THE MONIESON CENTRE

TRANSFORMING BUSINESS IN THE KNOWLEDGE ECONOMY

Knowledge Synthesis

AFFORDABLE RURAL BROADBAND

Dr. Abd-Elhamid Taha

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INTRODUCTION

This knowledge synthesis is part of the Monieson Centre's Knowledge Impact in Society (KIS) Project, a three-year endeavour to connect academic knowledge with economic development needs in Eastern Ontario. The synthesis is an accessible presentation of the latest research on issues affecting rural Eastern Ontario. The knowledge synthesis topics were determined through information gathered at 15 community workshops run in partnership with the Eastern Ontario Community Futures Development Corporation network. The KIS Project is funded by the Social Sciences and Humanities Research Council of Canada. For more information, visit www.easternontarioknowledge.ca.

Economic vitality in rural areas demands broadband Internet access, particularly in developing high-value sectors like the creative economy. In seeking to overcome the recent economic downturn, governments around the world have made providing broadband access a priority, in some instances recognizing it as a basic human right.[1] Various stimulus packages have thus invested in creating far-reaching networks to satisfy this objective. This Knowledge Synthesis discusses the challenges of deploying broadband Internet access in rural areas, as well as its benefits. The report includes discussion of the Eastern Ontario Regional Network (EORN), an initiative by the Eastern Ontario Wardens Caucus (EOWC) to extend broadband to 95% of rural Eastern Ontario.

The Need for Broadband Internet Access

The Internet has become a primary means of communication, employing a wide variety of media to facilitate learning, information exchange and understanding. The availability of reliable Internet access, however, is surprisingly lacking in substantial areas around the world. At a time where some countries have already recognized broadband Internet access as a legal right, lack of Internet poses a serious, detrimental hindrance to the personal and economic growth of many communities.

Statistics Canada defines "rural and small town" as those regions outside the commuting zones of centres with populations of 10,000 or more. The May 10, 2010 Statistics Canada Daily noted a persistent digital divide between rural and urban communities. Between 2007 and 2009 Internet usage was at least 10 percentage points lower in rural communities than in urban areas.[2] A view of Industry Canada's

[1] Don Reisinger, "Finland makes 1Mb broadband access a legal right", *CNET News*, http://news.cnet.com/8301-17939_109-10374831-2.html (Accessed Mar. 8, 2011).

[2] "Canadian Internet Use Survey," The Daily, May 10, 2010 http://www.statcan.gc.ca/daily-quotidien/100510/dq100510a-eng.htm (Accessed March 7, 2011).

National Broadband Maps provides a more detailed understanding.[3] The maps show the number of either un-served or underserved households per 25 square kilometers, represented as hexagonal areas. Examining the maps indicates that, as of 2009, there are still areas of over 800 households without broadband access.

To address this issue, in 2009 the Canadian Government made connecting rural Canadians part of its Economic Action Plan stimulus initiative, allocating $225 million over three years. Since then, several key projects have taken off through the *Broadband Canada* program, with the latest round of projects promising connectivity to a further 30,000 households nationwide.[4] Other government initiatives, including the *Rural Connections Broadband Program* from the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) have also contributed to extending broadband coverage to rural communities. *Rural Connections* alone has contributed over $10.6 million in Eastern Ontario since its inception in 2007. EORN has now accessed *Broadband Canada* funding, as well as matching support from OMAFRA and local municipalities, for a large-scale, regional project to extend broadband availability throughout Eastern Ontario by 2012-2013.

Technologies for Affordable Broadband Internet

A broadband network usually involves two parts: a backhaul and an access network. The backhaul is the main network, akin to large highways. The access network connects individual homes or small communities to the larger backhaul, much like local streets connect to larger highways. Fibre is usually utilized in the backhaul as it provides the greatest bandwidth and highest reliability. It relies on pulsated lasers to relay data for very long distances through very thin strands of high quality glass. These advantages, however, come at the high costs of extending the fibers through varying terrain. The backhaul includes many Points of Presence (PoP), which are access points to which a household would be directly attached.

There are several traditional technologies that can be utilized in creating a broadband access network:

- Wired technologies tend to be reliable, but are costly to install in areas with low population density:
    - Fibre-optic cable is highly reliable and has the greatest capacity for transferring data
    - Coaxial broadband utilizes the same infrastructure used by cable TV, a technology not generally available in rural communities
    - DSL (Digital Subscriber Line) communicates over regular phone lines but using dedicated modems. DSL differs from dial-up Internet access in that it utilizes non-audible frequencies, thus not interfering with regular phone operation.
- Wireless technologies have been easier to install in rural communities because they require a smaller infrastructure investment:
    - In recent years, 3G cellular has become widely used, now allowing transmission of large multimedia files; however, there are significant coverage gaps in rural Eastern Ontario. Adoption of 3G cellular in rural areas is restricted by the technology's limited capability in providing true broadband, in addition to relatively high subscription rates.

[3] "National Broadband Maps," Industry Canada, http://www.ic.gc.ca/eic/site/720.nsf/eng/h_50010.htm. (Accessed March 8, 2011).

[4] Industry Canada, "Government of Canada Announces Third Round of Broadband Canada Funding," press release, Nov. 6, 2010, http://www.ic.gc.ca/eic/site/ic1.nsf/eng/06045.html (Accessed Mar. 8, 2011).

- Fixed Wireless is another alternative that relies on what is called Line of Sight (LoS) communication. This option offers a substantial capacity advantage over 3G cellular and at a more affordable cost. The LoS nature of deployment, however, limits the applicability of fixed wireless to flat terrains with minimal physical obstruction. Certain weather conditions may also interfere with the operation of fixed wireless networks.
- WiFi is a popular technology which transfers data wirelessly from specially-installed transmission towers. A limitation, however, is that each tower has to be within the radio communication range of the next tower.
- Satellite broadband is usually reserved for areas where using other technologies is prohibitively costly or physically unviable.

The EORN initiative in rural Eastern Ontario is technology neutral, and is bound by the performance of proposed technologies. This approach allows EORN to utilize several technologies, including fibre, terrestrial wireless (WiFi) and satellite, to maximize the reach of broadband throughout the diverse geographies of the region, and allow for increased competition and improved service to the end-user. Depending on the applicability of each technology to the area of deployment, EORN accommodates any alternative for rural broadband that would satisfy the project requirements.

The recent surge of interest in realizing rural broadband has brought to light other, non-traditional, alternatives for creating an access network that is affordable to both install and operate. These technologies are discussed below. It should be noted, however, that these technologies are not applicable in all contexts, and need to be verified for each potential area in which they might be implemented. For example, the broadband over power lines option discussed below is not an applicable option for the Eastern Ontario region.

1. Broadband over Power Lines (BPL)

In December 2010, the Institute for Electrical and Electronics (IEEE) released standards for providing broadband Internet over power lines.[5] This has accelerated the testing and commercialization of Power Line Communications (PLC) that facilitate both creating power grids and broadband Internet access. Since BPL relies on an already existing infrastructure, deployment costs are substantially reduced; the power grid's minimal downtimes also produce a highly reliable network.

BPL has had several successful trials. One early hybrid solution employing both wireless and BPL technologies (W/BPL) was successfully installed in Larissa, Greece.[6] Initially, the network was designed for more intelligent power regulation to handle outages in the summer due to extensive use of irrigation pumps. This project required establishing robust communication over the power lines. Because this communication requirement only used 10% of the network's capacity, it was decided to explore the possibility of providing broadband access through the power grid as well. The network provided broadband to over 600 inhabitants using BPL to connect to a PoP on the existing, traditional backhaul. "Last-mile" access to those still unreached by BPL was then facilitated through WiFi.

2. Wireless Mesh Networks (WMNs)

[5] "IEEE Std 1901-2010, IEEE Standard for Broadband over Power Line Networks," IEEE, http://grouper.ieee.org/groups/1901/ (Accessed March 8, 2011).

[6] Sarafi, Tsiropoulos and Cottis, "Hybrid Wireless-Broadband over Power Lines: A Promising Broadband Solution in Rural Areas," *IEEE Communications Magazine*, pp. November 2009.

A network is usually described as a mesh of nodes, or intersections, usually connected by wires. Over the past decade, several networking and communication advances have made wirelessly meshing network nodes possible. The resulting WMNs have shown great promise as a networking strategy which is easy to deploy and manage, with a high resilience to failures. With careful design, they can also cover very large geographical areas.

Typically, a home connects to the Internet either directly through a PoP by installing fibre-optic cable directly to the house, or indirectly through DSL, BPL, or a similar service. WiFi has emerged as a popular application of WMNs, providing broadband access without an investment in wired infrastructure to the home. WiFi technology has also been widely standardized by the IEEE, providing Internet Providers (IPs) with clear references in regulating traffic on the network.[7] This provides end users with reliable, predictable service. While WiFi is often associated with short-range coverage (10m or less), it can also be applied to cover a large geographic area, thus becoming part of a backhaul network.

3. Cellular Broadband

Despite relatively high costs, cellular phones have enjoyed exponential growth in Canada over the past decade.[8] The introduction of "smart phones", which allow cell phones to access multimedia over the Internet, has made broadband over cellular networks a trend that is expected to grow more in the next five years.[9] However, current cellular technologies, often referred to as 3G, are limited by high deployment costs for enhancing capacity or extending coverage. These costs have been an inhibiting factor in extending broadband cellular coverage to rural areas.

Several emerging networking technologies offer further options for expanding cellular network infrastructure:

- *Relay Stations* (RS), crudely speaking, are towers that connect wirelessly to the main cellular network.[10] Cell phones can maintain service to the cellular network through up to two intermediary RSs. The cost of an RS is expected to be an order of magnitude less than that of a traditional wired cellular tower and RSs are expected to be easily, and cheaply, installed.
- *Femtocells* are similar to WiFi access points except, instead of connecting to broadband backhaul, they connect to a cellular network. Thus, a homeowner can plug a femtocell to their home broadband connection and receive high quality cellular service indoors.[11]

Indeed, many communication and networking technologies – both available and emerging – will play a greater role in wireless broadband in the very near future.[12] Many of these technologies are aimed directly at increasing broadband penetration at reduced costs for both the user and the provider.

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[7] "IEEE 802.11TM Wireless Local Area Networks," IEEE, http://www.ieee802.org/11/ (Accessed March 8, 2011).
[8] Chiehyu Li and Bincy Ninan-Moses, "An International Comparison of Cell Phone Plans and Prices," New America Foundation, http://nonproliferation.newamerica.net/publications/policy/an_international_comparison_of_cell_phone_plans_and_prices (Accessed March 8, 2011).
[9] This is based on Cisco's Visual Networking Index. An accessible summary can be found at http://www.fiercewireless.com/story/cisco-mobile-video-will-be-66-data-traffic-2015/2011-02-01.
[10] Loa et al, "IMT-Advanced Relay Standards," *IEEE Communications Magazine*, pp. 40-48, August 2010.
[11] Chandrasekhar et al, "Femtocell Networks: A Survey," *IEEE Communications Magazine*, pp. 59-67, September 2008.
[12] Ghosh et al, "LTE-Advanced: Next Generation Wireless Broadband Technology," *IEEEE Communications Magazine*, pp. 10-22, June 2010.

Realizing and Maintaining Broadband Affordability

In addition to installation and operating costs, several other cost factors should be considered:

- Network planning considers factors including the nature of the terrain where the access network is installed and the expected magnitude and nature of the network's traffic. A well-planned network is less prone to failures and requires minimal intervention.
- A growing "best practice" in network administration is that of instilling a "self-healing" structure. Networks can be designed to recognize specific failure types and be able to prevent, correct and/or adapt to the failure with no or minimal human intervention.
- As Information and Communication Technologies (ICT) can create substantial energy losses, use of renewable energy sources can further minimize costs.[13] Energy sources such as solar panels and wind turbines can greatly reduce operational costs at both the backhaul and network access levels; WMNs, in particular, can be grid-independent for very long time periods.
- Beyond network and power considerations, once a network is installed, end-user affordability will be determined by IP pricing. In addition to supporting projects like EORN and SuperNET, governments must encourage and support competition.

Leveraging Rural Broadband

Rural areas offer a range of unique lifestyle options compared to their urban counterparts, which are increasingly attractive to traditionally urban-based professionals. In attracting business development, as well as providing social services, the Internet is now a necessity rather than a luxury. General projections indicate that dependence on multimedia communications is ever increasing, especially applications like real-time video communication. Access to broadband will not only allow rural communities to acquire knowledge from around the world, but, more importantly, to share their experiences, both personal and professional, to the widest audience possible.

Broadband Internet also plays an important role in attracting and retaining youth. Reliable and capable connectivity, enables young people to seek information, certification and knowledge, in addition to establishing and maintaining communication with peers in different areas.

Provision of government services via the Internet can further encourage broadband usage by the general population. "E-government" services allow businesses and individuals to access government resources without having to travel long distances to central offices. Government use of on-line financial transactions provides an example to local businesses as to how they can use similar technologies securely and safely to expand their customer base. Broadband access can impact community health as well by providing easy access to health information, guiding patients to local clinics and hospitals, and allowing healthcare professionals to electronically transfer multimedia patient files and reports.

[13] See "ICTs and the environment" in *OECD Information Technology Outlook 2010* at http://www.oecd.org/document/20/0,3746,en_2649_34223_41892820_1_1_1_1,00.html

Concluding Remarks

Networks for delivering broadband Internet hold great potential for having a positive economic impact on rural areas.[14] Rural broadband should be viewed as the means, and not the end, to better rural economies.[15] While governments should support building network infrastructure, they should allow and encourage market dynamics to handle the deployment of Internet provision.[16] Broadband penetration in rural areas further depends on identifying how broadband connectivity will benefit the rural community, at both the personal and the collective level.[17]

[14] Stenberg et al, *Broadband Internet's Value for Rural America*, Economic Research Report No. (ERR-78), US Department of Agriculture Economic Research Service, 2009.
[15] LaRose et al, "The impact of rural broadband development: lessons from a natural field experiment," *Elsevier's Government Information Quarterly*, Volume 28, Issue 1, pp. 91-100, January 2011.
[16] Katz, "Estimating the Economic Impact of the Broadband Stimulus Plan," working paper, http://www.elinoam.com/raulkatz/Dr_Raul_Katz_-_BB_Stimulus_Working_Paper.pdf (Accessed March 8, 2011).
[17] Hudson, "Municipal wireless broadband: Lessons from San Francisco and Silicon Valley," *Elsevier's Telematics and Informatics*, Volume 27, Issue 1, pp. 1-9, February 2010