sector institutions. We are also in the process of calculating savings and benefits from using the new infrastructure, and we are planning to present some results in our next report.

3.3.1 Services to be provided to public sector

Services provided to public administration sector by Informatica Trentina include:

- Connectivity for data communication and internet access for specific public administration entities.
- VoIP telephony service for public institutions (in Trento, later for other municipalities).
- GIS (Geographic/Geospatial Information System) based services.
- Packages of IT services for municipalities (e-mail, video conferencing, server hosting, security solutions,…).
- Connections for the health care administration (APSS) to interconnect the central hospital in Trento with the health care provider institutions in provincial towns to provide telemedicine services. APSS has implemented a central PACS system of only two PACS servers (one main, one backup) instead of the original plan of a distributed network of five PACS servers. Radiology images from provincial hospitals will be transmitted to and centrally stored in Trento.
- A video conferencing network consisting currently of 15 sites for e-learning (a joint project with the University of Trento). The actual distance learning application was training of personnel about public tender procedures, but the network is a general purpose one so it can be used for any distance learning application.

3.3.2 Applications and services for the health care

Broadband communications is crucial for current healthcare applications. It is not surprising that in many cases the health care sector is one of the main users (or even an "anchor tenant") for the initiative. It is the case also in Trentino due to the following factors (Sartori, 2008):

- The health care sector belongs to a large extent to the public sector in this region (like in Italy in general).
- The province has several public hospitals in provincial towns. And although the distances in the province are not very big, and there is a good road and railway network, travelling times from provincial health care institutions to the capital city of the province can be long due to the geographic challenges, in particular in winter. Thus, inter-personal communication via electronic means and transmission of diagnostic information are of great importance.
- The IT management of health care administration (APSS – Azienda Provinciale dei Servici Sanitari) is highly professional, innovative and is ready for acceptance and implementation of new broadband technologies.

Our objective for this phase was to get acquainted with the current and planned e-health and telemedicine applications that can be (and partly are) implemented on the new

broadband infrastructure. The information was collected during two interviews with the IT management of APSS. The main applications are as follows.

1. Centralized management of diagnostic data based on a PACS (Picture Archiving and Communication System)

The project started in 2006 with a 4.5 M€ budget. Now a network between the 10 public hospitals, the 4-5 private clinics and the administrative/IS sites has been implemented. The system is composed of 10 mini-PACS located in the provincial hospitals that are connected to a central storage centre in Trento. Images are only temporarily stored at remote sites (for 3 days). The PACS costs 4 M€ (including hardware, software and digitalization devices, excluding the connectivity costs). 7-8 TeraBytes of diagnostic data is actually in use. This quantity increases by 100% every year.

The main benefit from the digitalization of images is saving the costs of materials e. g. films). There are important indirect benefits due to the availability of images in the whole health care system of the province, which results in a better service for the citizens. These indirect benefits can only be partly quantified but that would require a detailed analysis if the relevant health care processes.

Without the broadband infrastructure, the health care administration would have to implement the PACS system without the connections between each of the 10 mini-PACS and the central site. Availability of images only in the local area would certainly result in a limited quality of service.

The connectivity costs related to PACS separately are not known at the moment. The current total cost of broadband for the health care (fees actually paid to Informatica Trentina for the Telecom Italia CABLA infrastructure) was 850 k€ in 2007. New fees to be paid for the own infrastructure are not yet known.

2. VoIP service among the health care institutions.

It is under implementation. The savings will be calculated taking into account of:

a) Actual telephone costs paid to Telecom Italia.
b) Division of total costs into external and internal telephone costs.
c) Costs to be paid for the connections based on the new broadband infrastructure.
d) Maintenance costs of the IP-PBXs.

3. Telemedicine applications (in experimental phase):

- Tele-cardiology.
- Image-added consultation with Verona Hospital in Neurosurgery.
- Geo-referred ambulances control.
- ECG transmission between ambulances and hospitals.
- Remote control of pacemakers.
- Image-added consultation (patients and monitors) between ambulances and

hospitals.

- Remote control of the electronic microscope in the Pathologic Anatomy unit.

In the next stage when we will be able to collect more specific data, we are planning to build models for and calculate savings resulted from using the broadband province-wide network.

3.4 Service Delivery Platforms

As we pointed out in our D7.2, an important component in the architecture of community networks is broadly called “service delivery platform” or service platform or SDP. SDP has also emerged in the telecommunication world within the context of so-called Next Generation Networks which represents a significant change from the classic telco service model of independent, vertically integrated networks to a new architecture that comprises a variety of access networks and has a new horizontal layer or platform that supports service provisioning with important functionalities such as call control, quality of service provisioning, media gateways, authentication, authorization, and accounting (AAA) and the like.

This new architecture allows telcos to successfully compete with Internet-based services, and in general, supports the convergence of the Internet, telecommunication and media industries. This new architecture’s key element is SDP or Service Delivery Platform, meaning a set of components that allows an operator of the network to deliver new digital services through a horizontal service network and a multiplicity of access networks. In the narrower (technical) sense SDPs are middleware solutions between the network layer (which is based on the Internet Protocol or IP) and the applications. In a broader sense, it is a system that includes or integrates with the company’s business processes. It needs to be emphasized that open source software platforms play an important role in the implementation of this new service provisioning principle and gains increasing support from government organizations, EU and industry. The DBE platform is a good example, which is software delivered to the open source community by the European Commission-funded Digital Business Ecosystem (DBE) project.

Within our context of the community networks, the role of an SDP is even more important. It is critical to support those members of the communities that are not only users but can also act, permanently or occasionally, as service providers, too. These members are typically SMEs but can be also individuals who need a platform to put their service on the network. The aim is to provide such entities with a platform that allows for creating new services in an easy way through user-friendly interfaces.

During the next phase of our work, we are going to address the issues related to selection, design, implementation and operation of service delivery platforms in a specific environment of TasLab, the Trentino Living Lab based on the Trentino community network. Here we are going to address the variety of SDPs beyond the ones for supporting the provision of telecommunication services, including service delivery environments for e-business (e. g. ebXML), or collaborative environment. Open source software platforms will be given special emphasis.

CHAPTER 4: Participation

4.1 Strategies for a sustainable DCEs introduction

As Darking (2008) suggests, the DE research is faced with many possible issues concerning governance. Firstly, DE governance is far-reaching, multi-dimensional and constantly shifting. Secondly, because of the fragmentation of governance research (political science, organizational literature, socio-economic perspectives, regulation, ...) one could approach the same DE issue from a very different position. In this section we will criticize the earlier DE introduction model in favour of a more locally-based sense making process.

4.1.1 The earlier DE dissemination model

The earlier DE dissemination model is based on an approach that is a combination of top-down and bottom-up actions (Dory, 2007). At the first stage the Regional Catalyst engages with the regional policy makers and/or economic decision makers – the Influencers – and/ or economic development agencies and universities. The participation of local policy makers at this stage is absolutely relevant because shaping the implementation of DE in a region is primarily a political decision. Resources and infrastructure may need to be allocated in order to support its introduction.

Therefore a DE regional program is firstly a top-down decision by the local policy makers and with the facilitation of the Regional Catalyst. At this point the Regional Catalyst should start catalysing the process. This means that the top-down political decision at the regional level should meet with and be empowered by the bottom-up interest of enterprises.

The DE implementation or adoption is based on a multi-located ecosystems model that does not allow generic “best practices”, requiring instead local practices informed by key factors and some important variables to consider (Passani, 2007): pre-existing socio-economic situation; expectation/vision about DE as technological environment and as a local Innovation process; typology of selected Regional Catalyst; policy makers' level of interest; identified business domain/s; technological development of DE components.

4.1.2 The DE supporting local trajectories and meanings

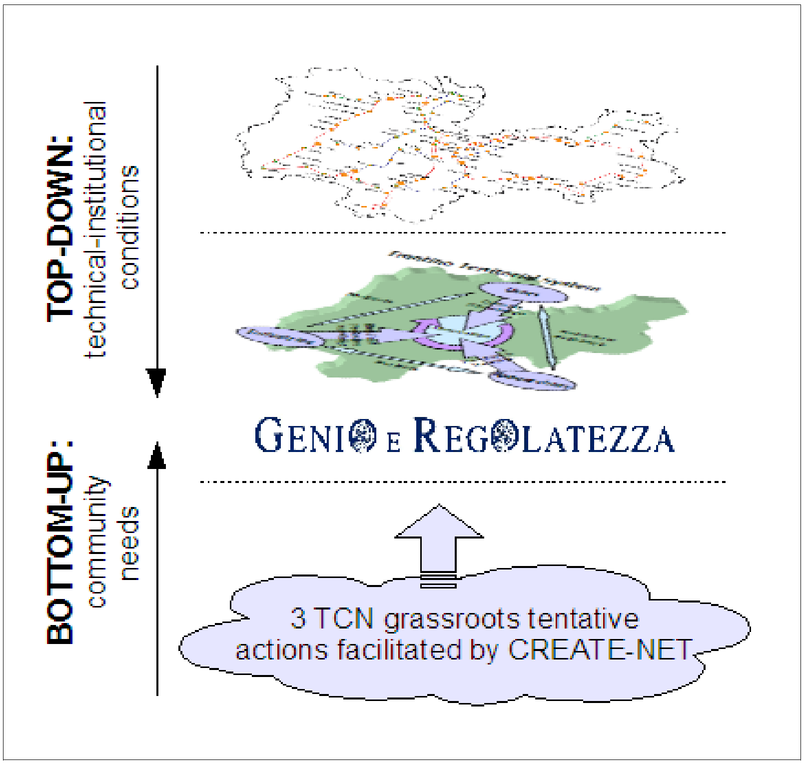
Like the most paradigmatic innovations, the DE adoption at the local level requires a *translation from differently-located experiences and a declination into the local context characteristics*. What we call “DE implementation” is therefore far away from being a mere top-down technological adoption. The top-down and bottom-up processes discussed above have exactly the meaning to start the process with a policy makers and users appropriation phase. The Regional Catalyst should assist this local sense making process.

As also suggested from Botto and Passani (2007), what counts in a regional innovation is the virtuous process composed by (a) the addressing of a concrete problem or need, and (b) the new meanings and ideas that emerge from a locally meaningful innovation trajectory. From this ecological perspective, the early DBE dissemination model is not wrong but only partial. It addresses the institutional model request. In addition, we suggest to adopt a participated innovation methodology (see below) that should consider the following points of attention:

- start from concrete local needs: a DE as a pure research need will be hardly sustainable in time;
- work with people at the many levels: after the policy makers, innovation should involve both the management and the lower levels of business organizations and communities;
- work on what makes sense for participants, not only on the DE idea: instead of "implementing" a DE (or DCE) as the core objective, focus on developing meaningful innovation for the community and use the DE ideas as a tool;
- avoid using the term "DE" or "ecosystem": the result of this innovation should be something meaningful for local communities also in its label. It is improbable – but not impossible – that they will adopt your own vocabulary.

4.1.3 An alternative DCE innovation introduction strategy

We therefore suggest a DCE innovation introduction strategy that instead of focusing on an unique DE implementation project, will sustain the ecosystem approach on different layers at the same time. The Figure 12 represents this strategy by taking the example of the Trentino Region experimentation.



The strategy consists of different layers of service-oriented projects that find place in the continuum between (a) the more top-down technical and institutional conditions, and (b) the bottom-up community needs. In the Trentino case we specifically found three layers of projects:

A) top-down technical conditions at regional level (on the top): the regional Community Network (T.Net) project, related to the regional broadband infrastructure;
B) intermediate enabling actions at regional level (in the middle): high level projects that translate the ecosystemic approach at the regional level providing an organizational infrastructure and regulatory framework;
C) bottom-up specific projects at the community level (on the bottom): connecting specific business and local community needs to the previous two levels.

4.2 Methodology of participation

When considering DCE introduction as driven from local sense making (Weick, 1995) practices we basically refer to participatory innovation methodologies.

In Scandinavia the *Collective Resource Approach* (Ehn and Kyng, 1987), now known as *Participatory Design* (PD) community, started contrasting the top-down and managerial logic of innovation in workplaces at the end of the '70s. It grew up in fact by inspiration of the socio-technical tradition of change management called *Action Research* (Reason and Bradbury, 2006).

During the '90s, an approach called *Business Process Re-engineering* has been the most quoted alternative to the managerial-style and technology-driven organizational change. In those years the PD approach sustained principles of design such as the final-user participation, the enhancement of skills instead of rationalization, and the relevant role of conflicts in design practices (Greenbaum and Kyng, 1991).

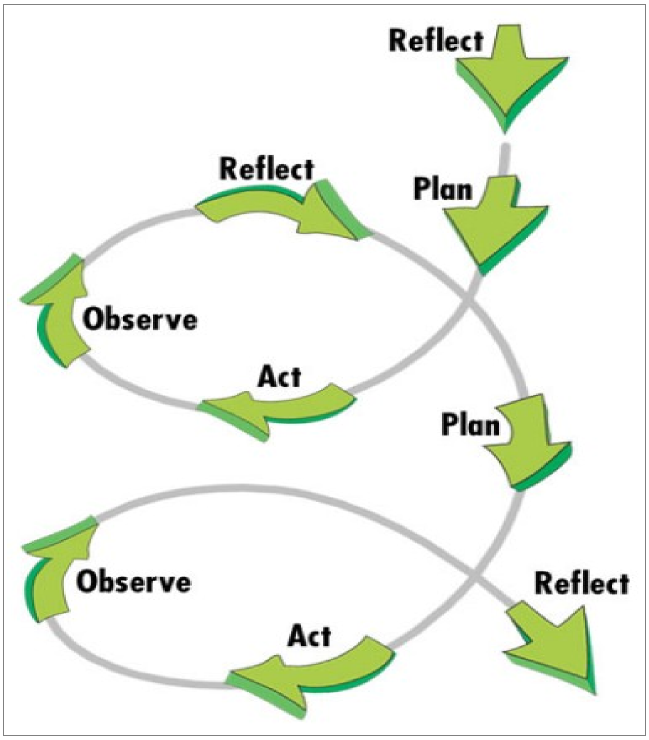
In the same period Lucy Suchman was just presenting the *Situated Action* proposal (Suchman, 1987) when the Scandinavian and the North American groups started reflecting together in occasion of CSCW and HCI conferences[3], generating a common vision called *Situated Design* (Greenbaum and Kyng, 1991). The two traditions were well inspired by the relational nature of artefacts common to both the socio-technical and the social studies of science schools. A huge amount of discourses have been spent over years on technical objects developed and used in the middle of the design process. Prototypes and mock-ups are two example of this relational attitude.

The AR and PD methodologies are not only consistent with our relational and situated approach also presented in the Deliverable 7.1 and 7.2. They enable us considering at the same time organizational and technological development in relation to specific empirical contexts. Indeed, PD lets us understand infrastructure as something that emerges for people in practice, connected to activities and structures (Star and Ruhleder, 1996), while AR is simply addressing as the needed background for anything that is organizational-aware. Without the core AR points of attentions, we will never have any real PD practices but only the more business driven User-Centered Design methodologies.

3 Computer Supported Cooperative Work and Human-Computer Interaction have been the most anti-positivistic groups inside the Information Systems Research community.

Actually there are many PD sub-methodologies and styles, from the Contextual Design (Beyer and Holtzblatt, 1998) to the MUST methodology (Bødker, Kensing and Simonsen, 2004). Nevertheless, a PD methodology is still considerably as son of some core Action Research principles:

- the first objective is to provide what is needed locally: research goals should be followed after local needs;
- start from concrete local needs developing ideas, visions and and concrete action plans;
- involve local people in real participation at the different levels;
- participants should provide the local knowledge;
- researchers should act as “resource persons”, therefore facilitating the most autonomous local innovation by providing ideas, specific consultancy, and managing the process (“change management” in Action Research);
- participants should provide the choices, based on their local knowledge enriched by researchers facilitation;
- the circular iterated process is composed by negotiation, action and reflection phases (Figure 13).



In conclusion, the participatory methodology for DCEs innovation introduction that we are suggesting is an application of the PD and AR idea to a complex innovation. Since the stakeholders and needs involved by any DE innovation are many, we suggested to work on more layers both (a) separately (see the previous section), focusing on the specific needs, and (b) in relationship, using the outcomes of the other projects as resources.

Summary

With this deliverable we introduce the Digital Community Ecosystems as the heterogeneous way to adopt the DE principles by a wide range of communities at the local level. DCEs have been presented as future possible innovations that stay in the line between two possible innovations: Digital Ecosystems (DEs) empowered by broadband Community Networks (CNs), and Community Networks with some Digital Ecosystems services. At this early stage of the DEs research, and with the socio-technical framework that has been developed in the Deliverable 7.1, we can simply theorize and experiment – see the forthcoming Deliverable 12.8 – this line of research.

The Deliverable 7.1 provided a socio-technical theoretical framework and suggested how the CN well developed experiences may provide to DE both ubiquitous broadband infrastructures and community participation models. The advanced ecosystemic services are also a possible added value for any regional innovation based on a public broadband infrastructure. With the Deliverable 7.2 we started analyzing how this interplay started in the Province of Trento experience. The forthcoming Deliverable 12.8 is updating the state of the art of the Trentino case study. The present report represents the needed reflections on the issues that deeply relate and may affect a DCE regional innovation, and it primarily comes from our regional case research.

In Chapter 1 we defined Digital Community Ecosystems (DCEs) in order to empower the Digital Ecosystem (DE) vision with other aspects of the broadband-based innovation like Community Networks. It is possible to approach the DE-CN relationship by analyzing how DEs could meet the sustainable deployment of ICT for development in a specific setting (see: Sarkar and Rajagopalan, 2008), providing interesting information for DEs applications for local communities. We followed the CNs and DEs conceptual framework that has been developed within WP7 of OPAALS 1st phase, and we drove ideas for DCEs business models to be considered in local settings (in Deliverable D12.8).

We considered both the conceptual interpolation between DEs and Community Networks (CNs) – provided by the OPAALS D7.1 (Botto and Passani, 2008) - and the technologies involved in the regional broadband-based innovation – provided by the OPAALS D7.2 (Szabo et al, 2008) -. Therefore we first summarized the dimensions that DCEs pay to DEs and CNs, secondly we defined DCEs by using the CISG framework that has been developed in D7.1, thirdly we focalised on DCEs services for participated local innovation, and finally we underlined some issues for DCEs business and sustainability models discussion.

Chapter 2 started with a brief summary of business aspects of state-of-the-art wireless technologies. We considered the “business aspects” of these technologies: availability in terms of standardization, maturity etc. In Sub-section 2.1, we reviewed novel technologies - such as mobile WiMAX - which is particularly suitable for building DCE infrastructures, and show how governments can help in introducing them. Regulatory issues are also addressed in Sub-section 2.2. The role of the regulatory environment for building network infrastructures by public participation is twofold. Firstly, it has to define what can and what

cannot be done in terms of network and application services provisioning by a local government. Secondly, and more importantly, the regulators, in particular those responsible for frequency allocation for wireless networks, have to offer the maximum possible freedom and flexibility of using wireless frequencies for publicly operated infrastructures so that important objectives such as supporting new entrants in the telecommunication market or solving the digital divide problem can be achieved. We outline the problems that Europe has to solve so that its lagging in penetrating broadband wireless technologies can be overcome. As a good example, we briefly present a novel regulatory approach exercised in the USA.

Main business models are dealt with in Sub-section 2.3. After a brief introduction of a market research on the reasons why municipalities want or do not want to be engaged in building and operating wireless community networks, the main types of business models, namely the “franchise model” and the “anchor tenant model” are identified. In the first model, the public administration grants the private company the use of public facilities. The private company pays for these assets to the public administration. The latter does not commit to be a major customer. In terms of our earlier PPP classification, this is a private/private model. In the second model the public administration or one of the organizations under public control commits to become a major customer of the wireless infrastructure. The latter can be implemented and/or operated either by a private company or by the public administration itself. Thus this model corresponds to several PPP models as the emphasis here is on the question “who is paying for the network usage?”.

We analysed the lessons learned from the many franchise type models and answered the question why many of them in the USA failed or are in trouble. On the other hand we pointed out that the anchor tenant model has been successful in the USA and worldwide.
We presented the anchor tenant model implemented in Trentino, Italy. With this aim we provided preliminary data on investment, operating costs, savings, based on interviews of Province officials. This is the first step towards building business models and carrying out calculations, which will be included in our next report.

A third model (also called “new grassroot”) is also introduced. It is an interesting revival of the original grassroot principle and is based on sharing resources such as internet access and a network router device. Comparing these generic models, we can conclude that while the first and second model aims at fully covering a certain geographic area, either to be able to offer Internet access to the whole population of the city (franchise models) or because the anchor customer’s application requires it, the model based on sharing facilities can be used as a supplementary method. In cases where the public administration cannot be an anchor tenant nor can or wants to invest in the infrastructure, this model can serve as an introductory step, a kind of pilot project, covering for example the tourist area of the city with some specific applications for tourists.

Close to 100% broadband coverage of the territory is the main challenge for local governments that intend to develop a community network (CN). Local government may decide to directly cover only a certain percentage of areas by the public broadband infrastructure, and facilitate the deployment of further access infrastructures. This approach that can be called capillary development of access networks is dealt with in Sub-section 2.5.

Having analyzed the business models for infrastructure development, we addressed the issues of the deployment of services in Chapter 3. First we pointed out to an important point of choosing the right business structure for the infrastructure creation, operation and for provision of services to public institutions and in the marketplace. Here the public administration has to comply with the relevant Telecom and competition laws and its own strategic objectives (of fostering the Telecom market and economy development) have to be taken into account.

We presented a possible business structure where two business entities are created in which the public administration has a (majority) shares, directly, or indirectly. The first entity is an “infrastructure company” which allows the local government to offer and sell network services in the market to all businesses on an equal basis, as a wholesale service provider. The second entity is a service provider company which would be in the business of providing services to the public administration itself and to other publicly operated organizations. In Sub-section 3.2 we briefly presented the business structure implemented in the Province of Trento, Italy. In 3.3 we summarize the planned services in Trentino and point out to the expected benefits: the services to be provided to public sector and applications and services for the health care.

As we pointed out in our D7.2, an important component in the architecture of community networks is broadly called “service delivery platform” or service platform or SDP. Within our context of the community networks, the role of an SDP is even more important. It is critical to support those members of the communities that are not only users but can also act, permanently or occasionally, as service providers, too. These members are typically SMEs but can be also individuals who need a platform to put their service on the network. The aim is to provide such entities with a platform that allows for creating new services in an easy way through user-friendly interfaces.

In Chapter 4, “Participation”, we criticized the earlier DE introduction model in favour of a more locally-based sense making process. The earlier DE dissemination model was based on an approach that is a combination of top-down and bottom-up actions. We suggested a DCE innovation introduction strategy that instead of focusing on an unique DE implementation project, will sustain the ecosystem approach on different layers at the same time.

We presented this strategy by taking the example of the Trentino Region experimentation. It consists of different layers of service-oriented projects that find place in the continuum between (a) the more top-down technical and institutional conditions, and (b) the bottom-up community needs. In the Trentino case we specifically found three layers of projects: top-down technical and institutional conditions at regional level; intermediate enabling actions at regional level; and bottom-up needs at the specific community level.

At the end we explained the participated methodology that would allow a regional DCE-inspired innovation out of this strategy. Action Research methodology enhance a fully participated and local knowledge aware innovation, while Participatory Design methodology is more technology-specific and lets us understand infrastructures as something that emerge in practice, connected to activities and structures. This approach is particularly connecting the socio-technical theoretical framework we adopted in the Deliverable 7.1 to the present and future empirical research in the Provence of Trento.

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