CWIRP – COMMUNITY WIRELESS INFRASTRUCTURE RESEARCH PROJECT[1]

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Date: April 2008

Fredericton's Fred - eZone: Defining and Designing Public Broadband

[1] Production of this case study has been made possible through a financial contribution from Infrastructure Canada. The views expressed herein do not necessarily represent the views of the Government of Canada.

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www.cwirp.org

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1. Executive Summary

This report details the history of the design, construction, and use of Fredericton, New Brunswick's co-operative community broadband network, and its Fred-eZone Wi-Fi network. It argues that these municipally-owned networks demonstrate pragmatic innovation in two ways: by defining broadband as a public utility, and by augmenting public spaces through the use of Wi-Fi and developing "public Wi-Fi space". The report argues that the small size of Fredericton, and the continued participation of municipal employees and decision-makers in the construction of the network played a key role in the ability to define broadband infrastructure as "public." It describes how the E-novations broadband and Wi-Fi networks have been part of an overall strategic focus on knowledge industries that attempts to brand Fredericton as a "smart" community. After describing in detail the technical and organizational choices made by the designers of the Fred-eZone Wi-Fi network, the report concludes by assessing the impact of the network. It argues that Fredericton's decision-makers need to go beyond their innovative framing of broadband and Wi-Fi as public infrastructure. They must now decide what type of public infrastructure they want to develop in order to take advantage of their innovative network. If the metaphor for Fredericton's public broadband is to be "public water and sewer" then decision-makers may want to expand the fibre network to provide universal access to broadband. If the metaphor is to be "public park" then E-novations may want to explore services and applications that augment and add value to the Wi-Fi hotspots already installed in public places.

2. Introduction

Where does innovation come from?

Conventional wisdom holds that innovation emerges on the margins, where creativity and experimentation are not constrained by conventional wisdom. This perception of innovation resonates with an understanding This underestimates the extent to which innovation can also be a practical response to a problem, developed in a specific context – for example, von Hippel's (2005) studies of user innovation describe windsurfers unhappy with commercial equipment inventing their own boards and sails. Similarly, innovations in providing connectivity also often arise from situations of need. In 1999, Fredericton, the capital of New Brunswick, a small city of 45,000 people, could not get affordable broadband connectivity. According to city officials, businesses were leaving the city, even as the city looked for a source of economic dynamism outside the university and bureaucracy that had sustained it since its foundation in 1783. A pragmatic solution that solved the connectivity problems of the city was to invest in a community fibre network that delivered high-speed connectivity to the city and other core tenants. By 2003, this pragmatism facilitated an innovative project: providing free Wi-Fi access in all city-owned property, and across most of the downtown business area. As the first free public Wi-Fi network hosted by a North American city, the eZone project, as it was called, attracted attention for its early arrival, but also criticism for not challenging incumbent providers or delivering internet via Wi-Fi to households.

As high-profile, high-tech municipal Wi-Fi projects spectacularly collapse across North America, the utility of the Fred-eZone's pragmatically innovative approach becomes clear. First, by creating the community network (fiber and point to multi-point wireless) and using the excess bandwidth freed up by collective purchasing, the eZone, unlike almost every other municipal wireless project in North America, defined internet connectivity as public infrastructure. Second, by providing Wi-Fi on city property and in "third spaces" away from work and home rather than explicitly in homes, the eZone defined a practical and spatial definition of "public Wi-Fi" that presumes that public space is different – at least in terms of internet use -- than home or work space. Practically, this implies that the level of access provided in public is different than in private or at work. Symbolically, this establishes municipally-managed "public Wi-Fi space"

These interventions in the structure of internet policy, technology, and finally the cultural interpretation of Wi-Fi, and IT in general as part of Fredericton's identity indicate that the "one-size-fits-all" model of Muni Wi-Fi as ubiquitous broadband connectivity needs to be reconsidered from the perspective of pragmatic innovation. The final question that must be asked of the eZone, is what the local impact of this policy, technical, and cultural innovation has been. Is the city better served after having built the community fibre network and the Wi-Fi network? What can the technical choices involved in the eZone indicate about appropriate technical choices for Wi-Fi

networks? Finally, what is the social and cultural impact of the "IT identity" that the Fred-eZone was part of?

2.1 Fredericton – an out-of-the-way "IT capital"

For the past two hundred years Fredericton, located on a bend in the Saint John river in southern New Brunswick has been best-known as a government and university town, often with a strong military presence – historically, it was a garrison for British soldiers after the American War of Independence, and is now the closest city to the Canadian Forces Base at Gagetown. This history has created a local culture where quality of life and a pleasant, orderly use of common space are valued. In the words of informants interviewed for this project, "it is a nice place to live." In the past ten years IT and new communications systems have begun to play a role in creating and sustaining this quality of life. Like many communities located away from national or international transportation hubs or natural resources, Fredericton's decision-makers have concentrated on obtaining, maintaining, and expanding access to ICT, and on defining the city as a regional (and national) "IT centre". The creation of a locally owned communications infrastructure has been crucial to achieving these goals, which can be interpreted as simultaneously containing policy, technical, and cultural elements. While outside of the "centres of power", Fredericton has demonstrated innovation in responding to practical policy and technical issues, in the process developing a new cultural image for itself.

Three key elements have contributed to this innovation: first, there is public ownership of backhaul and infrastructure; second, the technical and organization design of the network defines public space and appropriate "public use" of the network; third, the network quickly became part of the strategic planning and identity of Fredericton as an IT centre. Other municipalities or communities developing public Wi-Fi networks might draw from Fredericton's pragmatic approach of having the IT identity develop *from* public ownership and public network design, rather than attempting to construct a high-tech identity by embarking on an expensive public-private partnership.

E-novations, a city-owned company staffed entirely by city employees, was created to purchase and manage a cooperative wholesale fibre ring (the community network) for the city in 1999 in order to provide last mile connectivity to city offices and local businesses. As the network expanded, a public Wi-Fi component was added that used excess bandwidth available from the community network. E-novations manages both the fibre ring and the Wi-Fi network. At the same time, the principals of E-novations all hold positions within city government. As the following history of the eZone project indicates, this public ownership and public involvement at all levels of planning and constructing the network facilitated decision-making in the public interest. Drawing on backhaul bandwidth purchased for municipal government use using taxpayer's funds, the Fred-eZone Wi-Fi network is a small, but publicly visible addition to a public broadband network that was built a means of ensuring fair prices for internet service.

3. History

3.1 1999-2003: The Community Network and strategies for connectivity: creating competition

In 1999 the city of Fredericton was worried about the impact of connectivity on its competitiveness. One internet service provider (ISP) -Aliant - served the city, and broadband connectivity only available in certain areas. The cost of bandwidth was at least twice as expensive as in major centres, and businesses were paying $800 a month for dedicated broadband lines. According to city employees, businesses had begun to leave the city because of rising connectivity costs. The market was small enough that large providers did not want to sell in it, and one small operator went bankrupt. After realizing that the incumbents were unwilling to provide broadband coverage over the entire city, the city technology department, which had been laying fibre to connect its own city offices together in a local area network, created an organization called the Fredericton Community Network, with infrastructure owned by E-Novations. This organization acted as a means for local businesses to pool their resources to lease bandwidth delivered over city-owned fibre-optic cable, creating a co-operative wholesale model for distributing bandwidth (see Civitium, 2005), and a public utility model for the fibre network as a whole (see Potter, 2007). E-novations obtained a license as a non-dominant telecommunications operator[1]. This permitted the company to provide or resell internet connectivity. The tenants of the community network could thus purchase bandwidth at wholesale levels from E-novations.

The consortium of purchasers were able to purchase enough bandwidth to receive wholesale prices. City staff explain that prior to the city's investment in this network infrastructure, businesses paid up to $3000 a month for a T1 backhaul internet line. At present, members of the network purchase symmetrical 1MB service for $240 a month. This service is also "burstable" meaning that these speeds can be surpassed from time to time. Initially the community network also leased capacity to local businesses and provided resellers the ability to extend high-speed internet service to unserved neighbourhoods, although all neighbourhoods are now served by broadband connectivity offered by the dominant operator.

The original fibre network succeeded in reducing the cost of communication and introducing competition into the broadband market. The network lowered the costs for businesses significantly, and also incited providers to provide connectivity in more areas of the city as a means of achieving greater market share. As a result, more areas of the city had broadband connectivity, offered by the incumbent and by other providers at market price. This phenomenon of using a community networking project to "force

[1] According to the Canadian Radio-Television Commission (the CRTC) a non-dominant telecommunications operator is not required to file tariffs for telecommunications activity such as data transfer. This means that operators like E-Novation are not subject to government regulation of their data transfer (internet) services.

the hand" of an incumbent to provide better service has been documented by Puel, Fernandez and Fautrero (2007), who described the same phenomenon in France, where local community networks built DSL projects in unserved areas, and soon after the incumbent operator began to provide service. In Fredericton, within several years of building the fibre network, prices for business connections dropped by half, and most areas of the city had broadband connectivity. The city obtained a return on investment from constructing its own infrastructure within 16 months. In 1999, the dominant telecommunications operator, Aliant, had a virtual monopoly in the area. Although it is still dominant, there is now competition from Rogers, BrunNet (a local ISP) and EastLink communications. All of these companies provide high-speed service, sometimes bundled with other communications service. The community network sources its wholesale bandwidth from major providers including both Bell and Rogers. The network demonstrates how a co-operative model can establish competition in a broadband market. It now has 35 tenants and covers 60 km, with expansions planned. Its presence is an important driver of the local IT economy: businesses who are part of the community network gain cost savings of up to $600 a month for their broadband backhaul connectivity.

City involvement established political as well as infrastructure support for the network. When city council was deliberating on permitting construction of the project, the incumbent telecommunication providers attempted to place pressure on city councilors by sending letters and making phone calls. The councilors maintained their support however, and voted in favour of funding the network. In addition to political support for the fibre network, the city also acted as one of its core tenants, using the network to interconnect its offices and other public buildings. This meant that many city sites were connected to high-speed internet, but others, like the airport, were too far away to use fibre cost-effectively. E-novations connected the airport to the community network with point-to-point wireless transmission using 802.11 standard Wi-Fi technology. These experiments encouraged the city IT department to consider using Wi-Fi to share some of the excess bandwidth available on the network after all of the tenants had used the bandwidth they found necessary. Drawing on the mandate of E-novations, "to promote and support economic development through innovation" the players in the fibre network turned their attention to what they believed would be a small demonstration Wi-Fi project in the city's downtown.

3.2 Building the Fred-eZone and creating a Civic IT identity

In 2003 E-novations proposed experimenting with a public wireless network attached to the end points of the community fibre network. While this was initially proposed as a small scale network, city council support was so strong that the proposal was extended to cover most of the city's downtown, and, in a second phase, many other city-owned sites. Council voted on each expansion of the network, ensuring that its expansion was publicly supported. Unlike the community network which is funded through membership, the Wi-Fi network was entirely funded through public funds, and used existing city-owned infrastructure such as light poles and water towers. The network is structured as a set of hot zones broadcasting from antennas connected to broadband backhaul through the community network. Most backhaul is wireless, and the airport is connected through point-to-point fixed wireless. The coverage of city property and the city investment in infrastructure resulted from a policy innovation that defined broadband infrastructure as public infrastructure. The inclusion of the Wi-Fi network in strategic planning and economic development strategies represented another kind of innovation – a cultural innovation that linked IT with the identity that Fredericton hoped to develop and present.

The Wi-Fi network, the first of its kind in Canada (and one of the first in North America) attracted media attention, and became integrated into the city's tourism and economic development strategies. For example, promotional material aimed at conference delegates suggests, "...why Fredericton should be your next event location!. . .a flourishing IT-driven economy (free wireless access!) ...Fredericton's Fred-eZone, Canada's first free, community-wide Wi-Fi network, offers delegates mobile broadband access from virtually anywhere within the city's downtown core" (Visiting Fredericton brochure, 2006). The construction of the Wi-Fi project helped to reinforce the city's identity as an IT centre. Meanwhile, the lower prices for connectivity provided to businesses by the fibre network meant that these businesses – many of them in the IT sector – were motivated to stay in Fredericton. The city's identity as a "Smart City" thus grew along with its public connectivity infrastructure, especially the Wi-Fi infrastructure. As part of an economic development strategy and as part of a civic identity, the public communications infrastructure works to reinforce the definition of certain types of space as "public space".

It also forms part of a discourse that attempts to situate Fredericton as an attractive place with good connectivity but also a good quality of life. The city's marketing and economic development literature stresses the high quality of life in the city alongside its knowledge and IT-based economy. The municipal plan released in January 2007 hopes to help Fredericton develop as a "vibrant, prosperous and smart city." Councilor Tony Whalen is quoted as saying "from the 'smart' city perspective, we have 70 per cent of the knowledge based industries in New Brunswick" (quoted in The Daily Gleaner, Feb 13, 2007). Media reports and city publications align quality of life and the "smart" character of Fredericton's IT sector, while the eZone is touted as a showpiece of this sector and the "smart" quality of the community. The design of the eZone contributes

to this framing of the IT capacity of the city. While the eZone's Wi-Fi service is undoubtedly useful to many residents, it is perceived primarily as an "add-on" and not as a replacement of home internet service nor as a means of bridging the digital divide. The rest of this report examines the role of Fredericton's local culture in the design and planning of the eZone network, and the network's role – and potential -- in defining public space and public services within the city.

4. Profile of Fredericton

4.1 Demographics and Labour Force Indicators

Fredericton was founded in 1783 by British Loyalists, acting as a garrison for British soldiers. Canadian soldiers still train outside of Fredericton at the Gagetown military base, and the city is the seat of the provincial government and the home of the oldest university in North America: the University of New Brunswick, which has 7500 students. An associated Catholic university, St. Thomas University, has 2500 students. One third of these students are over 24 years old, often returning to studies after years working. These factors have shaped the culture of the community – stable employment in the public service (and the close proximity to a military base) fostered the development of a prosperous local economy influenced by a university-educated citizenry. However, as employment in the public sector declined during the 1990s, the city's strategic focus changed to prioritize knowledge-based industries, life sciences, consulting engineering, aerospace, defense, and manufacturing, and finally tourism and the cultural industries (Enterprise Fredericton, 2006). This shift in focus accompanies the period during which E-novations invested in fibre and built the eZone Wi-Fi network.

Statistics from 2001, near the beginning of the E-novations development process, paint a picture of a well-educated, settled community: of the population of 49,835

* 24,440 had not moved in the last four years and 10,980 have moved only within the city.

* 34,110 were born in New Brunswick

* 36,225 spoke only English

* 4,930 attended school full or part time

And 10,860 had a bachelor's degree or higher

According to labour force statistics provided by Statistics Canada, in 2001:

* 6,815 worked in sales and service occupations

* 5,500 worked in business, finance, and administration

* 3,150 worked in social science, education, or government

* 3,110 worked in management

While Census 2006 labour force statistics were not available at the time of writing, city sources argue that high-tech is beginning to replace government work as government departments at the provincial level have scaled back.

Fredericton has a very well-educated work force, with the 2001 census reporting 37.2% of the population with a university degree. The city also has a high average family income of $70,000 per year, higher than the New Brunswick average, which may have contributed to the sound financial state of the municipal government. City employees mentioned this financial stability as one of the key reasons that the eZone project was pursued, even without federal funding.

According to the 2006 Census, the city of Fredericton had a population of 50,535. It has grown by 6.2% since 2001. While the official census considers Fredericton to be a small urban center, the Greater Fredericton Area comprises 124,172 people. The growing population is supported by continued employment in the public sector – the largest single employer in the Fredericton area continues to be the provincial government, and the largest private-sector employers are reservation and call centres, businesses that depend upon reliable telecommunications infrastructure. However, the Canada New Brunswick Business Service centre estimates that the city has over 3,000 businesses, including many small businesses with between one and four employees (Team Fredericton, 2008). Interviews with business leaders in Fredericton suggest that many of these small businesses draw on IT-based expertise developed in the city, such as spatial mapping of natural resources, and e-learning. However, employment statistics suggest that while the city is very business-oriented, the "university and government" identity remains. More detailed analysis of labour force statistics from the 2006 Census (released in March 2008) may be able to indicate whether employment has shifted towards more "knowledge-based" industries meant to be facilitated by infrastructure projects like the community network and the eZone.

4.2 Existing Infrastructure

The development of the eZone project built a network using existing public infrastructure, augmenting public spaces and layering connectivity over public spaces. While the first phase of the eZone's development covered the downtown business district with Wi-Fi. Today, Wi-Fi hotspots are also located at the entry points to the city, and at sports and culture centres and at many more public spaces within the city.

Fredericton is located on the Trans-Canada highway, although the highway bypasses the downtown core. As a result, a secondary business district, including "big box" stores and malls has grown up closer to the highway exit. The second phase of the Fred-eZone Wi-Fi project covered many of these areas with Wi-Fi, including parking lots of grocery stores and shopping mall, which are sometimes used by tourists passing through the area who do not drive into downtown Fredericton. The only business directly accessible by the highway is the Irving Big Stop truck stop, which is covered by Wi-Fi. The truck stop, although far from the cafés and office buildings of the

downtown, is an important point of entry to Fredericton, and a Wi-Fi hotspot plays an important symbolic role in evoking Fredericton's "smart" identity. It is also one of the most frequently used hotspots, along with the hotspot located at the Fredericton airport. The airport, located 20 km outside of the city, is an essential transportation link, especially for business development. A 1999 study estimated that 70 per cent of the markets for the local knowledge industry were located outside the region, and that the airport contributed to the continued employment of over 5,000 people (Innes et al., 2000). The city and its business community have invested heavily in the airport, forming a consortium that pre-paid $2 million worth of flights to Boston in order to ensure that this international flight would continue to operate. As a city facility, the airport was one of the first city Wi-Fi hotspots, and was the first site to be connected to the community network using wireless, since it was too far from the city to lay fibre cable.

When arriving at the airport, a large poster advertises the eZone and provides instructions for connecting. Thus, along with investment in transport links connecting Fredericton to larger cities, the eZone connectivity symbolically marks the city as a "connected" place, even before the fifteen-minute drive through a rural river valley to the city itself. As at the truck stop, the eZone connectivity at the airport has always been well-used. By covering the entry points to the city with Wi-Fi, even when they are distant from the city centre, the eZone provides an immediate evocation of Fredericton's "smart" identity to arriving visitors.

Leisure and cultural centres across Fredericton are also eZone hotspots. Parks, indoor and outdoor rinks, indoor pools, and the Playhouse performing arts centre are part of the cultural infrastructure of the city. E-Novations provides Wi-Fi connectivity at many of these locations including indoor rinks, the pools, and the Playhouse. The city also operates several webcams on these sites, including one that records the construction progress of a sports complex. There are three libraries in Fredericton, including one main library branch and two school/community libraries where students and the wider community share the library facilities. All have eZone connectivity, and CAP (Community Access Program) sites, although one library-based CAP site charges a fee for access. The number of other CAP sites in New Brunswick is difficult to determine, with changes in management making enumeration difficult.

Although the levels of use of the eZone at leisure and cultural centres are lower than at transportation hubs, some sites, including the main branch of the public library, are well used. Still, layering Wi-Fi over cultural centres reiterates that they are public areas, and places for exchange and connection.

5. Organization and Design of the eZone

5.1 Public funding, public servants, public service

The city network, community network and eZone are all managed by the City IT department. They divided into three separate subnets providing different services including distribution wholesale bandwidth over the community ring, management of the city's own internal and external networked communication, and management of the eZone. The eZone is owned and operated by the City of Fredericton in partnership with E-novations.

Physical maintenance is provided by numerous subcontractors, most of them hired locally when this is possible, and managed by three staff members in the City's IT department. The City IT staff is responsible for network monitoring and troubleshooting of the eZone in addition to other responsibilities. The IT manager for the City, Mike Richard, played a key advocacy role in developing the network. So did the city's CIO Maurice Gallant, and the economic development officer Don Fitzgerald. These champions presented the E-Zone project to the city council, who voted on each phase of the project as it developed. Richard was responsible for the local police force's IT division. Two of his staff were also involved in developing and deploying the E-Zone: a technician and a network engineer. The local Motorola vendor was also involved in deploying and maintaining the radios, and has an ongoing on-call position in case repairs are required.

E-Novations, the non-profit company, is wholly owned by the city, and permits the city to own infrastructure. Key eZone champions hold positions in both the city government and in E-novations. Gallant and Richard are the CEO and President of E-Novations but continue to hold their positions in the municipal government, where they are the CIO and head of IT respectively.

Both the community network and the E-Zone were funded by the city of Fredericton through a loan to the E-Novations company, permitting the company to own the infrastructure. The initial loan was $45,000 and was paid back within three years. In 2004 the network's Wi-Fi infrastructure was valued at $175,000. In-kind contributions from vendors totaled $250,000 and included contributions from Cisco systems, who provided the wireless backhaul equipment. Fredericton was later used as a model case study in Cisco promotional material. The backhaul radios at each access point were purchased from Motorola and maintained by an experienced local technician.

Fredericton had originally applied for Smart Communities funding to undertake IT projects including some related to fibre development but the application was not successful; subsequently, it decided to fund its own IT projects. The city is already independent from the provincial government and has a culture of self-sufficiency. The city is also an ISO 9000 organization, meaning that it follows quality management and reporting practices. Some city employees claim that these quality practices, which

encourage communication across city departments and between the city and its citizens, may have made it easier for the eZone project to be completed, since interdepartmental cooperation is facilitated and strategic planning for goals such as economic development is streamlined and unified throughout the organization.

The city council approved each step of the development process individually, and the network was not planned from the outset but rather evolved, in keeping with the municipal government's strategy of strategic growth. Over a five year period various phases of the eZone were rolled out, each one building on the last, resulting in a network that requires regular maintenance of about one half-time employee.

5.2 Network Design

The eZone is a publicly-accessible Wi-Fi network added to the community fibre network owned by E-Novations. In a wholesale co-operative model, the community network members purchase wholesale internet bandwidth that is routed along infrastructure owned by E-Novations. The network customers are guaranteed a minimum level of service, but often receive more bandwidth than they paid for: "burstable" service. This excess capacity is also what makes the eZone possible – this excess capacity can be shared out to Fredericton's citizens at large. During business hours the bandwidth used by the city and by the eZone is limited to the minimum amount of bandwidth that the city has paid for, and outside of business hours (when paying customers are not using as much bandwidth) the amount available for the eZone is much less limited.

The eZone is a hybrid network using unlicensed and unlicensed spectrum, and a combination of hotzones and point-to-point wireless. When designing and building the eZone, the network managers chose Motorola radios sold and serviced by local vendors. They connected these radios, which use open radio spectrum and 802.11 b/g standards, to the Cisco wireless backhaul equipment, some of which uses licensed radio spectrum. The city designed its Wi-Fi network to use easily accessible, standard equipment that could be maintained by a local contractor. They have thus chosen robust, industry-standard equipment and have attempted to create a network that is functional and usable given the technology that most residents will have or are likely to purchase.

The network is built out using radio antennas mounted on city owned property. Each radio broadcasts Wi-Fi signals, and also connects to backhaul bandwidth wirelessly – sometimes this wireless backhaul uses unlicensed radio spectrum at 2.4 GhZ and sometimes it uses spectrum licensed for public service use at 4.9 GhZ or 5.4 GhZ. When E-novations began building the eZone, they encountered interference from other radios, as well as from other devices operating in the same parts of the radio spectrum, especially because they were connecting all of their radios to one backhaul bandwidth point, overwhelming the antenna with "broadcast storms" where radios malfunctioned. Eventually, they separated the network into three "virtual networks",

each with its own broadcast "tower" connected to the fibre network. Basically consisting of an antenna mounted on a tower, spire, or building on a hilltop, each "tower" acts as a relay point between the Wi-Fi antennas covering each eZone hotzone, and the bandwidth available on the network. Each of the three virtual networks has a single point of connection to the fibre network: one is on the city water tower, one on a clock tower, and one at the city's Knowledge Park business park. These points of consolidation communicate using wireless backhaul to city broadcast radios, who broadcast Wi-Fi signals. The airport's eZone hotspot is connected to the fibre network directly via fixed point-to-point wireless, which was originally intended as a means of including this distant location to the fibre network without laying expensive fibre-optic cable. All of the eZone traffic is consolidated through one single city server that authenticates the use of the network based on computers' MAC addresses. The network design reduces interference and allows the fibre ring's backhaul to be distributed to access points across the city, and for eZone traffic to be managed through a central server. This server includes a firewall and other management tools, including a gateway server that produces a captive portal page for each user of the eZone Wi-Fi network. This portal page includes the terms of service for the network.

5.3 Security

Security is an issue on an open network. The Fred-eZone does not require users to log in when they begin a network session; however, their MAC addresses are recorded when they begin a session. MAC addresses associated with abuse of the network are blocked. Recording MAC addresses has allowed the eZone to block users who abuse the network by sending spam or using too much bandwidth. Once, the MAC address tracking made it possible to correlate the MAC address of a stolen computer to a specific Wi-Fi antenna, allowing police to locate the area where the computer was located.

Originally designed as a completely open network, after the first year of operation network management software installed on the server determined that the eZone was being heavily used for peer-to-peer traffic and for sending spam. As a result the upload speed and download speeds on the network are reduced during the day, peer-to-peer traffic is rate-limited, and known virus ports are blocked. While ports that use mail sending proxies like SMTP are not blocked, there is a limit of 10 messages per day sent using SMTP, and outgoing mail messages sent using SMTP proxy are intercepted and run through an anti-virus program. The network managers monitor this process to determine how many spam messages are caught.

5.4 Openness and ideal uses

The network managers are considering requiring their users to register with a valid email before each session, but they are not convinced that this will provide much increased security since email is an unreliable means of identifying illegitimate use, since someone wishing to abuse the open network could invent a false email address. Although in many ways the Fred-eZone network is managed using a variety of

strategies to reduce excess consumption of bandwidth, to limit spam and peer-to-peer traffic, and to attempt to identify users to mitigate against abuse, it is also a public service network, intended to be open and accessible for citizens and visitors to use without too much restrictiveness. The city's network managers describe their ideal uses of the network as primarily the use of email and web browsing for short-term communication needs when not at home or at work. Although the initial "killer app" for the network was peer to peer traffic (one of the managers remembers receiving emails from major media companies who had tracked a large amount of P2P traffic back to Fredericton), after the network managers reconfigured the network, the majority of traffic is http or Web traffic: looking at websites, sending email, or using chat clients that do not consume too much bandwidth. During the day, downloading video or sound is difficult because of the reduced data transfer rate. The Fred-eZone model for a municipal network is rather restrained: although the community network extends farther and farther every year to serve corporate members of the network and new city buildings such as the new recreation complex, fibre is no longer provided in residential neighbourhoods. The Wi-Fi network, for its part, is not intended to replace home internet connectivity and is relatively restricted in terms of available bandwidth, support, and reliability. The eZone is a "best-effort" network: its managers explain that while they make efforts to ensure that all equipment is working properly and monitor the network's normal operations, they do not have dedicated client support. Online forums for users were removed after they received spam. While there was no explicitly desirable use for the network, a 2004 speech by Maurice Gallant, one of the network's founders, invites visitors and residents to "imagine checking your email just before that important meeting for the latest sales numbers or price quotes. Imagine checking your calendar in the client's office to see when you are available for follow up. Wi-Fi makes this possible" (Gallant, 2004).

5.5 Reliability and maintenance

The overall cost of deploying the eZone, including the $45,000 loan provided by the city to E-Novations, and the $250,000 of equipment provided in-kind by Cisco systems, is estimated at $450,000. When the project began, three city employees worked full-time on designing and deploying the networking. Currently, the equivalent of one half to one full-time position is occupied with monitoring of the network and the direction of maintenance. Costs for deployment and maintenance are rolled in to the city's telecommunication budget, which was significantly reduced by the creation of the community network. Thus the savings that this networking project created for the city are transformed into a public benefit in the form of the open Wi-Fi network.

Network reliability is best effort, and during fieldwork about seven of the access points of 128 were down at any given point.

6. Influence of Public Information Infrastructure

Overview

The eZone Wi-Fi network is currently in maintenance mode and is no longer expanding. It covers about 40 per cent of the city, accessible mainly over city-owned property like parks, but also over most of the downtown core and in areas visited by the public, like malls, cafés and bars. Providing the free network in these areas defines them as "public" areas – either as part of publicly-owned land or as areas where visitors are expected to take advantage of public services such as Wi-Fi or visit with others. The internet access itself is the eZone's key service: while an opening page asks users to agree to a user agreement, this opening page provides minimal interruption in the use of the internet. The bandwidth available for eZone users is relatively limited, and no mobile use is possible, since the signal drops between zones.

6.1 Applications

Logs from February 2007 indicate that several hundred users are online at any given period of the day, with peaks in usage at times when workers are on coffee break or away from their offices. The most popular access points are a downtown coffee shop, in the public library, at a coffee shop in the suburban mall, in a university computer lab, and at the truck stop on the highway. University and high school students, teachers, and workers who shared offices used the network in the downtown area during the fieldwork period, while the access point in the café at the mall were used primarily by university students and professionals for research, meetings or for email and game-playing after work.

From the perspective of the end user of the eZone, the service is relatively easy to use with a laptop computer or PDA with a browser. At the beginning of a session, the user is redirected to a captive portal page, where he or she must agree to the terms of use by clicking a button before being redirected to his or her regular home page. However, the necessity of using an https:// page to authenticate means that only devices with browsers can be used, eliminating the potential of using Wi-Fi equipped VOIP phones on the eZone.

The city did not specifically consult with end users before planning the network, but had a specific idea of what kind of uses they intended: specifically, web surfing and emailing for short periods in between home and work. They also initially developed an open resulting in unintended uses like peer-to-peer traffic. By restricting the amount of bandwidth available to the eZone during business hours, eZone managers have now configured the uses of the network to more closely resemble what they initially imagined. As the usage evolved in a direction unintended by the planners, they reconfigured the network's parameters to fill the niche that they had planned for.

This niche does not include bridging the digital divide. While there are still four CAP sites in New Brunswick, providing internet access for free or minimal cost, the City has never been interested in taking responsibility for these projects: "you end up wearing the problem forever. Who supports it? Who buys equipment? Who installs registered software?", one of the city employees said in interview. In locations like the public libraries, CAP programs funded by the province or the federal government coexist with Fred-eZone Wi-Fi service. The CAP site computers use wired broadband, not the eZone.

6.2 Impact and benefits

The IT projects developed by E-novations had economic and social impacts. Initially, community fibre network benefited Fredericton's business climate by lowering the cost of high-speed connectivity for business clients. As for the eZone, it helped to define public spaces as networked spaces, and contributed to the framing of Fredericton as a "smart community" and an IT centre. In the past seven years, the city has developed a small IT cluster of around 20 companies, as well as the IT business incubator at the National Research Council located in the city. Interviews with employees at IT based companies indicate that, although it does not serve businesses directly, the eZone is useful for their business, since it permits visiting colleagues to use the network in public areas and in some business locations. However, business owners place more emphasis on the eZone as a representation of their city's identity. Anecdotal evidence from the economic development and tourism departments indicates that Fredericton's identity as a "smart city" is bolstered by the presence of the E-Zone. References to the Wi-Fi project are present in marketing material and mentioned in economic development pitches. "Success stories" related by the network's builders include stories of businesses offering connectivity to visitors during meetings, real estate agents using the eZone to consult listings while traveling around the city, and students using the network in cafés or in their downtown apartments where connectivity is available. One story heard several times during fieldwork described a family who was moving to Halifax and stopped to visit family. They used the E-Zone during their visit and this combined with the city's culture made them decide to relocate to Fredericton instead. This story includes the E-Zone with other attributes that make Fredericton attractive to visitors and new arrivals.

Visits to the library and other public locations including cafés and the university suggest that the eZone is used regularly in public, as are the publicly-available computers provided through the CAP program. However, although it is not intended to offer household access, some people encountered during fieldwork indicated that they used the eZone at home, but since the signal was weak, they needed to use antennas, and could only gain access in one part of the house.

It difficult to tell what specific impact the eZone has had on Fredericton as a whole. Constructed as a free, open network, the bandwidth restrictions during the day mean that it is difficult to use the eZone during the day for much besides sending e-mail,

visiting web pages without video or embedded graphics, and using chat clients. As well, its limited range of coverage means that most residents do not use it on a regular basis, unless they have inadvertent home coverage by the network, or when they specifically choose to visit a public location with their computer. This suggests that visitors to the city may be the targeted public for the eZone. More research needs to be conducted to determine if the uses of the Wi-Fi network have specific public benefit.

6.3 Policy/regulatory/legal context

Sales of services on the community network are regulated by the CRTC, as E-Novations is licensed as a non-dominant carrier. As a non-dominant carrier, E-novations and the community network only serve commercial customers. There are no plans to expand Wi-Fi service beyond the relatively restrained, free service in public areas, suggesting that E-novations and the eZone do not currently provide much competition to commercial providers. These factors make it unlikely that there will be any specific challenges to E-novation's status as a non-dominant carrier.

A greater technical and policy issue may be interference between the eZone and other Wi-Fi networks. Fieldwork suggests that interference with and competition between an increasing number of Wi-Fi access points may become a factor in maintaining service as the network ages. The network can use spectrum reserved for municipal services, at 4.9 and 5.8 GHz in addition to unlicensed spectrum at 2.4 GHz. The wireless backhaul services use both of these portions of spectrum. During fieldwork several of the access points worked only intermittently because of interference on commonly-used channels, and network surveys using NetStumbler revealed 642 access points in the area covered by the eZone. Considering that the E-Zone provides 120 access points, this suggests that there could be as many as six access points in some of the areas covered by the eZone.

As of yet, E-Novations has no plans to restructure the network to respond to these potential interference problems. Potential solutions might include using proprietary mesh technology that operates on other portions of the spectrum, thus eliminating the potential for interference with other devices operating within the 2.4GHz unlicensed spectrum range. However, mesh networking technologies are expensive and some require end users to purchase expensive proprietary receivers. Pursuing a solution such as this might contradict the E-Novations approach of using tested, industry standard equipment that is owned by most of its potential users. However, as the network ages the network managers may have to try and balance the increased costs (either financial costs resulting from more expensive equipment or innovation costs from adapting to new types of equipment). At present, Wi-Fi is perceived as being an adequate technology for the purposes of creating a free network to be used in a limited number of locations. Mesh networking technologies running on unlicensed spectrum might alleviate some of the potential interference problems if meshed radios, which broadcast as well as receive signals, could be added to the network to repeat or bounce signals from one radio to another in areas of interference.

7. Lessons Learned

Two key elements of the Fredericton approach to connectivity may serve as examples to other projects: first, E-novations, through its ties to the municipal government and through public ownership, defined broadband as a public utility. Second, the small scale of the project – both in terms of the area covered and in terms of the close relationships between major actors – means that the eZone was built on a community scale. The eZone's public ownership is one of the key innovations that this project provides to municipal networking. As compared to municipalities in the United States where laws prevent public ownership of telecommunications, E-novations was able to obtain a license as a non-dominant operator and thus structure broadband access as a public utility. The strong interpersonal and professional ties of many of the E-novations team assisted in creating working relationships that created enough trust to leverage the fibre network into a community service, through the use of municipal infrastructure, and also facilitated the innovative addition of the Fred-eZone Wi-Fi zone. The community scale of the innovations in Fredericton allowed the network's structure and purpose to align with the structure and purpose of the municipal IT department, and thus gain access to public infrastructure managed by other city departments.

The way that the eZone, once developed, was adopted as part of the city's economic development strategy illustrates how connectivity can become a key pillar of community identity. However, it is important to note that the discourse of Fredericton as "Smart Community" or "IT Capital" emerged after the fibre network and Wi-Fi zone were developed, rather than as a means of justifying the construction of these infrastructures. Connectivity in Fredericton expanded along with the city's identity as a regional communication hub. Still, more consideration from city developers needs to given to the specific use of the Wi-Fi network. At present, the network primarily serves to facilitate occasional connectivity as opposed to bridging the digital divide or providing services or applications over the Wi-Fi network. Given the increasing interference between eZone antennas (which are not designed to overwhelm other Wi-Fi signals) and the increasing number of other open Wi-Fi networks in the city, the eZone's managers should carefully reconsider their network's purpose, and make adjustments to the network's structure and function in keeping with this purpose.

The practical goals initially articulated by the E-Zone's designers were modest: they provided a relatively restricted internet service in public areas, at a best effort service delivery. Although residents use the eZone in their home, it was never intended to provide residential coverage. While the fibre network provides public infrastructure as does, for example, public water and sewer services, the Fred-eZone wireless cloud provides public service using the metaphor of a public park. However, in contrast to Fredericton's actual public parks, where visitor centres provide a place to meet, hiking trails provide a direction, and organized activities have evolved, the eZone still appears to be an empty field. While other cities planning municipal wireless projects might learn from the pragmatic approach of the eZone's developers in solving their city's

high connectivity costs, using networked city services, as well as in their definition of "public" Wi-Fi, the eZone could learn from community wireless networks like Montreal's Île Sans Fil that have developed community media platforms for use in wireless hotspots, or from Austin Wireless Cities, that provides social software and location-based information at wireless hotspots. While for the moment these applications may not seem to fit with the culture of careful, financially-savvy planning evident in Fredericton, they do effectively extend the public nature of the eZone's network, and respond to the question of why (besides as a demonstration project) a city would develop, deploy, and maintain a free public Wi-Fi network.

8. Conclusion

Public water service or a Public park?

What are the positive and negative elements of creating this kind of "public" identity for Wi-Fi? Should the city have gone farther and created a different kind of symbolic form for "public" Wi-Fi? It could have been considered using the metaphor of "public water systems" rather than "public parks". This would have meant designing the Wi-Fi or fibre network to provide universal access to bandwidth. As it currently exists, the Wi-Fi network is primarily useful in providing email and web access in public locations, but does not follow through on the cost-sharing extension of connectivity that the co-operative wholesale model of the fibre network provided to the municipal government and businesses. Instead, eZone hotspots serve occasional Wi-Fi users in public places, but also perhaps pay a symbolic function: they help to mark certain areas as public, and to establish Fredericton as a networked, outward-looking, "smart" City. While this symbolic function plays an important role in the city's strategic plan and in its branding to tourists and investors, E-novations should also consider the eZone's potential as *communication* infrastructure, and think carefully about the metaphors they choose to describe how their city will communicate.

eZone network managers have three choices for the future of their network. First, they could decide to extend the network using the metaphor of the public water service, covering more of the city with Wi-Fi and changing the authentication procedures so that the eZone could be more easily used for voice traffic. This could potentially cut individual citizen's communication costs, much as community fibre helped businesses cut their costs. Second, they could continue developing the metaphor of the eZone as a public park by developing services and applications that augment the "public spaces" where the eZone is available. City news pages, location-based services, or citizen media or democracy tools might form part of this development. Third, E-novations could leave the eZone as is, with minimal investment for upkeep. Even this choice would require responding to the increasing interference between eZone access points and the increasing number of other unlicensed Wi-Fi access points. However, in an age of declining public infrastructure, this choice would seem not to take enough advantage of the public communications infrastructure that E-novations has already constructed. In short, after having indicated an innovative way of solving a practical connectivity project and developing a means of relating public networking to public space, E-novations and Fredericton need to decide whether and how to pursue policy and technical innovation on their networks.

9. Acknowledgements

Production of this case study has been made possible through a financial contribution from Infrastructure Canada. The views expressed herein do not necessarily represent the views of the Government of Canada.

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