GOVERNMENT POLICY AND WIRELESS CITY NETWORKS: A COMPARATIVE ANALYSIS OF MOTIVATIONS, GOALS, SERVICES AND THEIR RELATION TO NETWORK STRUCTURE

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ABSTRACT: Wireless City Networks are a recent, but growing phenomenon. In the United States hundreds of cities are looking into the possibility of rolling out Wi-Fi or WiMax based networks over substantial parts of the city. The underlying rationale is that wireless city networks are cheap and flexible alternatives for fixed broadband networks. Cities more and more see broadband Internet access as a necessary and therefore public utility to be provided to their communities at affordable prices or even free of charge. The deployment of wireless city networks is however more than just infrastructure provision. Initiatives are linked to broader city policies related to digital divide, city renewal, stimulation of innovation, stimulation of tourism, strengthening the economic fabric of the city, etc. In this article we will argue that explicit and implicit goals are directly linked to the coverage and topology of networks, the technology used, price and service modalities, etc. Furthermore we will argue that the differences in context between the US and Europe explain the different infrastructural trajectories taken. Overall and on the basis of empirical findings we caution for the over-optimistic view that Wi-Fi-based wireless city networks are an equal alternative for providing broadband access. There are both financial and technological uncertainties, which could have a serious impact on the performance of these initiatives.

INTRODUCTION

Wireless City Networks are a recent, but growing phenomenon. In the United States hundreds of cities are looking into the possibility of rolling out Wi-fi- or WiMax-based networks over substantial parts of the city. Worldwide it is estimated that more than 1 000 cities have plans to deploy such networks (CDG, 2005). The underlying rationale is that wireless city networks are cheap and flexible alternatives for fixed broadband networks. Cities increasingly see broadband Internet access as a necessary and therefore public good to be provided to their communities at affordable prices or even free of charge. As current market forces often fail to provide cheap services, cities argue it is their obligation to fill the void. Various authors have described the municipal wireless movement in the United States as a significant and potentially disruptive phenomenon (Schamp, 2004, Bar & Park, 2006, Gibbons & Ruth, 2006, Gillett, 2006). Developments in Europe have until now received less attention (Kramer et al, 2006).

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The deployment of wireless city networks is more than just infrastructure provision. Initiatives are linked to broader city policies related to the digital divide, city renewal, stimulation of innovation, stimulation of tourism, or strengthening the economic fabric of the city. In this article we will argue that explicit and implicit goals are directly linked to the coverage and topology of networks, the technology used, price and service modalities. Furthermore we will argue that the differences in context between the US and Europe explain the different infrastructural trajectories taken. Overall and on the basis of empirical findings we caution against the over-optimistic view that Wi-Fi-based wireless city networks are an equal alternative for providing broadband access. There are both financial and technological uncertainties, which may have a serious impact on the performance of these initiatives.

The paper is based on a comparative analysis of 17 cases in 15 cities, nine European and six American. On the basis of a literature study an analytical framework was developed, which was subsequently used to analyse, describe and compare the cases.[2] The analytical framework looked at technology options used, the networks and their characteristics, the goals and target groups envisioned, the business models adopted, the service and price modalities employed, the investments needed and the problems and results encountered. The outline of this article largely follows the analytical framework. In this article we will discuss

- the networks and their characteristics;
- the goals and target groups envisioned;
- the service and price modalities;
- the investments needed;
- the problems and results encountered; and
- overall conclusions and recommendations for policy and future research.

Each section starts with a generic discussion of the topic, followed by a discussion based on the empirical comparative analysis. [3]

2 The case studies underlying this paper were finalised by the end of 2006. We have followed up on trends up to October 2007on the basis of more general papers.

3 For an analysis of the business models used we refer to our paper at the ITS conference in Istanbul.The most important roles in the value chain of municipal wireless networks are network ownership and service provisioning. At the level of network ownership one can distinguish between the role being taken care of in the form of a private player, public player, an open site arangement and community player. At the level of service provision we can distinguish between the role being taken care of in the form of a private player, a public player, wholesale or no specific ISP. In reality we can identify six combinations of roles: 1) private-private model, 2) private-wholesale model, 3) public-public model, 4) public-wholesale model, 5) open site model, 6) community model (see Ballon et al, 2007). Other literature on business aspects see Bar & Park (2006) and Lehr et al. (2006).

Note on method and selection

Although many cities consider deploying wireless city networks, only a few of the networks are fully operational at the time of writing this paper. Many projects are still in the conceptualisation or pilot phase. As indicated the article is based on a comparative analysis of 17 cases. The case studies were developed on the basis of a review of internal preparatory reports, requests for information, requests for proposals, press releases, evaluation reports, etc. In some cases the information was complemented with email communication or short telephone interviews trying to clarify and complement some of the information. This article thus mainly draws on 'formal' information which is available in written format. Only a limited amount of cases have been studied, and systematic overviews and objective evaluation studies are rare. The literature, which is available, is often commissioned or written by parties having a direct or indirect stake in projects, such as cities, consultants or technology vendors. The literature has therefore to be looked at with some caution. In analysing the available information we have tried to assess critically the trustworthiness of the information, for example, by complementing them with interviews where possible.

The selection of cases in comparative research is important. Cases need to vary enough to be able to confirm or refute trends. On the other hand cases have to share a certain contextual background to be able to define sound policy recommendations. This article is based on commissioned research for the Brussels region in Belgium, which resulted in some specific selection criteria. The selection of cases was based on the following criteria:

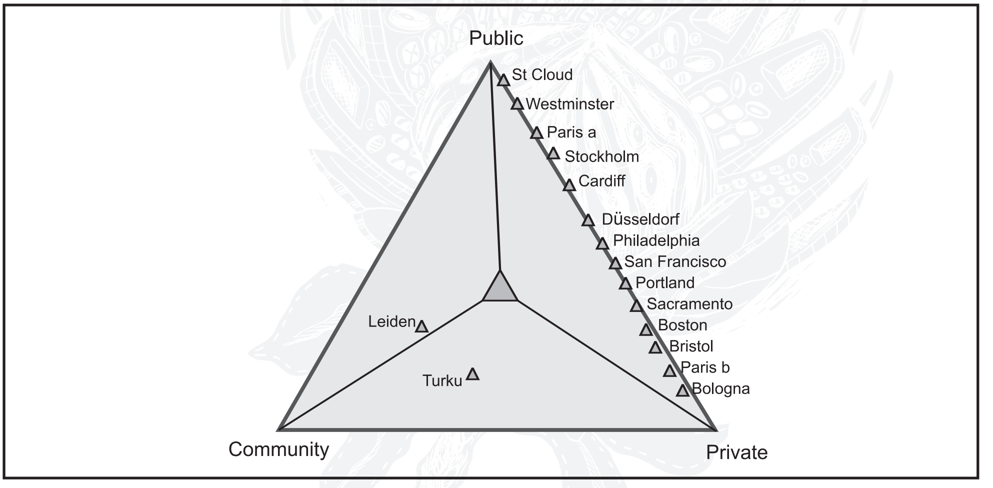
- The context had to be similar to the Brussels region. We therefore mainly selected European cases. However, as the implementation of wireless city networks is more advanced in the US we selected several US cases for comparison.
- The main focus lays on initiatives in which Government plays a certain role, be it by financing or stimulating the roll-out of networks. Pure private initiatives were not taken into account. We included two alternative community networks, ie Leiden in the Netherlands and Sparknet in Turku. These cases are interesting to look at as a) Government can/could play a stimulating role in their development, and b) they could be rather disruptive for public and private wireless city networks in the future.
- The focus was put on initiatives in larger cities. The only exception is Saint Cloud in the US as this is the only example of a citywide initiative free of charge for the whole population. Saint Cloud is also one of the only fully operational networks (Intel Corporation, 2006).

Using these criteria for the selection of cases means that we don't have a quantitatively representative sample of wireless city networks as a whole. However, from the point of view of a qualitative sample we have selected the cases with the largest possible variation in mind. In Table 1 we provide an overview of the cases, the phase of the initiative and the key driver of the project.

Table 1: Description, phase and key driver of wireless cities

City	Short description	Phase	Key driver
Bologna (IT)	Iperbole Wireless Network: Experimental Wi-Fi network providing wireless Internet access to selected groups	Pilot	Public: City of Bologna
Boston (US)	Gradual expansion of Boston Main Streets Wi-Fi project providing wireless Internet access to entire city	Request for proposal	Public: Boston Main Street
Bristol (UK)	Bristol Hot Zone: Wi-Fi hotspot zone providing wireless Internet access and walled garden services	Operational	Public: City of Bristol
Cardiff (UK)	BT Openzone: Wi-Fi hotspots and zones providing wireless Internet access	Operational	Private: British Telecom
Leiden (NL)	Wireless Leiden: community network of wireless nodes sharing Internet connections	Operational	Local Community
Paris a (FR)	Establishment of 400 Wi-Fi access points	Information phase	Public: City of Paris
Paris b (FR)	Site provisioning to private operators with the objective of full Wi-Fi coverage of Paris	Information phase	Public: City of Paris
Philadelphia (US)	Wireless Philadelphia: large-scale Wi-Fi network providing wireless Internet access	Roll-out	Public: City of Philadelphia
Portland (US)	Wi-Fi/WiMax network providing wireless Internet access to citizens, companies and city workers	Tendering phase	Public: City of Portland
Sacramento (US)	Large-scale Wi-Fi network for wireless Internet access and additional services	Tendering phase	Public: City of Sacramento
San Francisco (US)	Wi-Fi network covering the entire city for wireless Internet access	Request for proposal	Public: City of San Francisco
Saint Cloud (US)	Cyber Spot: Full coverage of city with Wi-Fi/WiMax network providing wireless Internet access	Operational	Public: City of Saint Cloud
Stockholm (SW)	Stockholm Mobile Connect: WiMax network providing wireless Internet access	Roll-out	Public: City of Stockholm
Turku (FI)	OpenSpark: Wi-Fi community network providing wireless Internet access	Operational	Private / Local Com munity: Sparknet
Westminster (UK)	Wi-Fi network for closed circuit television and other services	Operational	Public: City of Westminster

Figure 1: Initiatives along the Public Private Partnership triangle



The Network and its characteristics

In this section we discuss the characteristics of the networks deployed in terms of the technologies used, the topology and the coverage of the network. Wireless city networks can potentially be built using different wireless technologies and standards (for an overview of alternative wireless technologies see: Lindmark, *et al*. 2006). In all the selected cases initiatives use the Wi-Fi and/or WiMax families. Until recently Wi-Fi, based on the 802.11 standard, was predominantly used in houses, offices and hotspots. The technology has a number of limitations, especially in terms of coverage. As Wi-Fi uses microwaves its reach is often limited when travelling through hard materials such as walls, buildings and water, for instance in the form of raindrops and wet trees. This can have an influence on the quality of service offered, especially indoors. Furthermore, building larger networks using Wi-Fi technology was difficult. It was only possible to connect hotspots into a hub-and-spoke network. The main drawback of this setup is that these networks don't allow roaming over the different hotspots.

In the meantime it is possible to build meshed networks using Wi-Fi technology. These networks are much more like mobile cellular networks, allowing roaming between cells and allowing travelling within the network at a certain speed. This is important in view of certain applications, such as e-Government and e-security services for mobile groups and for VoIP. Meshed networks can secure coverage in larger areas in the form of hotzones – covering delimited areas such as shopping streets, commercial centres, tourist areas, etc – or wireless clouds – covering whole cities or neighbourhoods. Important to note is that so far there is no unified standard for wireless mesh. Many vendors – such as BelAir Networks, Bandspeed, Firetide, Nortel, Tropos and others – use proprietary standards (Intel, 2005). An important characteristic of meshed networks is that they are easily scalable and extendable.

WiMax is a newer technology which should allow for faster speeds with a much wider coverage (up to 50km), at least theoretically. It also has some other advantages over Wi-Fi. It penetrates more easily through obstacles and can more easily guarantee quality of service. It was developed with telecommunication services in mind, which allows for roaming and mobility within the network. Although there are some pre-standard products available on the market, WiMax is still in the process of standardisation. It is expected that the standardisation process – amongst others for the 802.16e allowing mobility at high speeds (100 km/h) – will only be finalised by 2009, about a year later than first projected (de Nijs, 2007, Intel, 2005). WiMax can be used in two different ways, either as an alternative communications network or as backhaul for Wi-Fi-based mesh networks. Initial tests with mobile WiMax are not as promising as first projected. When used in city environments with handhelds – featuring small and weak antennas – the area covered by a station shrinks to between 300 and 1000m (de Nijs, 2007).

Another important disadvantage of WiMax over Wi-Fi is its limited installed base. Once standards are in place the take-up of the new technology might be faster than previous technologies. However, it will take years before all computers have built-in capacity. Wi-Fi on the other hand, already has a huge installed base in computers, PDAs, etc. Therefore, most authors consider Wi-Fi the best solution for providing broad access to broadband in cities.

COMPARATIVE ANALYSIS

In our selection of cases Wi-Fi is the dominant technology to connect consumers/customers to the network (see Table 2). WiMax is seldom used to provide direct access to the costumer. In the selection of our cases we had to search specifically for initiatives using the technology. However, prestandardised WiMax is often used for the backhaul of the network. What is interesting to note is that the more recent initiatives, such as Bologna, Boston, Sacramento and San Francisco take a possible evolution to WiMax into account (RoamAD & HI-TEL, 2006; Wireless Task Force, 2006; City of Sacramento, 2006 & City and County of San Francisco, 2005).

These networks are technically easily upgradeable to WiMax. Only one initiative of those studied, currently in its tendering phase, considers both technologies. In Portland Wi-Fi would be used to connect citizens, whereas WiMax would be used to connect companies at higher speeds (City of Portland, 2006).

In Europe there is only one initiative effectively considering WiMax to roll out a new wireless city network – Stockholm (Lundgren, 2006). Düsseldorf has experimented with WiMax in a small pilot project on coordination of fire brigades and on city navigation services for tourists. The pilot project will not be extended. The initiators mention two specific reasons. There is still uncertainty about frequencies and possible licences for frequencies, and the city has access to public and private networks already, which cater for the current needs (Personal communication, 2006).

Most initiatives use or consider using mesh technology (11 initiatives) instead of hub-and-spoke (four initiatives). What is interesting is that there is a correlation with topology and coverage. The hub-and-spoke initiatives provide access in an often limited amount of hotspots spread over the city. The mesh initiatives want to provide access over larger hotzones and wireless clouds. Apart from Paris, all hotspot initiatives are operational, whereas most mesh-based initiatives are still in preliminary or pilot phases. If we make abstraction of the community-based initiatives in Europe – Leiden and Turku – it becomes clear that most European initiatives are less ambitious than their American counterparts.

Although we were careful in selecting our cases it is difficult to generalise on the basis of a small sample. Further research should warrant some of our preliminary conclusions. However on the basis of our sample we could conclude that there might be a tendency towards using mesh networks over larger areas in hotzones and wireless clouds; that this tendency is predominant in the US and less prevalent in Europe; and that there might be a link between coverage and goals set as explained in the next section.

In what follows we will further discuss why the European context is different from the US context.

TABLE 2: TECHNOLOGY, TOPOLOGY AND COVERAGE

	Technology			Topology		Coverage		
	Wi-Fi	WiMax	Backhaul	Hub-and-Spoke	Mesh	Hotspot	Hotzone	Cloud
Bologna	X	Upgr			X		X	
Bristol	X		X		X		X	
Cardiff	X			X		X		
Düsseldorf a	X			X		X		
Düsseldorf b		X			X			X
Leiden	X				X			X
Paris a	X			X		X		
Paris b	X		X	?	X			X
Stockholm		X			X			X
Turku	X	X		X				X
Westminster	X				X	X		
Boston	X	Upgr.	X		X			X
Philadelphia	X				X			X
Portland	X	X Pre	X		X			X
Sacramento	X	Upgr.			X			X
San Francisco	X	Upgr.			X			X
Saint Cloud	X		X		X			X
Total	15	4	5	4	11	4	2	11

Upgr. Stands for upgrade possible. Pre stands for preWiMax. In Portland

In terms of indoor and outdoor coverage 10 out of the 17 initiatives restrict their ambition to provide access outdoors. Thus only seven initiatives explicitly state the ambition to provide access indoors. Philadelphia prescribes that the network has to provide coverage in 90% of the households indoor and 95% of the territory outdoors. Indoor coverage is defined as being able to make a stable connection in each room of the house on the ground and first floor (Wireless Philadelphia, 2006).

GOALS AND TARGET GROUPS

Wireless city networks are seen more and more as infrastructures that contribute to the development of cities and their populations in multiple ways. The Centre for Digital Governance even defines these networks as vital public infrastructures comparable with fixed-networks, roads, bridges, sewage and water infrastructure. They are seen as an indispensable infrastructure for the economic vitality of the community. Due to its public importance and character, the Centre for Digital Governance argues that cities should take the lead in the development of these networks (CDG, 2005).

In principle wireless city networks are deployed to strengthen two types of service delivery – access to the Internet; and access to new services and applications.

In most instances both types of services are combined within a project.

The motives and goals to build wireless city networks as mentioned in the literature and rhetoric around projects are diverse. In a recent report by Intel on business cases for wireless city networks, a distinction is made between four groups of goals: city operations efficiencies; citizen satisfaction; economic development; and digital divide (Intel, 2005a). We use this framework to frame and categorise the goals we found in the literature and desk study. Although the Intel study can be criticised for not being neutral – the company has a stake in the debate on wireless cities – the distinction of four groups of goals is a logical one and can be found in other works. It is used here merely as a framework to map the goals set by cities in the second part of the section. The rationale as to why cities should invest in wireless networks is important to map out here, as they will often inspire cities to make the move towards public investments in wireless networks.

City Operations Efficiencies: wireless city networks give Government personnel faster access to information and databases. Equipped with PCs and PDAs they can perform tasks faster and more efficiently (Intel, 2003, 2005a, CDG, 2005). Often providing personnel with a mobile connection is seen as sufficient to augment services delivery and efficiency (CDG, 2005). CDG sees opportunities at the level of social services, health care, public works and public security. The deployment of an own network can help cut the costs of communication considerably for local governments (CDG, 2005) and provide a network for Government personnel.

Citizen Satisfaction: Governments can build new services on the basis of wireless city networks improving both communication with and service delivery for citizens. Citizens can obtain information on road works, payments, can download documents, can handle services online, etc. Schools, museums, government and public institutions can better interact with each other integrating service delivery in line with citizens' needs and expectations (Intel, 2005a). Wireless city networks can also stimulate citizens' participation in social life, both online and offline through providing:

- a platform for e-Government services;
- stimulation of the social fabric; and
- support of education.

Economic Development: broadband wireless city networks and related new services make cities more attractive for business and potential citizens. Wireless city networks can contribute to attracting new investments and jobs, especially in the service sector (Intel, 2005a). Apart from this they can contribute to the performance of local businesses. Business travellers and tourists can use the network for information, communication and online services catering for their specific demands. There are two goals, which often appear in literature on fixed broadband networks which could also be of relevance to wireless networks, but which rarely appear in the literature. These goals are firstly supporting creative networks, and secondly use the platform to support innovation. Cities often have creative networks in culture, arts, fashion, new services, etc. Wireless city networks can support the working of these creative sectors. The networks can also function as an innovation platform in itself. Different sectors such as business, Government, education and research can use the platform to develop and test new applications, and:

- stimulate local economic fabric;
- serve as a project platform for services and innovation;
- support creative networks;
- support business travellers; and
- support tourism.

Digital Divide: wireless city networks can help in bridging the digital divide. They provide citizens with cheap access to the Internet and Internet-based communication and services. The growth of local service can stimulate citizens to invest in PCs. Cheap and even free access to the network can help lower the barriers to the Internet (Intel, 2005a). Wireless city networks can provide access in poorer or more remote neighbourhoods in which there is no access to broadband networks (Intel, 2003). The last argument is especially valid in the United States, where operators do not invest in unattractive neighbourhoods. Another goal that is often related to the digital divide is lowering the cost to broadband access. A specific strategy is to strengthen competition in the market in order to put downward pressure on prices for broadband access.

The target groups envisioned when deploying wireless city networks are strongly related to the goals discussed. One can distinguish between Government and non-profit, business and more specifically SMMEs, consumers in general and more specific disadvantaged groups, students and tourists.

COMPARATIVE ANALYSIS

In Table 3 we provide an overview of the services provided and the groups targeted. Only a few initiatives do not provide citizens with access to the Internet. Both Westminster (operational) and Düsseldorf b (pilot project) use wireless city networks for specific applications, CCTV in Westminster, and city navigation and monitoring of fire brigades in action in Düsseldorf (Telindus, 2005). The other initiatives provide citizens with access to the Internet, often combined with the development of services and applications. This should however not lead to the conclusion that providing access to the Internet is the most important motivation in deploying networks. The use of networks for Government communication and e-Government applications is often – be it frequently implicit – the most important underlying strategic motivation and rationale for public financing. This is certainly true for many of the initiatives in the United States. In the case of San Francisco an important motivation is providing city personnel with qualitatively secure and stable access to Government communication systems (Earthlink & Google, 2006), in Sacramento the city is a tenant anchor of the network giving it priority on the network (City of Sacramento, 2006), in Philadelphia the city has 3 000 free accounts for city workers (City of Philadelphia, 2006), and in Portland the city has free access to the network for its own communication, service development and use by city workers (City of Portland & MetroFi, 2006). In other cities such as San Mateo (city police), Corpus Christi (automated meter reading) and Westminster (CCTV) augmenting efficiency and productivity within Government is the central goal in building a mesh wireless city network (Tropos Networks, 2004; Intel, 2005a; Telindus, 2005). Most often cited are Government, citizens in general and disadvantaged groups.

TABLE 3: SERVICES AND TARGET GROUPS

Initiative	Services		Target groups explicitly mentioned						
	Internet access	Specific Applications	Business			Consumer			
			Government	Companies-	SMMEs	Citizens in general	Disadvantaged	Students	Visitors
Bologna	X					X	X	X	
Bristol	X	Walled garden, CCTV	X			X	X	X	X
Cardiff	X	Multi-channel contact centre	X			X	X	X	
Düsseldorf a	X					X		X	
Düsseldorf b		City Navigation, fire brigade	X			X			X
Leiden	X	OpenKerk,...		X		X	X	X	
Paris a	X			X		X			X
Paris b	X			X		X			X
Stockholm	X		X			X	X		
Turku	X	Living Lab Innovation	X	X	X	X	X	X	
Westminster		CCTV	X						
Boston	X		X	X		X			X
Philadelphia	X		X		X	X	X	X	X
Portland	X		X	X		X	X	X	
Sacramento	X	e-Government applications	X	X		X	X	X	
San Francisco	X	Tourism and Government applications	X	X		X	X	X	X
Saint Cloud	X		X	X		X	X		
Total			12	9	2	16	11	10	7

In Table 4 we give an overview of the goals of the initiatives as explicitly stated in the communication around the project, in the Request for Information, the Request for Proposals and other official documents. The table shows that goals related to economic development are predominant. Stimulating the local economic fabric occurs 12 times, providing a platform for new services and innovations occurs 9 times. The goal of innovation is mentioned in almost all European cases. In the American cases, it is only mentioned in the case of Portland. This is probably the result of EU policy and regulation around public involvement in the deployment of networks. Bridging the digital divide is – with 11 initiatives – also an often quoted goal. Apart from Boston, it is an important goal in all bigger initiatives in the United States. The Boston initiative was initiated by Boston Main Street, an association around the centre shopping area. As already mentioned only a larger sample could confirm these trends.

The use of the network for e-Government is also often mentioned, both as a network for city workers (nine times) or as a platform for e-Government services (eight times). Both are often mentioned in the United States, where some of the initiatives state this as the primary goal. The goal of enhancing competition in broadband is only mentioned twice, ie in Philadelphia and San Francisco. Supporting creative networks is mentioned three times and more specifically in the two community networks of Leiden and Turku. Goals such as providing a platform for e-Government services, providing a platform for Government communication and bridging the digital divide necessitate larger networks, which cover large parts of the city. These types of initiatives will most often use mesh technology over a wide area. There is a strong rationale for public involvement in this type of initiative. Typically the business models used for this type of initiative will be a public-private partnership between the city as anchor tenant and one or several private companies as investors and ISPs (Ballon et al, 2007).

Apart from striving for specific goals related to the use of wireless city networks, most initiatives are embedded in broader city policies related to city modernisation and development. Cities and regions compete with one another and are constantly searching for new investments from innovative and high tech companies, from influx from highly educated and creative citizens, etc. Investments in wireless city networks should therefore be seen against the realisation of these broader macro-oriented goals.

Table 4: Goals

City Operations Efficiencies	**Total**	Bologna	Bristol	Cardiff	Düsseldorf a	Düsseldorf b	Leiden	Paris a	Paris b	Stockholm	Turku	Westminster	Boston	Philadelphia	Portland	Sacramento	San Francisco	Saint Cloud
Network for Government personnel	9		x			x				x	x	x	x	x	x			x
Citizens' satisfaction																		
Platform for e-Government services	8	x	x					x				x			x	x	x	x
Stimulating social fabric	5	x						x	x								x	x
Supporting education	8	x		x	x		x				x			x		x	x	
Economic development																		
Stimulating local economic fabric	12		x	x	x			x	x	x	x		x	x		x	x	x
Platform for services and innovation	9	x	x	x		x	x	x	x		x				x			
Supporting creative networks	3	x					x				x							
Supporting business travellers	3							x	x		x							
Supporting tourism	7		x			x		x	x				x	x			x	
Bridging the digital divide	10	x		x			x			x	x			x	x	x	x	x
Enhancing competition in broadband	2													x			x	

Service and price modalities

As only a few initiatives are fully operational so far, there is little literature on service modalities and prices. In general it is assumed that wireless city networks are cheaper to deploy than other mobile networks and can therefore provide services at low or lower costs (Muniwireless, 2006). It is furthermore argued that wireless city networks bring competition to broadband markets and therefore will have a favourable impact on prices in general (Muniwireless, 2006). Especially in a US context it is often claimed that broadband Internet is slower and more expensive than in other industrialised countries (Panettieri, 2006). One of the main reasons is often a lack of competition in local markets characterised by a monopoly or duopoly (telco/cable operators) for broadband services (Feld, 2006). In terms of pricing one can make a distinction between five categories: free access, free access for specific target groups, free access with restrictions, paid access; and access restricted to Government.

The amount of initiatives, which provide full and unlimited access to the Internet for free is rather limited. Furthermore, the type of initiative has to be taken into account. A distinction can be made between initiatives that provide citizens, business travellers, tourists and/or specific target groups with free access on the basis of several hotspots, and initiatives that provide all with free access to Wi-Fi-mesh hotzones or clouds. Paris and Philadelphia provide free access for all over a limited amount of hotspots in public places. Interesting to note is that both cities consider providing free access over hotspots with paid services for access to hotzones and clouds based on mesh networks (Wireless Philadelphia, 2006; Mairie de Paris, 2006). Two other initiatives, Düsseldorf and Cardiff, offer free services to specific target groups. In Düsseldorf students and teachers get free access in and around schools. In Cardiff, all citizens get free access in and around libraries and schools (BT, 2006).

The only mesh networks, which are fully free, are those of St Cloud (operational) and Bologna (pilot phase). The St Cloud initiative in the United States is fully financed and managed by the local Government. However, two remarks have to be made – the initiative is rather small, St Cloud has 24 000 inhabitants and this type of initiative has become more difficult due to new regulation in the US (Thomas, 2005; Kandutsch, 2005). The initiative in Bologna is only in a pilot phase. The analysis shows that the current business model, combining private investment with free access without advertising, is not feasible (Guidi, 2006). In general therefore – at least in our selection – we can conclude that fully free access to the Internet is limited and is often limited to selected areas on the basis of hotspots.

A few cities offer free access to the Internet, be it with either terms of access time or speed. In Bologna users have access for one and a half hours a day. In Sacramento and San Francisco users have access at lower speeds of 300Kbs. Users have to pay for higher bandwidth (City of Sacramento, 2006; Earthlink & Google, 2006).

Paid services are – again in our selection – more prominent in initiatives with mesh networks covering wider hotzones or clouds. In many cases, eg in Paris a, Stockholm and Philadelphia, these initiatives are public-private partnerships which have to attain a certain return on investment for the private partners. This does not mean that the public partners do not have an impact on service and price modalities. In Philadelphia for instance the city and the private partner Earthlink agreed that 25 000 disadvantaged citizens – 4% of the population – would get access at reduced prices (Daggett, 2006). In general cities have leveraging power in negotiations with private companies as they have control over giving access to public amenities (eg providing access to public sites for putting up antenna's or by providing fibre for backhaul). They are also responsible for other licensing and/or granting exclusivity; acting as launching consumer; providing financial support; or acting as anchor tenant.

In certain cases such as Westminster and Düsseldorf b, access is restricted to Government personnel. These types of networks also exist in the US. They are primarily focussed on very specific Government applications in the area of e-Government, e-security and automated metering.

Table 5: Service and Price Modalities

Initiative	Free Access	Government has impact on price	Hotspot	Hotzone	Cloud
Bologna	The private players have to provide free services but cannot use advertising in their business model. Use is limited to 1.5 hours a day. Bandwidth is 256Kb/s.	X		X	
Saint Cloud	Free access through simple registration.	X			X
Paris a	400 free access points.	X	X		
Philadelphia	22 free hotspots in public places (see also below).	X	X		
Initiative	Free access for specific target groups				
Düsseldorf a	Free access to the Internet in +-200 schools. Paid for others via different ISPs.	X	X		
Cardiff	Free access in libraries and schools. Paid via 'openzone' hotspots: 1 hour: GBP6; 24 hours: GBP10; 30 days: GBP40; 250 minutes: GBP10 (per month); 500 minutes: GBP15 (per month) and 4000 minutes: GBP25 (per month).	X	X		
Initiative	Free access with restrictions				
Bristol	Free access to 'walled garden'. Free Internet access for 1 hour, financed by advertising on splash page.	X		X	
Sacramento	Not known yet. Goal is free access for basic service at 300Kbs and paid access through different ISPs. The city would have free access for five years at speeds of 1Mbs and higher.	X			X
San Francisco	Free access at 300Kbs via Google, but obligatory registration via Google account. There are paid services through Earthlink and other ISPs. Around US$20 per month.	X			X
Portland	Free access to the Internet financed by advertising banners. Paid service without advertising at 1Mbs for US$19.95 per 1Mps. There is a pre-WiMax service at higher speeds for businesses.	X			X

Table 5: Service and Price Modalities (contd)

Initiative	Paid	Government has impact on price	Hotspot	Hotzone	Cloud
Leiden	Free access to the network; no free access through the Internet (subscriptions through ISPs)				X
Paris b	Paid service. No information on tariffs.				X
Stockholm	Paid service. No information on tariffs.				X
Philadelphia	22 free hotspots in public places. Internet access for US$10 for disadvantaged users and US$20 for other users. Earthlink has to offer 25 000 citizens (four percent of the population) with access to the Internet at reduced tariffs. Basic services are limited in terms of upload/download speeds at 0.75 and 1.25Mbs. Access at higher speeds is more expensive. The city has 3 000 accounts at lower prices.	X			X
Turku	Free use of the platform for non-commercial participants if they contribute to the roll-out of the network. Visitors and commercial companies have to pay: €8 for 10 hours, €30 for seven days or €60 for 31 days. Students and libraries have free access to the network.				X
Initiative	Access restricted to Government				
Düsseldorf b	Pilot project.				
Westminster	The network is not accessible to citizens.		X		
Initiative	Not yet known				
Boston	Not yet known	X			X

Tariffs and modalities for paid services vary according to the initiatives. In Table 6 we compare the tariffs for wireless access of a few cities with those for fixed broadband access in the same area. If possible we also compare service levels looking at best-effort speeds. It is important to note that effective speeds will often be considerably lower – wireless networks using Wi-Fi are prone to varying speeds depending on the number of users, physical obstacles, etc.

As indicated, apart from St Cloud, meshed networks covering larger areas tend to combine free access with restrictions, with paid access for unlimited access. In Philadelphia, Portland and San Francisco paid Internet over the wireless network costs US$20 a month. In both Philadelphia and Portland the service comprises access with download speeds of 1Mbs. In the same area Verizon and Comcast offer broadband services over fixed networks at similar price levels, be it for substantially higher bandwidths of 3Mbs and 5Mbs (Key, 2006). Due to the lower bandwidths Wi-Fi-based wireless city networks are currently no real substitute for fixed broadband.

Wi-Fi-networks are only attractive for users needing mobile Internet and users in areas without fixed broadband. This seems to be confirmed by recent uptake, or the lack thereof, in many cities in the United States. Although most business plans started from a projected uptake of 15-30% of an area's population, actual uptake seems to be as low as one to two percent (Kharif, 2007).

The hotspot-based initiatives are often free of charge. However, occasional access can be rather expensive. In Cardiff access costs GBP6 for one hour; GBP10 for 24 hours; and GBP40 for 30 days. The community networks have different business models and tariff structures. In Turku users have free access to the Openspark network after an initial investment of €95 in a wireless router. However, the user still has to pay for his/her own fixed broadband connection. Openspark is therefore just a free mobile extension of fixed services. Visitors who do not contribute to the network pay €60 a month (Saarinen, 2006). The speed of the wireless network depends on the bandwidth of the fixed access line behind the router and the speed allocated by the owner of the router. Quality of service can therefore not be guaranteed.

Table 6: Tariffs of Selected Wireless City Networks and ISPs in the same area

Philadelphia			
ISPs			
Verizon	US$14.95	768Kbs	
	US$21.95	3Mbs	
	US$31.95	5Mbs	
Comcast	US$19.95	5Mbs	
Wi-Fi Philadelphia			
Normal account	US$20		1Mbs (best effort)
Portland			
ISPs			
Earthlink	US$19.95		
Verizon	US$29.95		
AT&T	US$26.95		
Wi-Fi Portland			
With advertising	Free		1Mbs (best effort)
Without advertising	US$20		1Mbs (best effort)
Bristol			
ISPs (many players, only lowest taken)			
Eclipse	GBP14.99		
Wi-Fi Bristol			
With advertising	Free		54Mbs per node real speed per user not known

Table 6: Tariffs of Selected Wireless City Networks and ISPs in the same area (contd)

Turku			
ISPs (many players, only lowest taken)			
DNA	€19.90		
Elisa Lounet	€8.24 + cost of calls		
TDC Song	€30		
Wi-Fi Openspark			
Member	€95 initial cost of access point + own fixed broadband connection		Depends on 1) broadband connection, 2) speed allocated
Visitor	€8.10 hour	€30 7 days	€60 1 month
St Cloud			
ISPs (average price for St Cloud)			
Average	US$36.4		
Wi-Fi St Cloud			
Free			

Investment

There is some controversy as to investments in wireless city networks and especially concerning return on investment. In many of the promotional literature wireless city networks are seen as a low-cost alternative to fixed networks guaranteeing a high return on investment (Intel, 2005a). Wireless city networks are therefore often seen as disruptive technologies (Lindmark *et al*, 2006, Lehr *et al*, 2005). However, not all agree. Some experts believe that the return on investment from public access will be low and that the real return on investment will come from mobile workforce applications within Government (Settles, 2007). Recent information seems to confirm this. As already stated for cities in the United States, the current subscription rate of one to two percent of an area's population is way below the projected 15-30% (Kharif, 2007). It is not our aim to go into too much detail in terms of the financial aspects of networks. In our empirical study it was very difficult to obtain sound information on investments and financing arrangements. Part of the reason is due to the many projects being in preparatory phases, partly to the confidential nature of this information. Apart from this, initiatives vary in terms of goals, coverage, technologies used, etc. which make comparisons difficult.

If we single out those initiatives aiming for a cloud (based on meshed) technology, we can make some general observations. In all cases investment is considerable. If one were to ignore the operational costs, investment in the network alone amounts to an estimated US$22 million in Philadelphia (1 500 000 inhabitants – 349km^2), US$10 million in Portland (537 000 inhabitants – 347km^2) and between US$16-20 million in Boston (590 000 inhabitants – 125km^2) (Wireless Philadelphia, 2006; Rogoway, 2006; Wireless Task Force, 2006). In St Cloud the network ended up costing US$3.1 million, US$1.1 million more than the initial estimate of US$2.0 million (23 000 inhabitants – 24km^2). The variation in investment costs between initiatives can thus be high. Table 7 gives a very rough estimate of costs based on a simple calculation of cost per inhabitant and cost per km^2. It is only an indication of the variations in cost. On the basis of the information available it is difficult to explain these variations. However, explanations can be found in differences in terrain (stretched areas, city centres, skyscrapers etc.), goals (indoors versus outdoors, etc.), maximum speeds considered, quality of service guaranteed (often in relation to Government communication); and amount of simultaneous users anticipated. What is clear, however, is that the investments are considerable. Most cities therefore opt for business models that combine private investments with public participation eg an anchor tenant. As the uptake in terms of consumer subscriptions is disappointing, the role of Government might become much more important in many of the future networks.

TABLE 7: ROUGH ESTIMATE OF COST OF NETWORK

City	Cost per inhabitant in US$	Cost per km^2 in US$
Boston	30.5	144 000
Philadelphia	14.6	63 400
Portland	18.6	28 818
St Cloud	134.7	129 166

As many wireless city networks are still in a preliminary phase little is known about operational costs. In St Cloud the operational cost amounts to US$500 000 annually. Again the cost is higher than the anticipated US$350 000. We should note that St Cloud offers free Internet access, which means that the operational cost in terms of customer management, billing, etc. is low. In networks with variable tariff structures the operational cost could be substantially higher.

St Cloud is the only case where we have an estimate of the return on investment – US$1.2 million per year. The return on investment comprises:

- savings on communication costs for mobile policy patrols;
- saving on the connection cost for schools;
- saving on leased lines to connect Government buildings; and
- an increase in productivity of Government staff.

The increase in productivity would amount to three percent and cover US$900 000 – or two-thirds – of the return on investment (Baltuch, 2005). How this was estimated is not clear and should therefore be interpreted with care. However, St Cloud is not the only city that is indicating that Government communication and increase in efficiency are expected to be the main drivers for Government investment in wireless city networks.

TABLE 8: INVESTMENT COST AND OPERATIONAL COST IN ST CLOUD

Demographics		
Inhabitants	**Surface**	
23 000	23,8 km^2	
Investment costs		**US$3 100 000**
	Estimated cost	US$2 000 000
	Effective cost	US$3 100 000
	Per household	US$310
Operational cost		**US$500 000**
Techn. maintenance	Contract with HP	US$350 000
Connection Internet		US$54 000
Personnel	1 FTE	
Return on investment (estimated)		**US$1 200 000**
Police patrol	Substitutions of mobile use	US$60 000
Schools	Substitution of connections	US$10 000
Leased lines	Substitution of leased lines Gov buildings	US$50 000
Productivity	Estimated increase of productivity 3%	US$900 000
Others	Others	US$180 000

PROBLEMS AND RESULTS

In this section we provide a short overview of some of the problems encountered in current networks. On the basis of some evaluations of current initiatives we give a brief overview of current results. The section only provides a snapshot of some initiatives and results. As already indicated the literature is very scant. There is certainly scope for further sound academic research on many of these issues.

An important first problem is the coverage of the networks. As we have indicated this issue is related to the Wi-Fi technology used. Although most cities strive for full coverage, technically this seems very difficult to achieve. Full coverage is therefore often translated to 90-95% coverage. The case of St Cloud shows indeed that full coverage has not been attained. Some houses or areas have bad or even no reception (Baltuch, 2006). It is anticipated that in large cities with difficult topographies – high buildings, small streets, etc – coverage might be spotty in certain areas. First results seem to confirm this (Fehrenbacher, 2007).

A second problem is coverage indoors. As indicated seven out of the 17 initiatives aim for coverage indoors. Again the case of St Cloud demonstrates that connectivity indoors is difficult to guarantee. Although the initiative has the explicit goal to provide indoor coverage, part of the households have – on their own account – to invest in extra antennas and receivers to reach affordable service. In the San Francisco pilot case the connectivity indoors was also not always optimal (Shandle, 2006). Testimonies on blogs related to other wireless city networks seem to confirm this. Boston – in the request for proposal phase – starts with the assumption that repeaters and bridges will be necessary to guarantee optimal indoor connectivity (Wireless Task Force, 2006).

A third possible problem is mobility within the network. On this issue little is known. In principle mesh networks provide the possibility to roam between cells and to move within the network at relatively high speeds. However, mobility is seldom guaranteed. The St Cloud case demonstrates that mobility is indeed possible (tested on the basis of streaming audio in a car). On the other hand in San Francisco doubts have been cast on the quality of service related to mobility within the network. The quality would be guaranteed for Government personnel only. They would get priority on the network to enable secure and stable connections (Shandle, 2006). A first study on frequencies in Philadelphia indicates that the density of the city centre, with many tall buildings, would have a substantial impact on the quality of service related to mobility. This research came to the conclusion that for the city centre, mobility cannot be guaranteed and coverage as such might be spotty (Wireless Philadelphia Executive Committee, 2005).

However, this performance should be seen against the performance of other mobile networks. Especially in the US with weaker mobile systems, Wi-Fi is often the better alternative. In the third quarter of 2006 Novarum – a US consultancy company – reviewed 2.5G, 3G and Wi-Fi networks in 10 US cities. At that time Wi-Fi covered 60% of the envisioned coverage area – more than 3G networks. The Wi-Fi networks achieved twice the throughputs of 3G networks, with an average of 869Kbs. However, in terms of service quality and service availability Wi-Fi was described as an immature service (Novarum, 2006).

The above poses certain questions for Governments. If Governments invest in wireless city networks on the basis of public means and offer these services for free, should they be providing services on a non-universal basis? In other words should Government provide services, that are not able to be used on the same basis by all citizens?

So far the number of operational initiatives is rather limited. As already indicated one of the only initiatives fully operational over a larger area is the St Cloud network. The first user studies of the initiative are not outright positive. Around 70% of the users indicate that they are satisfied with the quality of the network as such. However, in comparison with the quality of existing cable or DSL broadband services the score drops to 50%. Between 55 to 60% of the Internet users with cable or DSL indicate that the speed of the wireless networks is lower than their current access. Even if the wireless network provides access for free such as in St Cloud, less than half of the users cancelled their fixed service. Users use the free wireless alternative as an additional access to the Internet (Cyber Spot, 2006). For paid networks the uptake is downright low. This is in line with testimonies on blogs from other cities with pilots or operational networks. This indicates that for many users wireless city networks are no direct substitute for fixed broadband networks. The higher speeds and higher quality of service of the fixed service seem to be an important factor in the readiness to pay for these services. At this level more research is needed to better understand the substitution effects between the two networks.

Conclusion

As already indicated a sample of 17 cases is rather small. It is therefore difficult to formulate stringent conclusions. The conclusions below should be seen as trends, which need further research to be fully substantiated and deepened.

On the basis of our research we have the strong impression that the difference in context between the United States and Europe explains the different approaches to wireless city networks. The US context is characterised by 1) cities which are in need of upgrading older communication networks for Government communication and e-Government, 2) cities in which certain – mostly disadvantaged – areas are not serviced by the classical cable or telco operators in terms of fixed broadband infrastructures, 3) fixed broadband networks that are less performing than in other industrialised countries and 4) mobile networks that are less well developed – both in terms of coverage, standardisation and bandwidth – than in Europe. This might explain why many cities in the US opt for the installation of mesh-based wireless city networks covering the whole area. Whether this will continue remains an open question. In 2007 – when the first real results of networks started to be known – many cities started to reconsider their plans. Large corporations such as AT&T and Earthlink are reconsidering their strategies towards municipal wireless networks. What is clear is that the leverage of cities in negotiations with these investors/operators is diminishing. The city itself will probably have to play a more important role as the anchor tenant and business models will have to be based on returns on investment realised by government communication and services.

The European cities seem to prefer a more cautious and staged approach, building on existing networks with specific goals in mind (Bristol, Cardiff, Westminster, Bologna, Düsseldorf). Full coverage is not always the end goal and many initiatives stick to hotspots and hotzones. The fact that in Europe there is a high uncertainty about the possible interpretation by the European Commission of these initiatives – competition distortion under state-aid rules contributes to the cautious attitude. The recent decision by the Commission that the use of the WiFi network in Prague should remain restricted to Government communication and e-Government services, in other words that the network cannot be used to provide citizens with access to the Internet, has further contributed to the uncertainty (European Commission, 2007).

As the literature suggests the legitimacy of initiatives is often based on a mix of objectives. These include the effectiveness of city operations, citizens' satisfaction, economic development and reducing the digital divide. However, although formal goals often state bridging the digital divide as the main objective, initiatives are frequently driven by a search for augmenting Government efficiency and the strengthening of the local economic fabric. This is largely in line with some critics who state that the return on investment of these initiatives will have to be found in the public domain and not in subscriptions. In Europe innovation is another central goal of many networks. A closer look at European initiatives should uncover whether these goals are really met or whether they are stated to legitimise the initiatives in view of the EU laws related to competition distortion.

In our selection almost all initiatives use Wi-Fi technology, either in the form of hotspots, meshed hotzones or clouds. WiMax is often used for backhaul of the network, but so far not to provide direct access to customers. In Portland Wi-Fi is combined with WiMax geared at providing fast access to businesses. What is interesting to note in more recent initiatives is that they require vendors to install networks that can be easily upgraded to WiMax. It might be wise for other cities to consider this option as Wi-Fi does have some technical shortcomings compared to WiMax. Although several cities have as a formal objective to provide connectivity indoors and outdoors, the experiences so far are mixed. In St Cloud a substantial part of the population does not have good coverage indoors. Citizens have to invest in supplementary repeaters and antennas to have acceptable coverage. Case studies do not answer the question what is the effect of aiming at indoors coverage on the cost of the network. However, most cities that strive for full coverage foresee that 10% of the area might have bad coverage and that a certain amount of citizens will have to invest in additional infrastructure to reach acceptable service levels. This poses serious questions in terms of quality of service guarantees and in terms of using the network to bridge the digital divide.

Tariffs for access to wireless city networks differ considerably according to the various initiatives. They differ from free to prices substantially higher than those for fixed broadband access in the area. If we focus on those initiatives that provide access to a larger cloud the picture changes. Only St Cloud – itself a small initiative – provides free access without publicity. But even those initiatives providing free access on the basis of publicity restrict access in terms of the duration of sessions or speed. Most other initiatives charge prices of around US$20 for unlimited access at higher speeds. Very important to note is that these prices don't deviate that much from prices for fixed services in the same area. Furthermore, best effort speeds of wireless networks are often lower eg 1Mbs, than fixed services in the area (in the US ranging from 3 to 5Mbs, in Europe often even higher). These initiatives are typically based on a public private partnership in which the city plays an important role in terms of providing public amenities, financing, or as an anchor tenant. In general the cost of the network is too high to build these infrastructures as pure public initiatives. Furthermore, both in the US and Europe this type of network would be considered as a distortion of competition vis-à-vis fixed and mobile communication operators.

As St Cloud – with completely free access – already indicates, not all consumers will change to the wireless networks. Fixed networks still have serious advantages of speed and reliability over wireless networks. For all players involved it will become very important to study and understand the substitution effects of the networks and their impact on consumer behaviour in this field. The first indications of actual uptake in the United States are rather bleak.

An important question for developing countries, who often do not have competing fixed broadband networks, is whether wireless networks can be a fully fledged substitution for fixed broadband or for that matter other mobile broadband offerings. If alternative networks exist, uptake will largely depend on substitution effects between networks. The question also arises – as in the US and EU debate on state aid – as to why Government would support one specific technology or network over another. ❑

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