

ICT Infrastructure as Public Infrastructure: Exploring the Benefits of Public Wireless Networks

Community Wireless Infrastructure Research Project (www.cwirp.ca)

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Paper presented at the 2006 Telecommunication Policy Research Conference

Abstract

To date, research on municipal and community wireless networks has focused on understanding types of network deployments, policy issues around network ownership, and technical issues of infrastructure design and capability. These are all necessary issues as this nascent form of public infrastructure becomes established, and as stakeholders understand the potential benefits of the deployment and use of wireless networks. However, public wireless network deployments do not always achieve the desired outcomes, resulting in networks that do not realize their potential value for citizens, communities and municipalities. As such, it is also important to consider the extent to which such public infrastructure actually does deliver on its promises, by developing a set of criteria with which to assess public network deployments. This paper presents a "desiderata" for public wireless internet infrastructure. Developed from our understanding of the potential of wireless networking, the desiderata is intended to provide a foundation for a discussion of what public wireless networks should look like. The paper also outlines some enabling conditions that can help to establish public networks to meet the needs of citizens, communities and municipalities.

Introduction

The ongoing deployment of public broadband and wireless networks by hundreds of communities and municipalities across North America and around the world (including for example Fredericton, Philadelphia, Toronto, San Francisco, Chicago, London and Paris) constitutes an important development in the evolution of public information and communication technology (ICT) infrastructure. As legislative battles over such networks at the local, state and congressional levels in the U.S. have recently demonstrated (Tapia, Stone, & Maitland, 2005), their deployment is sparking controversy and public policy debate. While governments consider the merits of municipal broadband and wireless networks (Gillett, Lehr, & Osorio, 2004; Strover, 2003), the telecommunications industries in the U.S. and, to a lesser extent, Canada, are attempting to block their expansion via the courts and legislatures (Gillett, Lehr, & Osorio, 2006a). At the same time, community-led wireless initiatives are thriving. How can the research community contribute to the discussions around community and municipal broadband and wireless networks? What research has been carried out thus far and what are the major findings? What are the major models, benefits and challenges, as well as the risks, of such municipal and other community-based broadband deployments? These are questions addressed by a new Canadian research initiative, the Community Wireless Infrastructure Research Project (CWIRP).

CWIRP seeks to better inform current policy debates about the role of communities and municipalities in ICT infrastructure provision. We utilize a variety of methodologies to conduct our research, including institutional and policy analysis and participatory action research. Institutional and policy analyses will draw from political-economic perspectives, broadly defined as studying the relationships between ICT industries and institutions and economic and political systems (Mosco, 1996). We follow Dutton's framework of 'an ecology of games', a model that

investigates stakeholders in the policy process, the intended beneficiaries, and the process of policymaking, to examine various levels and agencies of governments, and the role of civil society groups (Dutton, Peltu, & Bruce, 1999). Identification of groups left out of the policy process, and the increasingly active role of public interest groups and citizens is also a focus.

In this paper, we address an issue that has received limited attention in the debate to date, that of assessing proposed and actual wireless broadband network deployments on the basis of their contributions to improved municipal, community and citizen outcomes. Drawing from academic and practitioner literatures on the promise of public wireless networking, our paper proposes a desiderata for a public wireless internet utility.

Background and Literature Review

Access to advanced information and communications technology (ICT) infrastructure is increasingly vital to the socio-economic well-being of cities, regions and nations in the global knowledge-based economy (Bleha, 2005; Castells, 1989; Sassen, 2002; Wilhelm, 2004). Firms, investors, skilled workers, researchers and governments rely on such infrastructure to share data and information, transact business, innovate, communicate, and work more efficiently. The availability of so-called 'smart' or 'intelligent' infrastructure is used increasingly by states and communities to compete for investment and skilled workers (Caves & Walshok, 1999). Citizens, meanwhile, are increasingly reliant upon advanced ICT infrastructures like the internet to carry out their daily lives, from accessing news and information and communicating with friends and relatives, to working, learning, finding employment, and accessing health and other public services (Horrigan, 2006; National Broadband Task Force, 2001). Indeed, the accessibility and reliability of such infrastructure is assuming an importance to the knowledge-based economy and society analogous to that of the great public infrastructures and utilities of the twentieth century – electricity, highways, telephony, power grids, and water and sewage treatment -

leading some to suggest that broadband networks too ought to be owned and operated as public utilities (Geist, 2005).

By and large, however, with the exception of modest public investments and programs devoted to public access and provisioning broadband to rural and remote areas (e.g. Industry Canada, 2002; Industry Canada, 2005), since the mid-1990s federal policy in Canada and the U.S. has been to leave the development of ICT infrastructure to market forces (Brown, Irving, Prabhakar, & Katzen, 1995; Information Highway Advisory Council, 1997). A growing body of evidence suggests that such a laissez-faire approach has failed to keep the U.S. and Canada among the leading nations in broadband and wireless deployment (Fransman, 2006). While initially among the most 'connected' nations in the world, North Americans are falling behind countries like Iceland, South Korea, Japan, the Netherlands and Denmark in broadband uptake (Organisation for Economic Co-operation and Development, 2006). U.S. broadband consumers, in particular, pay among the highest prices in the OECD for broadband services that don't even begin to match the quality and speed of services available to Korean, Japanese and European consumers (Bleha, 2005). Lagging broadband infrastructure development in North America jeopardizes economic competitiveness, employment growth, technological innovation, and overall quality of life (Bleha, 2005).

While broadband service is available to nearly all Canadians, barely 50 per cent choose to subscribe (CRTC, 2006), and in the U.S., only 42 per cent have residential high speed internet access (Horrigan, 2006). Persistent gaps in broadband access infrastructure development continue to exclude many from the benefits of new ICTs, including inhabitants of rural and remote communities, Aboriginals, the disabled, and low income families (CRACIN, 2005; Middleton & Sorensen, 2005; Servon, 2002; Warschauer, 2003). The consequences for individuals and communities without access, or without the desire, knowledge or skills to take

advantage of access where it exists, can be serious (Servon, 2002; Warschauer, 2003).

Collectively, the slow household uptake of broadband networks in serviced areas, and the lack of affordable service to many rural and remote communities signal the failure of free market forces alone to equip North Americans with the broadband and wireless infrastructures they need to compete and thrive in the global economy. The lack of government leadership on the broadband file has led to calls for governments to reassert themselves in this policy field through such means as regulatory reform and renewed public investment (Bleha, 2005; Wilhelm, 2004). A recent review of telecommunications policy in Canada (Telecommunications Policy Review Panel, 2006) recommends the development of "affordable and reliable" broadband connectivity to all citizens by 2010, acknowledging that the 2004 target date for universal broadband (National Broadband Task Force, 2001) was not met.

Impatient with waiting for the private sector or federal government agencies to roll out adequate and affordable broadband infrastructure, municipalities and communities across North America are planning and deploying their own networks, using a range of technologies including fibre, broadband-over-power-lines, and wireless, to provide citizens with internet connectivity (American Public Power Association, 2005; Feld, Rose, Cooper, & Scott, 2005; Powell & Shade, forthcoming; Sandvig, 2004; Schuler & Day, 2004; Strover, 2003). These municipal and community-based models of broadband and wireless infrastructure provision take a variety of forms, ranging from regional fibre backbones owned and/or managed by major institutional bandwidth users (utilities, hospitals, universities and local governments, for example, the City of Fredericton's e-Novations ComNet Inc., e-Novations, 2005), public/private municipal Wi-Fi ventures such as San Francisco's (in which Google provides an advertising-supported free service), local hydro-electric utilities (e.g. Toronto Hydro Telecom) offering both wired and wireless broadband service and, lastly, all-volunteer community wireless networks (CWNs) that

install and operate free Wi-Fi 'hotspots' or mesh networks in public places (Bar & Park, 2006), for example Ile sans Fil in Montreal, NYC Wireless in New York, and Champaign-Urbana Community Wireless Network (CUWiN), among many others.

Wireless networking is a particularly interesting development because it provides community groups, municipalities and individuals with a relatively simple and affordable mechanism for internet service delivery. Using 802.11x wireless ethernet standards, commonly known as Wi-Fi (for wireless fidelity), wireless local area networks (WLANs) can be established using unlicensed spectrum to share internet connectivity (Galperin, 2005; Lehr & McKnight, 2003; Mackenzie, 2005; Sawhney, 2003)¹. WiMax (802.16) networks use licensed spectrum to provide fixed or mobile wireless coverage over larger distances (International Telecommunication Union, 2004).

Research relating to wireless networks can be divided into two basic categories: a systemic perspective and a player perspective. From a systemic perspective, research has raised questions about how future wireless networks may be structured. This debate has focused around centralization/decentralization and what possibilities may exist for network structures as wireless technology and systems become more established (Fuentes-Bautista & Inagaki, 2005; Tapia et al., 2005). An important factor influencing these potential structures is spectrum policy (Buck, 2002). In addition, researchers have investigated or theorized how various community, public, and private players in a wireless system might work together (Fuentes-Bautista & Inagaki, 2005; Tapia et al., 2005). Work based on case studies has also defined various infrastructure models for wireless networks. For instance, Powell and Shade (forthcoming) name and briefly describe three models for wireless provision: hot spots, hub & spoke, and

¹ Wi-Fi networks also support peer-to-peer connectivity, allowing direct wireless information transfer without using the internet. Most wireless networks are connected to the internet, and this paper focuses on the use of Wi-Fi for internet access.

dynamic mesh. Shamp (2004) focuses on two types, Wi-Fi zones and Wi-Fi clouds. Bar and Galperin (2005) distinguish between "hot zones" and "city-wide wireless broadband", and Vos (2005) categorizes wireless projects as "regional wireless broadband networks," "citywide networks," "city hotzones," and "countrywide networks."

From a player perspective, work has concentrated on the roles that various groups may play in wireless networks. Some research has considered the community, municipal, and private sectors (Bar & Galperin, 2005), but most focuses on either municipal or community players, likely because of the potential these two groups have to significantly alter how citizens access telecommunications services. Key issues in municipal wireless debates centre around policy issues and the legal and regulatory aspects of deploying networks (e.g. can and should municipalities compete with the private telecommunications industry?) (Gillett, 2006; New Millennium Research Council, 2005). There has been some discussion of the purpose of such networks (Bar & Park, 2006), and the role of municipalities as service providers (Gillett et al., 2004; Gillett et al., 2006a).

In the community wireless arena, networks have emerged from two sources. Some community wireless networks developed as extensions of existing community networks or community technology centres, using wireless technologies to expand access and coverage (Strover, Chapman, & Waters, 2003). Others were established by grassroots users with the express purposes of providing community-operated, inexpensive alternatives to commercial internet service provider offerings (Sandvig, 2004), using the technology to foster a sense of community (Powell & Shade, forthcoming), and/or challenging regulatory policies and practices that favour private sector interests in the provision of internet access (Meinrath, 2005). The nature of community-based wireless networks has been influenced strongly by the local context, with a variety of models serving the needs of different communities.

While there has been little work that relates specifically to the relationship between community and municipal wireless networks, the Austin, TX experience of converging networks offering overlapping services is becoming more common (Fuentes-Bautista & Inagaki, 2005). In Toronto, for instance, citizens will soon have a choice between Toronto Hydro Telecom's pay-for-use municipal service, Wireless Nomad's subscription cooperative or Wireless Toronto's free community network, in addition to commercial hotspots. Following Fuentes-Bautista and Inagaki, we use the term "public wireless networks" to encompass both community and municipal wireless, with the assumption that these public wireless networks offer broadband internet access. Regardless of the ownership structures of such networks, we consider wireless networks to be forms of public infrastructure that provide public benefits (Infrastructure Canada, 2004).

The section below outlines the anticipated benefits of public wireless networking. Community and municipal wireless networks have been established in a climate of technological enthusiasm (Sawhney, 2003), with little attention paid to date to the benefits they offer or assessing how they are being used (Strover et al., 2003) or whether they are living up to their potential. Most press coverage of public wireless networks paints a positive picture of their deployment, but there are some examples of failed or underused networks (e.g. Belson, 2006; Ewalt, 2005). As public wireless networks move into the mainstream and attract increasing numbers of users, it is important to be able to assess their performance as public infrastructure, moving beyond discussions of how the networks are built to understand how public internet infrastructures provide value to their stakeholders.

The Case for Public Wireless Network Provision

The past year has seen the announcement of many new public wireless internet projects (in cities including London, Paris, Boston, Chicago and Toronto), as well as continued interest in

projects where development is now well underway, like those in the cities of Philadelphia and San Francisco (see muniwireless.com, 2006, for a list of projects that had issued official bids for network development as of early 2006). Politicians announcing new Wi-Fi projects speak eloquently but vaguely of “new era[s] in telecommunications” (Miller, 2006), for example, without offering concrete evidence or examples of what such projects can bring to citizens. What is the case for a municipality, public utility or community organization to get into the business of Wi-Fi service provision in the first place? A number of arguments in favour of public wireless networks been put forward by municipalities, community wireless groups and academic researchers. As is noted below, there is not universal agreement on all points, however, the arguments presented here reflect the current discourse on public Wi-Fi.

1. The electricity of the 21st century: Broadband internet access is an essential service.

A number of prominent advocates of public wireless argue that as the internet and other communication networks and devices become central to our daily lives, access to broadband service ought to be treated as a basic amenity provided by a public utility, just as other basic amenities such as electricity, water, roads, sidewalks and street lights often are. Broadband and Wi-Fi, according to this line of argument, will be to the needs of 21st century communities as electricity was to those of the 20th (Geist, 2005; McChesney & Podesta, 2006). As such, communities and municipalities that remain un- or underserved by market forces must fill the gap in order to ensure that they can offer residents, businesses and other local institutions the kind of modern infrastructure they need.

Municipal governments and municipally-owned utilities own, manage and maintain essential and technologically sophisticated services including: electricity, roads and bridges, public transit, traffic and street lighting, water purification, and waste management (Feld et al., 2005), and there is a history of municipal ownership of telecommunications and information

infrastructures (Carlson, 1999; Gillett et al., 2006a; Graham, 1992). While not all have recent experience managing telecommunications systems, many municipalities and rural communities successfully operated telephone networks in the early days of telephony (Sandvig, 2002). Bar and Park (2006) suggest that most municipalities that own and operate public utilities possess the skills and capacities necessary to build, operate and administer a broadband network.

2. Public broadband and wireless internet access can spur economic development.

The development of ICT infrastructure can lead to improved economic outcomes (Caves & Walshok, 1999; Ford & Koutsky, 2005; Gibbs & Tanner, 1997; Gillett, Lehr, Osorio, & Sirbu, 2006b). Wired and wireless public broadband networks are thought to encourage competitiveness and productivity by, among other things, reducing telecommunications costs incurred by local businesses, residents, large institutional bandwidth users (e.g. hospitals, power utilities, universities), and local governments. Whether or not a community has access to fast and reliable networks is an increasingly important factor taken into account by potential investors, as well as by existing businesses considering relocation (Dawe & Curri, 2003; e-Novations, 2005; Feld et al., 2005; Strover et al., 2003). The presence of a fast and reliable network infrastructure helps communities retain existing businesses while also attracting new ones. Municipal broadband and Wi-Fi schemes can also be used to brand communities as 'hip,' 'innovative,' and 'hi-tech' and to market them to investors, tourists and skilled workers. For example, cities including Austin, TX; Grand Haven, MI; and Marion, IN have set objectives for their wireless projects to attract business and tourism to the area (Turner, 2005). It is noted however that broadband networks alone are not sufficient to foster economic development. Supporting elements in a community, like the presence of a highly skilled workforce, are required to realize the benefits of broadband (New Millennium Research Council, 2005).

3. The deployment of wireless networks can improve efficiency within municipalities.

It is argued that municipal broadband and Wi-Fi networks save municipalities and taxpayers money by making city services more efficient and cost effective (Gillett, 2006). In this context, municipalities are consumers of Wi-Fi networks, and the development of a network may make financial sense based on the municipality's need for service alone (Tapia et al., 2005). Such networks can save municipalities on the costs of their own telecommunications services, as well as enable them to introduce new automated and mobile work processes for employees, such as online service delivery and having employees such as building inspectors report from the field (thus saving on fleet and gasoline costs). In addition, Wi-Fi networks are frequently used to provide public safety applications (Wireless Task Force, 2006). Together, such savings help municipalities save money, reduce upward pressure on tax rates and, ultimately, attract and retain investment (Dawe & Curri, 2003; Feld et al., 2005).

4. The development of municipal broadband and Wi-Fi can stimulate competition and improve service in local telecommunications markets.

Broadband consumers in many markets have been subjected to poor service and high prices by incumbent telecommunications firms, who have had little incentive to invest, improve service or keep costs down (Bleha, 2005; Turner, 2005). Some U.S. research shows that where municipalities have entered local telecommunications markets, consumers have benefited from increased competition, better service and lower prices (Feld et al., 2005). Gillett (2006) argues that contrary to the discourse that states that municipal control of broadband networks reduces or eliminates the possibility of alternative service provision, municipalities' involvement in network provision can lower entry barriers for private sector providers and provide an opportunity for increased, not decreased, supply and service in local communities.

5. The deployment of public wireless networks improves citizen access to the internet and can help to bridge the digital divide.

Most public wireless deployments explicitly offer improved access to the internet, making promises to help reduce the digital divide by providing “universal and affordable broadband internet access to their residents” (Bar & Park, 2006, p. 111). The availability of public wireless can help to connect individuals to the information society and knowledge economy, by reducing economic and/or geographic access barriers (The Wireless Philadelphia Executive Committee, 2005). But while wireless networks have the potential to make it easier to access the internet for a lower cost, and in more places, Ross (2006) argues that their availability will not necessarily help to bridge the digital divide. Wireless networks are often built first for areas where high usage is expected, and where many people already have broadband access (Fuentes-Bautista & Inagaki, 2005). In addition, many other factors (including time constraints, availability of computer hardware, technology literacy, financial priorities, and awareness of the potential benefits of the service) determine whether or not wireless will be used even if it is available.

6. Public wireless networks can increase civic engagement both on and offline.

There is an extensive literature on the role community networks can play in stimulating local civic engagement and the development of social capital, both on and offline (Kavanagh & Patterson, 2001; Schuler & Day, 2004). Community networks serve both as sites of civic participation, (in which community members are engaged in the development, management, and maintenance of the network through essential volunteer activities such as serving on committees, providing technical support and training, or engaging in content development) and as enablers of civic participation (by providing services and supports, including access to and training on ICT equipment and software, information and communication services like internet service provision, email/listserv/web hosting, community directories, and electronic discussion

forums) (Rideout & Reddick, 2005). O'Neil (2002) summarizes the potential of community networks for local civic engagement in the following terms: "strong democracy," social capital, empowerment, and a sense of community.

Researchers have recently begun exploring the relationship between civic participation and community Wi-Fi networks (Cho, 2006; Powell & Shade, forthcoming; Sandvig, 2004). Municipal and community wireless networks can be used to better inform and engage citizens about local politics and community issues, through the use of a community portal, location-based information and event alerts (facilitated by software like 'Wifidog', <http://dev.wifidog.org/>), online forums and online polling. In addition, the provision of free Wi-Fi in public spaces can revitalize and re-populate parks, pedestrian walkways, outdoor cafes, and civic squares by attracting citizens, tourists and mobile workers equipped with wireless devices.

7. The development of public broadband and wireless services can encourage local innovation.

Municipalities, consumer co-ops and other community-based organizations have played an historic role in the technological development, diffusion and provision of telecommunications (Fischer, 1992), radio (Douglas, 1987) and energy services (Hughes, 1983). Community-based technology initiatives have been important in the development and diffusion of computing and the internet as well, initially among early-adopters, and later among regions and populations un(der)served by the private sector (Sandvig, 2004). Today, community and municipal networks, along with "disorderly groups of amateurs" continue to break ground in technological innovation and the diffusion and popularization of emerging technologies, including Wi-Fi and open source software (Krishnamurthy, 2005; Powell & Shade, forthcoming; Sandvig, 2002; Tuomi, 2001). Such ventures often serve as experiments to establish "proof of concept" before commercial actors risk investing in similar projects.

As a form of community innovation, such projects are often explicitly informed by a set of normative principles and codes of practice governing technological development, diffusion and use that are distinct from those governing commercial innovation. The principles embodied in cooperative/community-based technological innovation include collaboration, participation, consultation, open access, transparency, democracy and a regard for the public interest. Ideally, by adhering to such principles, community-based innovation processes lead to the development of new products, services and applications that respond to locally-determined social needs, engage a broad cross-section of local citizen and stakeholders, and promote social learning.

Within municipalities, Gillett (2006, p. 562) also notes that the development of wireless broadband services provides “a fertile setting for innovation,” at both a technical and organizational level. For example, she notes that a variety of models of public-private cooperation have been developed in the context of delivering wireless broadband services within municipalities.

Summary

Figure 1 presents a summary of espoused benefits of public wireless networks. The primary motivators for the development of *municipal* wireless networks are found at the top of the figure. As grassroots organizations, *community* wireless networks are motivated primarily by the benefits that are found at the bottom of the figure. Motivations for developing public wireless networks coalesce around desires to improve citizen access to information and communication technologies through the deployment of public wireless networks. It is not our intent to suggest that municipalities are disinterested in the benefits at the bottom of the figure, or that community wireless network organizations are disinterested in those at the top. Rather, the figure points out that the basic motivations for network development within the two types

of deployments are different, reflecting different priorities and objectives. Recognition of this point allows for contextually appropriate assessment of both municipal and community networks.

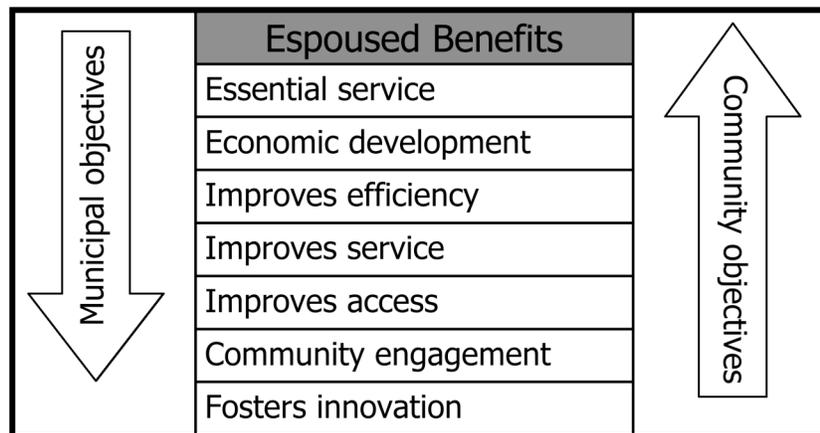


Figure 1: Espoused Benefits of Public Wireless Networks

To date, research on public wireless networks has focused on understanding types of network deployments, policy issues around network ownership, and technical issues of infrastructure design and capability. These are all necessary issues as this nascent form of infrastructure becomes established, but it is also important to consider the extent to which such infrastructure actually does deliver on its promises, by developing a set of criteria with which to assess public network deployments. In the section that follows, we present a “desiderata” for public wireless internet infrastructure. Developed from our understanding of the potential of wireless networking, the desiderata is intended to provide a foundation for a discussion of what public wireless should look like.

Desiderata for Public Wireless Internet Infrastructure

Much of the discourse around municipal Wi-Fi developments thus far has been framed in terms of whether wireless internet should be provided by public versus private entities. Absent from the debate, however, has been any meaningful discussion of what a properly constituted

public wireless internet service ought to look like. Here we offer a checklist of principles for operating a public Wi-Fi enhanced internet infrastructure that is arguably in the public interest.

If high speed internet service is to achieve the status of public amenity, what sort of infrastructure is necessary to provide it? In the context of wireless internet access, what features are required to deliver the public benefits identified above? The most commonly acclaimed key principles of public internet infrastructure are universal accessibility for all citizens, at a reasonable cost (Industry Canada, 1994; National Information Infrastructure Advisory Council, 1995). Public infrastructure should also provide reliable and secure service that does not impose avoidable risks on its users. Refining these principles in developing the more specific desiderata draws upon the seven-layer Access Rainbow model of information and communication infrastructure developed by Clement and Shade (2000). The focus here is on the first, Carriage layer, but also brings in related elements from the other six – Devices, Software, Content/Services, Service/Access Provision, Literacy/Social Facilitation, and Governance. For each of the following infrastructural characteristics, we highlight the particular role that wireless plays in enhancing the capabilities of the internet infrastructure more generally.

1. **UBIQUITOUS** – service coverage should include every household, business, organization, public space, tourist destination, and public transit corridor in the network's coverage area, within the limits of what is technically feasible. Wireless contributes to enlarging service coverage to areas that are not easily reachable by wireline.

2. **AFFORDABLE** – in order to ensure universal access for all, including low income households, the service should be available at affordable rates (e.g. <\$10 per month) and preferably for free. Ideally, the service should provide free access to basic broadband service (e.g. 1.5 Mbps, bi-directional as specified by National Broadband Task Force, 2001), with the

possibility of fees for premium, higher speed services to support high bandwidth uses.² Wireless service, because it can greatly reduce the cost for extending service into areas where wireline is relatively expensive, can help make internet access more affordable.

3. RELIABLE – the service should be as reliable as the other common utilities, such as water, power, and the telephone, with clear performance standards established (99.99% availability, 4 hours mean time to repair). This likely represents the major technical challenge to wireless internet, as the unlicensed 2.4 Ghz spectrum used by 802.11b/g protocols is subject to interference by other devices (e.g. microwaves, door openers) and is highly susceptible to attenuation (e.g. by trees in residential areas).

4. HEALTHY – electromagnetic radiation emissions associated with network equipment shall be within known safe limits, and should be routinely monitored.³ Given that Wi-Fi power levels are relatively low and their placement in relation to human bodies is no more hazardous than existing sources of electro-magnetic radiation (e.g. mobile phones), there should be no additional concerns with wireless. However, the health risks of unusual situations should be identified.

5. SECURE – state of the art technology and best practices should be adopted to ensure that personal communication and internet browsing are secure against unwarranted interception. Non-intrusive means should be incorporated into the service to protect users

² Even free basic internet service will not remove all the barriers to access. However, as hardware costs continue to fall dramatically and usable free/open source software becomes increasingly available, access costs have not diminished and now constitute the major cost barrier.

³ There has been little research done on the potential health effects of long term exposure to wireless networks. A study conducted in a Swiss hospital concluded that exposure to non-ionizing radio frequency radiation emitted by wireless local area networks was well below acceptable levels (Oertle, Lehmann, Fritschi, Müller, & Berz, 2006). Feychting and colleagues report “no persuasive data suggesting a health risk” (Feychting, Ahlbom, & Kheifets, 2005, p. 165) from exposure to radio frequency fields, but do stress the need for more research. Nevertheless, there is public concern about the long term health effects of ubiquitous wireless networks, and at least one public institution has decided against deploying wireless internet access for this reason (Blackwell, 2006).

against spam, viruses, spyware, etc. Reasonable, lawful means should be adopted to protect users against illegal content (e.g. child pornography, hate speech). As an over-the-air service, wireless is more susceptible to interception and corruption than more physically secure wireline transmission. However, commonly available encryption and authentication techniques are currently adequate if implemented properly.

6. WIDELY USEFUL – Good infrastructures allow for a wide range of applications that people find useful in conducting their daily affairs. While some of the most important ones can be anticipated and designed for, others will emerge over time. Wireless brings obvious benefits of portability and mobility, but also opens up new possibilities (such as location-based services) that were not previously feasible. This expands usefulness, while serving as a platform stimulating new economic activity as suppliers enter with new service offerings.

7. COST EFFECTIVE – Independent of the pricing for affordability mentioned above, public infrastructures should make efficient and effective use of the resources they require to offer service. Wi-Fi makes very efficient use of a spectrum that historically has been regarded as having marginal utility and low value. Where wireless services can be built on top of existing physical, electrical and wireline communications infrastructures, the marginal costs can be kept relatively low. For instance, Toronto Hydro Telecom's One-Zone wireless internet efficiently leverages existing publicly-owned fibre backbones and street lighting in creating a high quality, city-wide service at a fraction of the cost of conventional alternatives.

8. CONVENIENT & READY-TO-HAND – Ideally infrastructures 'disappear' in the sense that they can be taken for granted – always ready to be used effortlessly, but never getting in the way of the immediate task at hand. Wireless internet offers a significant step towards this ideal with its potential ubiquity and growing availability of easy to use wireless-enabled devices.

9. OPEN – the service should be designed to maximize openness at various levels (e.g.

openness to a variety of access devices, the use of open source software, and all kinds of content, applications and services.) Unlike in wireless telephony, the key standards and regulations for Wi-Fi communication, notably the 802.11 family, are oriented to openness, not competition among rival incumbents, and sufficiently stable to support the development of an expanding range of interoperable devices and applications (Noam, 2001).

10. NEUTRAL & NON-DISCRIMINATORY - no restrictions on access to lawful content/services, and no discrimination on the basis of content or services (e.g. P2P networks) beyond what is necessary for efficient network operations (Sandvig, forthcoming).

11. HIGH QUALITY – the service should maintain a good standard of throughput and response time for streaming or other time sensitive transmissions requiring particular Quality of Service (QoS) standards (e.g. public emergency, telemedicine). However, these should not be discriminatory in the sense of allowing the network provider to favour arbitrarily some communicants over others or permit inspection of packet content. As with Reliability above, wireless internet is challenging in this regard because of spectrum contingencies, such as interference and variable attenuation, as well as the greater difficulty in determining device identities as the basis for assigning bandwidth priorities.

12. PRIVACY ENABLING – operation of the service shall be fully compliant with applicable privacy laws and best practices. No personally identifying information shall be collected beyond that which is necessary to ensure access to and operation of the network. The service should enable both pseudonymous and anonymous use. Location-based and other services requiring additional personal information may be offered on a strictly voluntary, opt-in basis. As with Security above, wireless internet presents inherent difficulties beyond those already problematic with the wired internet. However, the content of messages (if not traffic patterns) can be protected technically. Some legal and legislative changes may be necessary to

deal with the ambiguity of 'personal' communication via 'public' airwaves' and detectable in 'public spaces'.

13. ACCESSIBLE & USABLE – access to the system should be as barrier-free as possible, accommodating a wide range of cognitive and physical disabilities. The service should also accommodate a community's linguistic diversity. Wireless enhancement can help make internet services more adaptable to particular populations and individual user needs.

14. COMMUNICATIVE COMMONS ENABLING – the service should encourage users to author and share content, accommodating a diversity of views and perspectives. Wireless service can enable communicative spaces that are locale specific at various geographic scales – e.g. street, neighbourhood, community.

15. CIVICLY-ORIENTED – the service should support a wide variety of civic-oriented information services, including community portals, news and event listings, and citizen policy discussion forums.

16. ACCOUNTABLE & RESPONSIVE – mechanisms of governance and citizen oversight and control to ensure that the service and its operator are responsive to citizen input and needs. Wireless access can help expand the modes of citizen involvement and oversight.

These various desirable characteristics of wireless internet infrastructure contribute in multiple ways to the espoused benefits outlined earlier. The following table summarizes the linkages.

Espoused Benefits	Desiderata
Essential service	1. Ubiquitous 2. Affordable 3. Reliable 4. Healthy 5. Secure
Economic development	6. Widely useful 9. Open 10. Neutral and non-discriminatory
Improves efficiency	7. Cost effective 8. Convenient and unobtrusive 9. Open 10. Neutral and non-discriminatory
Improves service	9. Open 10. Neutral and non-discriminatory
Improves access	13. Accessible 1. Ubiquitous
Community engagement	14. Communicative commons enabling 15. Civically oriented 16. Accountable and responsive
Fosters innovation	1. Ubiquitous 6. Widely useful 9. Open 10. Neutral and non-discriminatory

Enabling Conditions

In outlining specific, desirable network characteristics, the desiderata offers a starting point for the planning and development of public wireless networks that will provide benefits to communities, municipalities and citizens, and also provides a means to assess the extent to which existing projects can deliver public benefits. The issue of determining who will build new networks, while important, is beyond the scope of this discussion. However, our research to

date does offer some insights on how to develop infrastructure that offers the functionality outlined in the desiderata.

It is noted that public wireless networks should be ubiquitous, and Wi-Fi technology provides a simple, cost-effective way to extend network capacity. In most cases however, Wi-Fi technologies are effective because they are a complement to existing broadband infrastructures that provide high speed connectivity for specific geographic locations. The capacity to provide robust ubiquitous access is greatly improved when a network provider has access to a high bandwidth 'backhaul' channel (e.g. fibre, satellite, fixed wireless). Fibre networks appear to offer the most reliable backhaul service at present. Municipalities that have built their own local broadband networks have a strong platform on which to build a ubiquitous wireless network service, and often realize significant cost savings as owners and operators of their own networks.

The Wi-Fi standard allows users basic internet access at broadband speeds, but it does not support quality of service (QoS), meaning that it is unreliable for voice and video applications. As wireless networking becomes an essential service, and as users become more sophisticated and have higher expectations of a network's capabilities, providers will need to move beyond Wi-Fi protocols to offer infrastructure that is reliable, of high quality, and widely useful.

Wireless networking has been successful to date in part because the widely used Wi-Fi standards enable easy access to unlicensed spectrum. This unlicensed spectrum can be accessed for free, but has technical limitations in terms of quality of service, bandwidth, and network reach. As demands for more robust networks increase over time, the Community Wireless Networking community is advocating for increased access to open (unlicensed) spectrum (Meinrath, 2005). From a policy perspective, it is noted that debate over open

spectrum policies is important, and continued access to open spectrum would promote the achievement of cost effective, open, communicative commons enabling network characteristics.

We argue that access to networks must be affordable, with the ideal situation being one where connectivity is provided to citizens free of charge. But networks are not deployed for free. Because public wireless networks should be cost effective, the development of viable business models for service provision is essential. When assessing business models, an understanding of the context of the network deployment is crucial. Local conditions (e.g. ownership of existing physical infrastructure, geography, the willingness of politicians to take on incumbent telcos to develop locally owned infrastructure, availability of technically knowledgeable people to champion infrastructure development, availability of supportive local organizations/businesses to extend sponsored access points) influence what will and won't work within a community, thus an approach that works in one location may not be easily applied to another. Technical and social factors are both important in determining a business model that will meet the needs of a particular community or municipality.

Conclusions

This paper has identified the principal arguments in favour of developing public wireless internet access. Linked to these espoused benefits, we have also offered a preliminary series of desiderata that public wireless internet infrastructures developments may aspire to and be assessed by. We also offer some thoughts on 'enabling conditions' that will support the development of beneficial public infrastructure. Future work in the CWIRP project will refine these desiderata through using them to assess a variety of municipal and community Wi-Fi initiatives.

While exploring the ideal of public infrastructure, we have not addressed directly the important but vexed question of what may be the best means for achieving this. Much of the

debate about this issue so far has focused on whether this should be done with government involvement or entirely through market forces. One contribution this paper can make is providing a set of criteria for judging alternative proposals that may shift the debate away from ideological grounds to ones that are relevant to the intended beneficiaries – namely members of the public.

Acknowledgements

Production of this paper has been made possible through a financial contribution from Infrastructure Canada. Ryerson University, the University of Toronto and York University also supported this research.

The views expressed herein do not necessarily represent the views of the Government of Canada.

References

- American Public Power Association. (2005). *Community Broadband Fact Sheet*. Retrieved 28 September, 2005, from <http://www.appanet.org/files/PDFs/TelecomFlyer.pdf?sn.ItemNumber=9965&tn.ItemNumber=10000>.
- Bar, F., & Galperin, H. (2005). Geeks, Cowboys and Bureaucrats: Deploying Broadband, the Wireless Way, *A Sociedade em Rede e a Economia do Conhecimento: Portugal numa Perspectiva Global*. Lisbon, Portugal.
- Bar, F., & Park, N. (2006). Municipal Wi-Fi Networks: The Goals, Practices, and Policy Implications of the U.S. Case. *Communications and Strategies*, 6(1), 107-125.
- Belson, K. (2006, 26 June). What If They Built an Urban Wireless Network and Hardly Anyone Used It? *New York Times*, p. C1.
- Blackwell, G. (2006). *WLAN Sickness: Rubbish or Reasonable?* Retrieved 20 September, 2006, from <http://www.wi-fiplanet.com/columns/article.php/3591071>.
- Bleha, T. (2005). Down to the Wire. *Foreign Affairs*, 84(3), 111-124.
- Brown, R. H., Irving, L., Prabhakar, A., & Katzen, S. (1995). *The Global Information Infrastructure: Agenda for Cooperation*: Information Infrastructure Task Force.
- Buck, S. (2002). Replacing Spectrum Auction with a Spectrum Commons. *Stanford Technology Law Review*, 2.
- Carlson, S. C. (1999). A Historical, Economic, and Legal Analysis of Municipal Ownership of the Information Highway. *Rutgers Computer & Technology Law Journal*, 25(1).
- Castells, M. (1989). *The Informational City: Information Technology, Economic Restructuring, and the Urban-Regional Process*. Oxford, UK ; Cambridge, Mass., USA: B. Blackwell.
- Caves, R. W., & Walshok, M. G. (1999). Adopting Innovations in Information Technology: The California Municipal Experience. *Cities*, 16(1), 3-12.
- Cho, H. (2006). *Explorations in Community and Civic Bandwidth: A Case Study in Community Wireless Networking*. Unpublished MA Thesis. York University, Toronto.
- Clement, A., & Shade, L. R. (2000). The Access Rainbow: Conceptualizing Universal Access to the Information/Communication Infrastructure. In Gurstein, M. (Ed.), *Community Informatics: Enabling Communities with Information and Communications Technologies* (pp. 32-51). Hershey, PA: Idea Group.
- CRACIN. (2005). *Written Submission to Telecommunications Policy Review Panel*. Toronto: Canadian Research Alliance for Community Innovation & Networking.
- CRTC. (2006). *Broadcasting Policy Monitoring Report*. Ottawa.
- Dawe, T., & Curri, M. (2003). *Town of Tillsonburg: Economic Impact Case Study*. Industry Canada.
- Douglas, S. J. (1987). *Inventing American Broadcasting, 1899-1922*. Baltimore: Johns Hopkins University Press.
- Dutton, W. H., Peltu, M., & Bruce, M. (1999). *Society on the Line: Information Politics in the Digital Age*. New York: Oxford University Press.
- e-Novations. (2005). *The Chronicles of E-Novation and Fred e-Zone*. Fredericton.
- Ewalt, D. M. (2005). *Orlando Kills Municipal Wi-Fi Project*. Retrieved 22 September, 2006, from http://www.forbes.com/home/technology/2005/06/23/municipal-wifi-failure-cx_de_0623wifi.html.
- Feld, H., Rose, G., Cooper, M., & Scott, B. (2005). *Connecting the Public: The Truth About Municipal Broadband*. Washington, D.C.: Consumer Federation of American, Consumers

- Union.
- Feychting, M., Ahlbom, A., & Kheifets, L. (2005). EMF and Health. *Annual Review of Public Health, 26*, 165-189.
- Fischer, C. S. (1992). *America Calling: A Social History of the Telephone to 1940*. Berkeley: University of California Press.
- Ford, G. S., & Koutsky, T. M. (2005). Broadband and Economic Development: A Municipal Case Study from Florida. *Review of Urban and Regional Development Studies, 17*(3), 216-229.
- Fransman, M. (2006). *Global Broadband Battles: Why the U.S. And Europe Lag While Asia Leads*. Stanford: Stanford Business Books.
- Fuentes-Bautista, M., & Inagaki, N. (2005). *The Wi-Fi's Promise and Broadband Divides: Reconfiguring Public Internet Access in Austin, Texas*. Paper presented at the Telecommunication Policy Research Conference, Arlington, VA.
- Galperin, H. (2005). Wireless Networks and Rural Development: Opportunities for Latin America. *Information Technologies and International Development, 2*(3), 47-56.
- Geist, M. (2005, 28 February). Let Towns, Cities Provide Cheap, Everywhere Broadband. *Toronto Star*.
- Gibbs, D., & Tanner, K. (1997). Information and Communication Technologies and Local Economic Development Policies: The British Case. *Regional Studies, 31*(8), 765-774.
- Gillett, S. E. (2006). Municipal Wireless Broadband: Hype or Harbinger? *Southern California Law Review, 79*, 561-594.
- Gillett, S. E., Lehr, W. H., & Osorio, C. (2004). Local Government Broadband Initiatives. *Telecommunications Policy, 28*(7-8), 537-558.
- Gillett, S. E., Lehr, W. H., & Osorio, C. A. (2006a). Municipal Electric Utilities' Role in Telecommunications Services. *Telecommunications Policy, 30*(8-9), 464-480.
- Gillett, S. E., Lehr, W. H., Osorio, C. A., & Sirbu, M. A. (2006b). *Measuring Broadband's Economic Impact: Final Report*. Washington, DC: U.S. Department of Commerce, Economic Development Administration.
- Graham, S. D. N. (1992). Electronic Infrastructures and the City: Some Emerging Municipal Policy Roles in the UK. *Urban Studies, 29*(5), 755-781.
- Horrigan, J. B. (2006). *Home Broadband Adoption 2006*. Washington, DC: Pew Internet & American Life Project.
- Hughes, T. P. (1983). *Networks of Power: Electrification in Western Society, 1880-1930*. Baltimore: Johns Hopkins University Press.
- Industry Canada. (1994). *The Canadian Information Highway: Building Canada's Information and Communications Infrastructure*. Ottawa: Supply and Services Canada.
- Industry Canada. (2002). *Broadband for Rural and Northern Development*. Ottawa.
- Industry Canada. (2005). *Broadband - The Programs - National Satellite Initiative - About Us*. Retrieved 24 August, 2005, from <http://broadband.gc.ca/pub/program/lsi/aboutus.html>.
- Information Highway Advisory Council. (1997). *Preparing Canada for a Digital World: Final Report of the Information Highway Advisory Council*. Ottawa: Industry Canada.
- Infrastructure Canada. (2004). *Enhancing Knowledge About Public Infrastructure: Perspectives in the Federal Family Report*. Ottawa.
- International Telecommunication Union. (2004). *The Portable Internet*. Geneva: ITU.
- Kavanagh, A. L., & Patterson, S. J. (2001). The Impact of Community Computer Networks on Social Capital and Community Involvement. *American Behavioral Scientist, 45*(3), 496-510.
- Krishnamurthy, S. (2005). Special Issue #2: Open Source. *First Monday, 10*(10).

- Lehr, W., & McKnight, L. W. (2003). Wireless Internet Access: 3G vs. WiFi? *Telecommunications Policy*, 27, 351-370.
- Mackenzie, A. (2005). Untangling the Unwired: Wi-Fi and the Cultural Inversion of Infrastructure. *Space and Culture*, 8(3), 269-285.
- Mcchesney, R. W., & Podesta, J. (2006). Let There Be Wi-Fi. *Washington Monthly*, 38(1/2), 14-17.
- Meinrath, S. (2005). Community Wireless Networking and Open Spectrum Usage: A Research Agenda to Support Progressive Policy Reform of the Public Airwaves. *The Journal of Community Informatics*, 1(2).
- Middleton, C. A., & Sorensen, C. (2005). How Connected Are Canadians? Inequities in Canadian Households' Internet Access. *Canadian Journal of Communication*, 30(4), 463-483.
- Miller, D. (2006). *Wifi Announcement*. Retrieved 2 September, 2006, from http://www.toronto.ca/mayor_miller/speeches/wifi.htm.
- Mosco, V. (1996). *The Political Economy of Communication: Rethinking and Renewal*. London ; Thousand Oaks, Calif.: Sage Publications.
- Muniwireless.Com. (2006). *List of Bids Issued by Cities and Counties in 2005 and 2006 (January 30 Update)*. Retrieved 4 September, 2006, from <http://www.muniwireless.com/reports/docs/RFPs2005-2006.rtf>.
- National Broadband Task Force. (2001). *The New National Dream: Networking the Nation for Broadband Access*. Ottawa: Industry Canada.
- National Information Infrastructure Advisory Council. (1995). *Common Ground: Fundamental Principles for the National Information Infrastructure : First Report of the National Information Infrastructure Advisory Council*. Washington, D.C. (14th & Constitution Avenues, NW, Room 4892, Washington 20230): The Council.
- New Millennium Research Council. (2005). *Not in The Public Interest – The Myth of Municipal Wi-Fi Networks: Why Municipal Schemes to Provide Wi-Fi Broadband Service with Public Funds Are Ill-Advised*. Washington, DC.
- Noam, E. (2001). *The Next Frontier for Openness: Wireless Communications*. New York: Columbia Institute for Tele-Information (CITI).
- O'neil, D. (2002). Assessing Community Informatics: A Review of Methodological Approaches for Evaluating Community Networks and Community Technology Centers. *Internet Research*, 12(1), 76-102.
- Oertle, M., Lehmann, H., Fritschi, P., Müller, M., & Berz, R. (2006). Electromagnetic Fields in Hospitals: Wireless-Lan as a Risk Factor? *Elektromagnetische felder im akutspital: Wireless-LAN & Co. als risiko?*, 95(23), 933-941.
- Organisation for Economic Co-Operation and Development. (2006). *OECD Broadband Statistics, December 2005*. Retrieved 31 July, 2006, from http://www.oecd.org/document/39/0,2340,en_2825_495656_36459431_1_1_1_1,00.html.
- Powell, A., & Shade, L. R. (forthcoming). Going Wi-Fi in Canada: Municipal, and Community Initiatives. *Government Information Quarterly*.
- Rideout, V. N., & Reddick, A. J. (2005). Sustaining Community Access to Technology: Who Should Pay and Why. *The Journal of Community Informatics*, 1(2), 45-62.
- Ross, S. S. (2006). *WiFi: A Great Amenity, a Lousy Cure for The Digital Divide*. Retrieved 3 June, 2006, from http://www.broadbandproperties.com/2006issues/june06issues/editors%20note_june.pdf.
- Sandvig, C. (2002). *Disorderly Infrastructure: Wi-Fi in the Shadow of the Rural Telephone*

- Cooperative*. Paper presented at the Casting a Wider Net: Integrating Research and Policy on the Social Impacts of the Internet, Oxford.
- Sandvig, C. (2004). An Initial Assessment of Cooperative Action in Wi-Fi Networking. *Telecommunications Policy*, 28(7/8), 579-602.
- Sandvig, C. (forthcoming). Network Neutrality Is the New Common Carriage. *Info: The Journal of Policy, Regulation, and Strategy*.
- Sassen, S. (2002). *Global Networks, Linked Cities*. New York: Routledge.
- Sawhney, H. (2003). Wi-Fi Networks and the Rerun of the Cycle. *Info*, 5(6), 25-33.
- Schuler, D., & Day, P. (2004). *Shaping the Network Society: The New Role of Civil Society in Cyberspace*. Cambridge, Mass.: MIT Press.
- Servon, L. J. (2002). *Bridging the Digital Divide: Technology, Community, and Public Policy*. Malden, MA: Blackwell Pub.
- Shamp, S. A. (2004). *Wi-Fi Clouds and Zones: A Survey of Municipal Wireless Initiatives*. Mobile Media Consortium, University of Georgia. .
- Strover, S. (2003). The Prospects for Broadband Deployment in Rural America. *Government Information Quarterly*, 20(2), 95-106.
- Strover, S., Chapman, G., & Waters, J. (2003). *Beyond Community Networking and CTCs: Access, Development and Public Policy*. Paper presented at the Telecommunication Policy Research Conference, Arlington, VA.
- Tapia, A. H., Stone, M., & Maitland, C. (2005). *Public-Private Partnerships and the Role of State and Federal Legislation in Wireless Municipal Networks*. Paper presented at the Telecommunication Policy Research Conference, Arlington, VA.
- Telecommunications Policy Review Panel. (2006). *Telecommunications Policy Review Panel - Final Report 2006*. Ottawa: Industry Canada.
- The Wireless Philadelphia Executive Committee. (2005). *Wireless Philadelphia Business Plan: Wireless Broadband as the Foundation for a Digital City*.
- Tuomi, I. (2001). Internet, Innovation, and Open Source: Actors in the Network. *First Monday*, 6(1).
- Turner, S. D. (2005). *Broadband Reality Check: The FCC Ignores America's Digital Divide*. Northampton, MA: Free Press.
- Vos, E. (2005). *Muniwireless.Com July 2005 Report*.
- Warschauer, M. (2003). *Technology and Social Inclusion: Rethinking the Digital Divide*. Cambridge, Mass.: MIT Press.
- Wilhelm, A. G. (2004). *Digital Nation: Toward an Inclusive Information Society*. Cambridge: MIT Press.
- Wireless Task Force. (2006). *Wireless in Boston*. Retrieved 30 August, 2006, from <http://www.cityofboston.gov/wireless/Boston%20Wireless%20Task%20Force%20Report%20-%20Final.pdf>.