Sharing Wireless Internet in Urban Neighbourhoods

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Introduction

Over the last decade, Internet use in countries around the world has grown dramatically. This is especially true in Canadian cities, and Canada is widely acknowledged as having strong broadband penetration rates (Frieden 2005; Wu 2004). Residential households are increasingly adopting Internet technology and using it in their daily activities. In large urban centres, Internet usage rates approach 80%, overwhelmingly via broadband connections (Statistics Canada 2006). Users commonly report using the Internet for many facets of their lives, including communication, entertainment, and information-seeking in the home, at work, and at school (Dryburgh 2001).

One development that in particular has influenced the growing use of Internet services is the standardization of wireless Internet technology. Wireless Internet, commonly abbreviated as WiFi for "wireless fidelity," is based on the IEEE 802.11 group of protocols. The 802.11 "b" protocol was introduced in 1999, primarily to extend or replace traditional wired networks with a wireless equivalent (Varshney and Vetter 2000, pg.74). Since then there has been rapid growth and development in the wireless market, with wireless technology such as routers and antennas becoming both abundant and affordable for the home consumer. Schmidt and Townsend (2003) noted that in 1999 wireless base stations cost as much as $1000, but only four years later the price had dropped to $100. Several

authors have attributed this drop in consumer cost to the explosion in home networking (Damsgaard et al. 2006). Wireless "hotspots" in public spaces such as cafes and airports have also become more available (Battiti et al. 2005, pg.278). In addition to its practical benefit in urban areas, WiFi has been shown to be very useful as a means of connecting disadvantaged, rural, isolated, or smaller communities where cabling costs may be prohibitive (Tully and Riekstins 1999; James 2001).

The effect that this explosive growth of wireless networking has had around the world is striking. It is estimated that roughly 200 million WiFi chipsets were sold in 2005 (Shah and Sandvig 2005, pg.7). Wireless networking is being used as a way to provide access where it was never considered before. Now wireless ubiquity is growing, and signals spread out to other people's areas and to public spaces. These signals often overlap one another and create dense "clouds" of wireless coverage. Such clouds have implications for both ad hoc local sharing between neighbouring homes and community-wide access infrastructure projects, two common areas of interest. Ad hoc networking refers to a haphazard organization of network nodes where nodes can move and organize arbitrarily (Mahmud et al. 2006, pg.1). In contrast, infrastructure networks use a planned organization and central administration of access points (Potter 2006).

Infrastructure and ad hoc networks represent the extremities on the spectrum of wireless networking possibilities and present different kinds of challenges, both technical and social. Ad hoc networking is arguably simpler, since it is as easy to create as leaving a home wireless router in an unprotected state. With this form of networking, some degree of trust and goodwill is expected of the user because all participants in that wireless network collectively share the bandwidth capacities of the connection. This can become more of an issue when access is shared among strangers (the "open" case) rather than trusted or at least authenticated parties (where access is authorized) because with anonymous strangers there may be no control over their usage. Sharing in well-resourced infrastructure networking, as exemplified by some city-wide WiFi projects such as those in San Francisco or Toronto, may pose less of an issue, with high-capacity backbones mitigating bandwidth contention. Furthermore, administration of the network and granting of access would likely be handled in a systematic and centralized way that prevented some forms of abuse, while creating other vulnerabilities with the potential of system-wide compromise or failure.

WiFi signal sharing is often inadvertent, the result of networks being left "open." Indeed, users are often cautioned about leaving their networks unprotected against hacking, privacy invasion, or unauthorized

use (Shah and Sandvig 2005). How do individuals feel about sharing in an environment with such concerns? Are people interested in sharing? What issues are important for wireless users? Under what conditions, if any, would people be willing to share? How are people who currently share doing so? What motivates them to do so? In terms of community-wide access projects, what are the issues that arise from the growing ubiquity of WiFi signal access? Many community-wide projects also make broad claims about addressing inequality of access while presuming communitarian values. These too need to be examined in light of wireless users' attitudes towards sharing.

In this paper we report on some of these attitudes as they were investigated among wireless users in urban, residential neighbourhoods of Toronto, Canada. The paper begins with a brief discussion of wireless Internet sharing, some background motivations for wireless community projects, and an overview of the attitudes we anticipated among participants. This is followed by an account of the study's methodology and its findings. The discussion section integrates these findings to shed light on how community-wide infrastructure and local, ad hoc projects might be developed; it concludes by identifying some of the key design features that could enable viable sharing.

Wireless Internet and Community Networking

When we consider the increasing number of wireless projects that have been announced worldwide (Vos 2005) and the high-profile nature of deployments in major North American cities, interest in deploying community and municipal networks seems to be developing rapidly. For example, Tapia and Ortiz (2006) identify nearly 360 municipal wireless projects in the United States. There are likely many smaller, less formalized, grassroots initiatives as well.

The interests and objectives of community and municipal wireless Internet projects can be loosely grouped into two broad goals – improving access through wider availability and lower costs and improving democratic ownership over public goods, in part by gaining control of communications infrastructure that would otherwise be in the hands of private telecommunications companies (Gibbons and Ruth 2006; Goth 2005; Sandvig 2004; Lentz 1998).

There may be additional benefits for these community networks. "Digital communities" such as the Blacksburg Electronic Village (Casalegno 2001) and Netville (Hampton and Wellman 2003) demonstrate

some of the benefits of using computer technologies to promote community organization and relationships. These benefits include facilitating communication through email lists and local-content Web pages. Such opportunities can improve social interaction and inclusion among members of a community. Indeed, even smaller-scale operations such as opening up one's wireless network to neighbours may foster improved social relationships, above and beyond the benefits of cost-sharing.

Attitudes Towards Sharing and Wireless

When we consider the potential benefits of wireless projects utilizing connection-sharing, it is important to examine what attitudes may exist or be anticipated. For example, people's attitude towards a product or service is often influenced by external factors, such as other people and media sources. These factors may affect how individuals perceive something and lead to changes in their personal opinions. Rogers (2003) called such elements "change agents," from his earlier work on the diffusion of innovations. Consider that in the wireless case, individuals may be swayed by change agents to adopt it for its mobility, but at the same time be warned to encrypt their networks to prevent signal theft or hacking attempts. This concern may further affect individuals, depending on their personal disposition towards the Internet. Individuals accustomed to a dedicated home connection may be reluctant to risk a reduction in their bandwidth or service slowdowns as a result of sharing.

When considering whether to adopt a recognizably superior infrastructure service to replace their current ISP, customers may be deterred by high "switching costs," defined as "the psychological, physical, and economic costs that consumers face in switching between technologies" (Pae and Hyun 2006, pg.19). Such costs may include the inconvenience of changing email addresses, the purchase of new equipment, or entering into a new contractual agreement. Particularly with telecommunication or cable companies that offer bundled services (e.g., television, phone, and mobile service agreements), it may be increasingly difficult to justify the switch to another service provider, even one with the benefits of wireless networking.

Finally, in addressing issues of sharing, it is important to consider attitudes and perspectives about trust, particularly with neighbours or other members of the community. Individuals may not want to share with others because they are wary of how others may use their connection or

concerned about computer privacy and security. Furthermore, individuals may be reluctant to share on the basis of contractual restrictions in their ISP's Terms of Service or User Licensing Agreements. On the other hand, splitting costs or helping out neighbours who could not otherwise afford Internet service may be powerful motivators for sharing.

Methodology and Findings

The study made use of both qualitative and quantitative data collection, carried out in two distinct phases. First, we conducted radio surveys of wireless signals in two urban neighbourhoods in October and November of 2005. Between November 2005 and May 2006 we then recruited current wireless users for two successive questionnaires, followed by in-depth interviews with selected questionnaire respondents.

Radio Surveys

Radio surveys were conducted in order to assess the intensity and forms of wireless use in residential neighbourhoods. A receiver was used to passively detect wireless Internet radio signals of the 802.11 b/g standard operating in the 2.4 GHz frequency range. The purpose of these surveys was to examine the kind of wireless signal density available in these two areas. The data were collected using a number of tools. A HP-Compaq TC4200-tablet PC with an integrated Intel PRO/Wireless 2200BG Network adapter acted as the receiver. The laptop ran the application Network Stumbler, Version 0.4.0 (Build 554).[1] The laptop was placed inside a backpack, and one of the researchers walked up and down the streets in the chosen neighbourhoods. A Pharos GPS receiver was connected to the laptop to provide coordinates. The radio surveys were conducted in two downtown Toronto residential areas, selected primarily for convenience. The first survey zone constituted a roughly 1 square km area, while the second was approximately 0.16 square km. These two zones can be characterized as older, urban Toronto neighbourhoods, and as such, they were typical of large areas of the residential city core. Both were relatively affluent in that zone one had median family income equal to the average for Toronto, while zone two had above-average median income.

The results in table 1 present the findings from the two radio surveys that were conducted.

[1] www.netstumbler.com

Table 1: Wireless radio survey results

Zone one (1km^2)	
Number of named networks detected	219
Number of encrypted named networks* (N=219)	127 (58%)
Number of unencrypted named networks** (N=219)	92 (42%)
Number of unencrypted named networks w/ default SSID*** (N=92)	44(46%)

Zone two (0.16 km^2)	
Number of named networks detected	77
Number of encrypted named networks* (N=77)	37(48%)
Number of unencrypted named networks** (N=77)	40(52%)
Number of unencrypted named networks w/ default SSID*** (N=40)	19(40%)

* Encryption schemes included WEP, WPA, AES.

** Unencrypted does not necessarily mean accessible: there may still be a password-based log-in.

*** Default SSIDs were interpreted from known manufacturer names such as Linksys, DLink, SMC, and "default"; however, care should be exercised with this value.

These results indicate fairly high wireless density in these urban areas, with an average of 206 named networks per square kilometre. In zone one, with approximately 1500 houses, this figure represents about 1 antenna for every 7 houses. In zone two, with approximately 480 houses, the density is 1 antenna for every 6. Of the networks detected, an average of 53% were encrypted. While an average of 47% was unencrypted, 63 networks were in their original "open" default state, representing about 22% of the 296 networks detected. This finding conversely suggests that 78% of the networks had been modified by their owners in some way. Sixty-nine signals (or 24%) had modified names but were left unencrypted. From their names it appears that few used captive portal technology and so likely indicated some explicit willingness to share unrestrictedly.

Questionnaires and Interviews

The second phase of the study utilized two online questionnaires and a number of one-on-one interviews with selected questionnaire respondents. The first questionnaire was a short, Web-based online survey that contained 15 questions pertaining to Internet and wireless use (as well as participant contact information). The primary objective in using the short questionnaire was to produce a general picture as to what kind of Internet service individuals were using at home by asking questions about their Internet provider and how long they had had Internet access. A total of 58 people responded to the short questionnaire. Participants were solicited via

flyers distributed in the university area, as well as the two radio survey zones. Participants were also solicited from the Faculty of Information Studies mailing list and the Department of Computer Science electronic forum. A Toronto-based co-operative ISP called Wireless Nomad also assisted in recruiting by displaying a link to our research website on its website and among its subscribers. The questionnaires sought individuals who were currently using wireless Internet at home, school, or work.

The second questionnaire was also an online survey that was significantly more detailed than the first and contained 42 questions pertaining to Internet and wireless use and 7 questions about personal information. Forty-three participants from the first questionnaire indicated a desire to continue participating in the study. However, a total of 33 participants eventually responded to the long questionnaire, for a 77% response rate.

From the participants of the second questionnaire, approximately half were solicited for potential participation in interviews. These individuals had indicated a willingness to be interviewed on their questionnaires or had left many additional comments on the questionnaire forms (suggesting they had more to offer the study). The study was interested in speaking to individuals who reflected a range of opinions on wireless Internet use and sharing, although no particular attitudes towards it (either supportive or unsupportive) were sought. The interviews were semi-structured and lasted for approximately one hour. Nine participants who were available were interviewed.

The questionnaires and interviews asked an array of questions on the issue of wireless Internet use and sharing, and the results in the following tables summarize some of the key questions and responses. The demographic data for the second questionnaire is shown below (table 2).

Table 2: Demographic data from the second questionnaire

Gender (N=32)	
Male	23 (72%)
Female	9 (28%)
Age (N=33)	
20-29	25 (76%)
30-39	5 (15%)
40-49	2 (6%)
50-59	1 (3%)
Employment status (N=33)	
Employed full-time	14 (42%)
Full-time student	16 (48%)
Not working	1 (3%)

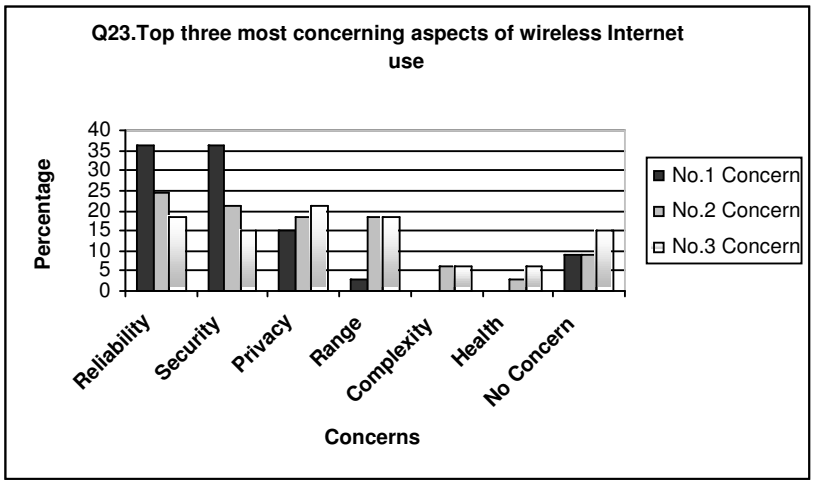
Combination of work and school	2 (6%)
Highest level of education attained (N=33)	
High school diploma	8 (24%)
College diploma or undergraduate degree	17 (52%)
Graduate degree	8 (24%)
Yearly household income (N=30)	
Less than $25,000 a year	7 (23%)
$25,000-54,999 a year	9 (30%)
More than $55,000 a year	14 (47%)

As the demographic data suggest, respondents can be characterized as predominantly young, affluent, educated males. Slightly more respondents were full-time students than employed full-time. Clearly, these results are not characteristic of the general Toronto population; however, they may be more indicative of the kind of individuals who use wireless Internet.

Participants were asked to rank their concerns about using wired and wireless Internet. Figure 1 shows this ranking. For wireless access, security and reliability were tied for the number one, most frequent concern. In the wireless context, security was described by example as "people cannot access your network or use your connection" and signal reliability as "the strength and quality of the radio signal, lack of interference."

Comments in the interviews shed some light on why this emphasis was placed on security. Interviewee A said, "If someone that I didn't know was [using my connection] and I didn't know why [or] what they were up to…that would be a concern" (19:53). Interviewee E said about unauthorized access, "I think that however you slice it, then I would feel a little bit like 'wait a second, you're stealing from me.'" (25:15). Interviewee H, who felt that she had personally been affected by unauthorized access, said, "I would have said it's like a radio station. You're just picking up someone's signal and there's no harm … but now that I see you're using someone else's bandwidth and it…slows down other people's connections, I think I feel differently about it" (22:27).

Fig. 1: Ranking of wireless Internet use concerns



Many respondents felt strongly about reliability, as demonstrated by their responses and comments or their bringing up the issue themselves (in the interviews). For example, respondents commented that one of the reasons they would use other people's wireless signals would be when their own failed. One respondent commented that "on the rare occasions when our router's signal strength falls for a moment and I get disconnected on my laptop, I use the other people's signals as a brief backup to continue whatever I'm doing"; another said that "once my own DSL line was down, but my neighbours wireless was up." Reliability was also found to be more important to participants than who their provider was. That being said, most participants felt that their current connections were of at least moderate value and were generally satisfied with their providers.

When it came to sharing, our participants appeared resistant if they were not informed ahead of time. Conversely, participants were asked if they used other people's wireless without asking, and if so, whether they felt any guilt over their actions (see table 3).

Table 3: Attitudes to unauthorized wireless use and using other people's wireless signals

Q36. "I don't mind if people use my wireless signal without my knowledge." Do you agree or disagree with this statement? (N=32)	
Agree	8 (25%)
No opinion or mixed feelings	6 (19%)
Disagree	18 (56%)

Q27. If you have used other people's wireless signals before without their knowledge, how do you generally feel about this? (N=28)	
Feelings of guilt	9 (32%)
Not sure	1 (3%)
No feelings of guilt	18 (65%)

Question 27 is an approximate gauge of the attitudes that respondents exhibited when it came to using other people's wireless signals without permission. Most respondents seemed to exhibit little or no guilt over doing so, even though it was an activity that three of the interviewees considered theft, stealing, or leeching. Some respondents seemed able to justify such practices because they did not feel they were doing anything wrong. For example, in comment to question 27, one of the participants wrote, "I'm doing nothing illegal while on the Internet, and I only use it for urgent things," while another wrote, "As long as I'm not d/l-ing [downloading] enough to affect their maximum d/l [download] limit a month, or slowing down the provider, I don't think it's a big deal." Others even felt that individuals not encrypting their network was their own fault and that they should bear the consequences, presumably in this case someone else using it without permission. For example, one online questionnaire respondent commented that "people with wireless networks should have the knowledge to secure them from unauthorized use, or at least understand the risks." Another respondent went so far as to state that "everyone should know how to put on an encryption key. If not, it's public domain for public use." Notably, no respondents mentioned either via comments or in the interviews the legal status of sharing a wireless connection in the context of their relationship with their ISP. Thus this factor was probably not an important issue in sharing for our respondents.

Respondents had an interesting view of permission with regard to other people using *their* wireless networks. While many respondents seemed more open to sharing if others asked first, that support dropped dramatically when it came to people using it without asking first. The discrepancy between question 27 and question 36 should be noted. While 65% (N=28) of respondents felt little guilt about using *other people's* signals, nearly 55% (N=33) disagreed with other people using *their* signal without permission. This finding may be interpreted as respondents being comfortable with sharing signals, just not their own. Only 8 of the respondents indicated that they would not mind sharing without their knowledge.

To further test this result, a Goodman and Kruskal coefficient of ordinal association (Gamma) test (Freeman 1965) was calculated for participants' responses to Q27 and Q36. The Gamma value was 0.456, suggesting a moderate positive association between feelings about the participants' own unauthorized wireless Internet use and how they felt when other people used their wireless Internet without asking. It appears that for the participants, as feelings of guilt about using other people's wireless increased, they were more agreeable to other people using their wireless without asking. This response may be due to feelings of justification or reciprocity. That is, participants felt badly about using wireless without permission; so they opened their own networks to reciprocate, presumably to the general public. Or, in another sense, if they "took" from the "general pool" of wireless access, they contributed back to it. Some participants did note an interest in trying to make their wireless activities better known, as well as some interest in promoting community or neighbourhood initiatives (see table 4). Conversely, the Gamma value suggests that participants who felt less guilty were also more disagreeable about other people using their wireless. In this case, as the interviewee comment suggests, it is your own fault if you do not encrypt your wireless. So someone who uses it without permission is not really "at fault."

Table 4: Attitudes about greater sharing awareness and desired shared network attributes.

Q39. "I would feel better about using other people's wireless signals if I could thank them or let them know that I was using it somehow." Do you agree or disagree with this statement? (N=30)	
Agree	20 (68%)
No opinion or mixed feelings	5 (16%)
Disagree	5 (16%)

Q41. Assuming that your concerns about using a shared wireless network were addressed, what characteristics or conditions would be of interest to you? Select all that apply. (N=33)	
Reduced monthly cost	27 (82%)
Ability to access free signals from home	22 (67%)
Membership in a co-operative	15 (45%)
Local/community Internet content	12 (36%)
Promoting access for others in your neighbourhood	13 (39%)
Not interested at all	2 (6%)

Question 39 suggests that most participants would be in favour of removing some of the anonymity of wireless sharing by being able to identify themselves or thank the person who was sharing his or her wireless signal. Question 41 also indicates some support for other neighbourly activities such as promoting access for others, viewing local or community Internet content, and entering into co-operative membership for the service. However, more "selfish" motivations were more appealing to participants, such as reduced monthly cost and accessing free wireless signals from home. Furthermore, participants expressed reservations about paying extra for some of these neighbourly or community activities.

Discussion

The findings from our research shed light on the prospects for two quite different perspectives on wireless Internet use and sharing: that of the community-wide infrastructure and that of local, ad hoc sharing. While these two models are at the extremes of the wireless Internet network deployment spectrum, with models such as hotspot access somewhere in the middle, they represent two key means of access.

Infrastructure deployment

The use of large-scale infrastructure-based wireless systems can vary greatly from project to project, and it should not be suggested that they will have universal deployment. Municipal and community projects may be publicly owned and deployed like other utility services such as water or power. They may also be privately owned, with consumers subscribing to these services in much the same way they subscribe to their current ISPs. In this particular study, some questions posed to participants (questions 40-42) dealt with a hypothetical shared wireless service that would be centrally administered by a provider. In this kind of arrangement the findings generally suggest that the key factors for participants in choosing a particular Internet service are reliability, security, privacy, and speed. To a lesser extent, lower costs are valuable too. What is interesting about our findings is that in a market such as Toronto, dominated by two major Internet providers, participants were less concerned with the brand or the company providing the service than with the functional aspects of the system. Furthermore, whether or not the system was deployed wirelessly instead of the more conventional wired service mattered only insofar as it affected reliability, speed, and privacy. However, it does also seem evident from participants' responses that subscribing to a service entails certain

expectations for good-quality service, as well as other typical features such as technical support and customer service. Thus the conclusion we draw from our research regarding wireless infrastructure adoption is that if the system is proposed to prospective users like any other ISP, even if wireless-based, consumers would consider its adoption much as they would choose between any other service providers. Unless there were very clear advantages to the wireless service, the switching costs would likely discourage a change in provider.

Local Ad Hoc Sharing

Deploying networks in a local ad hoc arrangement is arguably a more difficult proposition. In addition to its being subject to the same concerns as infrastructure networking, there are other issues. Firstly, respondents seemed interested in a shared network service primarily for what it could do for them (things such as reduced personal costs, better reliability of the connection, greater availability of signals, and so forth). Of course, this is an entirely predictable attitude: there was never any expectation that respondents would put the needs of others in the community above their own or their household's. Indeed, as Gaved and Foth (2006) note, building in such community-oriented functionality does necessarily ensure participation and may in fact be perceived as a burden. Thus our findings suggest that if there is little perceived personal benefit to sharing, there will be great reluctance to share.

Secondly, we found a certain degree of comfort with the current tendency to use other people's signals anonymously. Participants seemed to justify this behaviour by classifying their own use as harmless. While there may be some interest in thanking or identifying oneself to the WiFi owner, this is not the same as entering into some systematic relationship, such as a shared wireless system. For example, one of the researchers, in a friendly way, identified himself to his neighbour and mentioned that occasionally when he lost his own Internet connection, he would use this neighbour's wireless unencrypted high-speed connection as a backup. A few days later, the neighbour encrypted his signal, preventing any further "backup" usage! Perhaps as an example of the kind of discrepancy that exists between sharing for one's own use and sharing with others, the neighbour even admitted to using other people's unprotected signals too.

As much as respondents may consider themselves open to neighbourhood or community participation, it is relevant to consider whether there may in fact be some deep-seated reluctance to creating these new social networks. Deploying a shared network as an expressly community-building exercise may start to trigger the question amongst

potential participants: "How well do I really want to know my neighbours?" – at least if it requires involvement with people beyond one's immediate circle of acquaintances. Gans (1967, 1968, as quoted in Hampton and Wellman 2003) found that "in a traditional suburban community, the most viable relationships are the most physically accessible, generally between those who live in homes that are no more than three or four homes distant" (pg.297). As this is typically the range of consumer-grade WiFi equipment, it could mean that one viable way to create neighbourhood networks would be to build upon very local cooperation arrangements. However, Hampton and Wellman (2003) caution that there may be psychological barriers to interacting with neighbours, specifically "a fear of embarrassment, a fear of giving offence, and a general fear of imposing on neighbours' commitments can also inhibit neighbouring" (pg.285). Foth (2006) also notes that while sometimes the role of neighbour may evolve into sustained friendship or social cluster, "in urban neighbourhoods, roles other than neighbour are not obvious, so socializing depends greatly on good fortune, fate, and serendipity" (pg.46). The results from our research seem to reflect these findings in that people appeared somewhat distant with their neighbours and only had selective contact with them.

People are often wary of the uncertain. Consider Kahneman and Tversky's *Prospect Theory* (1979), which suggests that when it comes to decision-making, "outcomes which are obtained with certainty are overweighted relative to uncertain outcomes" (pg.268). In this case, leaving one's network open to use would definitely have uncertain outcomes. Participants seemed to lack trust in strangers, in that opening up a connection would expose themselves to too great a risk of negative effects. These might be impairment of one's speed/bandwidth or the possibility of hacking or other security and privacy concerns. Sharing one's own network means potentially exposing oneself to trouble in exchange for the vague benefit of others (i.e., you may not even know who is sharing with you). This may be a questionable value proposition for wireless users and may explain the reluctance to share *with* others but also the ease with which users *take* from others.

The importance the Internet plays in the everyday lives of our respondents was also a factor in sharing. Zaltman (2003) writes that understanding the emotional benefits of a product or service is a strong component of consumer experience and that "for consumers, emotional benefits stem in part from the important values and themes that define and give meaning to their lives" (pg.18). For users for whom the Internet plays a significant role in daily life, fulfilling functions such as a communications tool, information source, or productivity and

entertainment centre, interruptions may not be tolerated. Consider that 72% (N=33) of respondents agreed that wireless Internet was less reliable than wired Internet. Furthermore, 79% (N=33) of respondents believed that sharing Internet connections impaired their speed/bandwidth. Our respondents seemed to highly value their Internet connections. Not only did 81% (N=33) of long questionnaire respondents consider themselves at least moderate Internet users, but 75% (N=33) of respondents also strongly agreed that they would have a hard time adjusting to life at home without high-speed Internet (question 32). Enjoyment and fun for the user might also be supported through their ability to play online games, share files via Peer-to-Peer networking, or watch streaming video, for example, all activities that consume relatively large quantities of bandwidth. Indeed, what might contribute to a reluctance to share is the belief that strangers might use an open network to participate in these high-bandwidth activities as well, which would impede shared network usage.

Opportunities for Sharing

Of course, the reality is perhaps not so isolationist and cynical regarding neighbourhood and community participation through Internet sharing. Indeed, our sample was composed largely of individuals without clear connections or community ties (although these may have existed without our knowledge). Closely-knit communities where individuals know each other and have strong social ties may be less likely to experience problems such as free riders or difficulty managing collective resources. For these kinds of communities, individuals may be comfortable talking to others about their use of the collective resource. There may be enough existing respect for the shared nature of the connection to discourage potential abuse. Even so, individuals may be more tolerant of minor impairments to their connection when utilizing ad hoc networks with friends and neighbours. Kavanaugh et al. (2005) write that their notion of community commitment is "related to an individuals' sense of collective efficacy: the belief that members of the community can pull together and act effectively to foster desired change" (pg.13). If an individual has a strong sense of collective efficacy, he or she is more likely to put a greater effort into a group endeavour – in this case, supporting wireless sharing.

On the other hand, in communities that are not close and are composed more of strangers, collective efficacy may suffer, and there may be no interest, and perhaps even distrustfulness, in sharing with neighbours. Since our data was collected from individuals who lived in many different communities, it is not possible to ascribe any results to one community in particular. However, results from our questionnaires

indicate a somewhat mixed picture on the specific topic of sharing. For example, when asked if they agree or disagree with the statement "I think that other people sharing the same connection I use will diminish my Internet experience," 51% (N=33) agreed while 39% disagreed (10% had no opinion or mixed feelings on the matter). In either case, for communities, a forthcoming study by Bina and Giaglis (2006) on the motivation of members of wireless community networks may shed some light on these choices and behaviours.

The permission questions suggest some flexibility. Most respondents supported sharing if permission was asked. Similarly, most did not support unauthorized sharing. This finding suggests that there is some tolerance among respondents for sharing as long as it is a pre-arranged agreement. Importantly, an underlying theme among respondents amenable to sharing was that the additional use would need to be "within reason." This was defined, albeit anecdotally, as shared use that did not infringe on users' own access (e.g., they did not detect appreciable connection slowdown) and that usage was fairly prioritized (with the sharer having priority over the sharee). There was a distinct sense that sharing in which others could dominate the connection was unacceptable to the individual making his or her signal available.

Among participants who generally viewed sharing negatively, there still seemed to be some support for the practice. For example, one interviewee noted how "silly" it seemed that in a high-density apartment building, each tenant was paying $45 a month for Internet access when a few wireless routers would easily cover all of them. Another interviewee remarked that she had shared her connection with others in her building who she knew could not afford high-speed themselves. Our results suggest that if users could be assured of the reliability of their connection and that their security and privacy were not in danger of being siphoned off via the airwaves, sharing would be a much more viable option. This research, then, lends support for sharing models such as FON[2] and Wireless Nomad,[3] in which one can choose to share with other service members, while the provider administration handles authentication and security/privacy. In these models, in exchange for sharing access from his or her own wireless router, an individual can access the signals hosted by other members of the network in a quid pro quo arrangement.

Our research also highlights a number of design features that might promote sharing among infrastructure or ad hoc networks. Notification or identification, to encourage the sociality of wireless

[2] www.fon.com

[3] www.wirelessnomad.com

networking and remove some of the anonymity of connecting, would be one. This would be helpful to both the sharer (to know who was using his or her signal) and the sharee (to alert the sharer and perhaps thank her or him). Secondly, a prioritizing scheme of some sort would be necessary to alleviate concerns for the sharer that he or she would be reduced to back-of-the-line access to the individual's own router. Finally, given the current somewhat selfish attitudes of many respondents towards sharing, there would have to be tangible benefit to the sharer beyond altruism or a sense of community participation. Cost-sharing, greater access to signals, and improved reliability would definitely constitute such benefits. Our research suggests that adopting such features would improve the prospects for sharing, even in urban neighbourhoods that were already well provisioned with Internet access.

Conclusion

The findings from our research provide useful insights about Internet usage and attitudes towards wireless. They suggest that respondents highly valued Internet access and that for many it had become heavily integrated into their daily lives. Furthermore, respondents placed great value on the mobility and freedom of wireless access, not only in their own homes but when on the move, at friends' homes, or in the city. Respondents generally seemed positive towards shared wireless Internet in their neighbourhoods, but unsurprisingly, they had a number of concerns about how such a service would be deployed, administered, and operated. In particular, for local, ad hoc sharing, an important question concerned what kind of benefit sharers could expect and at what cost. While currently, for sharers who simply open their wireless signals for all others to use, there seemed to be only vague benefits, outweighed by some well-recognized risks, our findings do suggest a number of design features which, if incorporated into future wireless networks, might promote sharing and create some more tangible benefits. In addition to ensuring the reliability, security, and privacy of an individual's connection, design features could include a notification/identification system, a prioritizing scheme to preserve dominant access to the sharer, redundant signal coverage, and a cost-sharing arrangement. Incorporating such features might go a long way to assuaging concerns that wireless users have about sharing and might improve the viability of wireless networking projects.

There are a number of limitations to this study, notably the small sample size and general lack of demographic diversity. As a result, readers

should exercise caution in generalizing from any conclusions found in this study to other communities and/or wireless experiences. However, while it may be the case that our sample is biased towards highly educated, Internet-savvy users, it is important to consider these individuals' opinions, particularly because they may be leading adopters of wireless technology and may affect others' choices within their spheres of influence.

Indeed, there is much work to be done in this field as new city WiFi deployments are announced and commercial wireless technology becomes more ubiquitous. It will be important, above and beyond the technical aspects of deploying shared networks, to understand the social dynamics of these networks and how potential users will feel about adopting them. As our study highlighted, people certainly hold a variety of opinions when it comes to wireless Internet and sharing.

Acknowledgments

The authors would like to thank all of the study participants, the Social Sciences and Humanities Research Council of Canada, and the CRACIN and CWIRP research teams for their support. We would also like to thank our reviewers for their valuable comments and suggestions.

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