Rural Broadband Networks and Economic Development: The South Dundas Story

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Abstract

This paper discusses the implementation of a broadband network in the rural community of South Dundas, Ontario, Canada. A hybrid wireless/fibre network was deployed in 2001. In 2003 a study was commissioned demonstrating a correlation in economic improvements and developments as a direct result of the broadband system implementation.

Keywords:

Rural Broadband, Wireless, Networks, Economic Development.

1 Introduction

South Dundas is a small rural township in Eastern Ontario, Canada, with a population of approximately 10,780. The township covers a geographic area approximately 520 square kilometres and is predominantly agricultural and residential based. The township encompasses 4350 dwellings, 48 institutions and 366 businesses. There are two areas of concentrated housing and small business (population approximately 3800) located on the St. Lawrence River, with access to the Trans Canada Highway. In these villages are some small industrial businesses, but they are not the size of facilities that are normally seen in a small city.

The town rates high in commercial attractiveness in terms of facilities, infrastructure, low taxes, pleasant environment and the quality-of-life. In spite of these benefits, there was a net job loss of about 600 positions over the decade prior to 2000. Research suggested a key difference between South Dundas and more successful urban areas, was the lack of reasonably priced high-bandwidth communications in general and Internet access in particular.

2 The Problem - Rural Economics

Aspects that attract businesses and people to rural areas are the key factors that also inhibit participation in the knowledge economy. Rural settings offer short commutes, clean air, quiet lifestyle and generally a lower cost of living. Businesses are drawn to lower tax basis and knowledge that a skilled labour force is available, can be drawn from larger urban centres close by, or can be easily created. People are drawn by the opportunity to have larger property at reasonable prices as well as the pleasant life that living near a small town can offer. In some cases residents represent several generations of families that have stayed and operated the family farm or business, or have added to the community with their own business ventures.

However, these aspects conspire to produce the low client density and long distances between clients that make capital based expenditures so difficult in rural environments. For new infrastructure builds like broadband these market factors can create insurmountable obstacles for investors. The realization that any possible return may be many years away (5+) and that the profit margin may be slim (due to insufficient base to support the investment) discourages investors.

Thus, broadband network planning in rural environments presents significant challenges. In addition to limited returns, costs associated with the distance between clients and the effectiveness of available technology further limit progress.

3 Business Model

Embarking on rural broadband involves a need to consider a business model that differs from that used for urban areas. The low client density, slower speed of growth, lower pricing targets and high user education requirements signify the need to tackle the business with a different approach. One might conclude that in this environment, to nothing would be appropriate. However, given the depopulation of rural areas and the universal movement to broadband in the industrialize world, to do nothing, or even delay implementation, will harm the economic progress of the rural region in particular, and the province and country in general.

While the number of houses/users per square kilometre is much lower than in urban areas, this does not make the need for connectivity, in terms of business or personal use, any less important for rural residents. Thus the issues become the cost of equipment and services in concert with return on investment, from initial capital investments to ongoing operations and maintenance. These considerations are not trivial and the answers may result in interesting alternatives not always considered necessary or even reasonable in urban areas, such as the need for public support for the venture.

For the municipality, the real justification for broadband, the ability to partake in the information age, is basically threefold, the delivery of services to

ratepayers, viability of its commercial enterprises, and the quality of life for its rural citizens. This and the fact that governments need this capability to deliver info-based services to citizens while maximizing communication efficiencies, puts key benefactors of services delivery systems squarely in the public domain. Add economic development possibilities, and one wonders how services delivery infrastructure could ever have been thought to be only that of the private business domain.

"Broadband is rapidly becoming a key component of our nation's systems of education, commerce, employment, health, government and entertainment. The transformative potential of broadband technologies is, I believe, akin to the major infrastructure developments that built America to greatness. I believe that when the history of our times is written, the broadband transformation will be discussed in the same vein as the building of the roads and ports and harbors that made commerce possible in pre-Civil War America; as the Transcontinental railroads that made us a continental power in the late Nineteenth century; as the national highway system that opened the way for rapid transportation and demographic migration in the last century; and as the first great telecommunications revolution that brought telephone service to the far corners of America, a job mostly, but not yet totally, completed. …..Historically, business and government worked closely together in all of the great economic infrastructure transformations……"[1]

This quote demonstrates the past co-operation that business and governments have shared in pursuing large capital infrastructure projects that set their goals on providing all citizen's with affordable access. In recent years, during the "boom" of the telecom industry the popular opinion has become that private business should be the sole source of investment for broadband initiatives. We must stop and consider what would have happened if one of the other large infrastructure transformations had relied on similar ideas. Where would North America be today if the railroads and highways had not been built at the time and with the speed that they were? What impact would a different history have on the economic history of this continent?

Thus, when developing a business plan, the focus should be on who, where, what and how much and not why build.

3.1 Target Market

As with most technology implementations, initially, it is businesses that can foresee and justify a cost benefit than consumers. Other than domestic services, being able to compete for opportunities against their urban counterparts is critical for a rural business's success. Studies and trends indicate that many commercial operations are migrating to on-line transactions and communications, making broadband a base requirement. In rural markets affordability of service is the key criterion. Many want the service but due to the nature and size of their business, often cannot afford pricing similar to the larger cities or afforded by larger operations. Therefore, pricing has to be set in ranges that are acceptable to the market. The impact on sustainability is large. In the early years, as the network is growing, simply put, revenue will rarely meet the operational support cost. Marketing to the current and future small business is a vital and important aspect to attaining the required customer base. This requires the ability to educate the customer as well as use language that is central to their business and not that of services suppliers.

3.2 Customer Requirements

A compilation of the services that would rely on on-line communications for the various industry sectors is a first step. In South Dundas, this list, and services indicated, suggested that a minimum connectivity of 1 Mbps full duplex was needed. Commercial operations rely on transactions, whether between clients, suppliers, or financial based, they become a reflection of the capability and quality of the business. In competitive business environments speed can be critical for success.

Larger business operations, manufacturing and some government institutions require a bandwidth of 10 Mbps due to advanced management applications. Large, bandwidth intensive applications, such as Geographic Information Systems, are now being implemented in municipal and other government operations.

While residential and commercial farming are not so bandwidth intensive at the moment, to facilitate the evolving applications and services, 1 Mbps is a reasonable standard for those markets as well, with commodity traders requiring full duplex operation.

3.3 User Readiness

In assessing the user readiness it is essential to understand the level at which the user operates today. In industrial facilities, even small manufacturing locations, the need for computing is high. Such operations have the knowledge and need for connectivity, especially with other branch or head office locations. In many instances these clients have already sought solutions, which although may be excessive in cost, are necessary as there are no alternatives.

Rural areas, where small and medium business is the rule, limited exposure to broadband technology and the benefits of the "need for speed" are a significant problem. While larger more organized operations have associations and or external influences to boost the newer methodologies, bringing the rank and file of a rural business base up to 'speed' is problematic. In deed, South Dundas has businesses that do not even take credit or debit cards, something that can be hard to believe for urban city dwellers.

Although some of these rural users may have dial-up services, they generally do not have the wherewithal to develop a business case for a more expensive broadband connection, as to assess these benefits; one has to understand how their business operations may

change. Usually these influences come from outside in unpredictable methods. For example, a snowmobile supplier may tell his dealer that to get brochures he will now have to download .pdf files, arduous over dial-up.

A large hardware franchise uses the system as an integral part of their operations. They have reported a significant jump in on-line training per person, as the system provides delivers course material, the courses can be completed in less time. They now are going on-line with an international auto parts supplier with an integrated inventory and supply system for purposes of locating, ordering and delivering parts in a just-in-time fashion.

4 Implementation

4.1 Engineering considerations

When designing networks for rural communities one must consider the trade-offs that will impact its implementation and operation. A robust network is mandatory to deal with the issues found in rural networks. The following characteristics resulted from the South Dundas experience:

- **An Ethernet network.** It must be affordable and maintainable with community available resources. Gigabit Ethernet switching meets this requirement.
- **High-grade delivery to Commercial and Industrial clients.** Fibre-optics in urban areas to offer maximum performance and future growth.
- **Wireless delivery to farming area.** A typical base-station pair can serve up to 20 clients without over booking, with a range of 5-8 km radius.
- **Accessibility**. Junction boxes, terminating a fibre bundle in the vicinity of government, business and industrial clients (typical drop distance 50m).
- **Broadband Backbone.** Urban and rural distribution networks interconnected using 45-Mbps, full duplex, microwave, point-to-point radio, connected to the respective GigE switches by a fibre circuit.
- **Open access to all service suppliers** that meet community criteria.

4.2 Wireless design

Distribution is an important consideration in designing a rural network that has to reach a disparate client base. Wireless is often the only option due to distances and lower quality existing infrastructure. In South Dundas, the terrain is gently rolling, 10-15m with areas of 15-20 metre deciduous forest. Experience in South Dundas and surrounding areas provided the following design considerations:

- **Frequency Bands.** In South Dundas, the 2.4 GHz band is used for distribution and the 5.2-5.8 GHz band is used for backhaul links. While these bands offer no frequency protection, availability, adequate performance and the cost of equipment were the determining factors.
- **Equipment Quality**. While consumer requirements may vary, a high quality radio capable of reliable 24/7-service is necessary for business. The higher cost is the trade-off.
- **Fade Margins.** To provide reliable 24/7-service, a high fade-margin is required. The trade-offs are range and antenna costs.
- **Signal Path.** Above 2 GHz, at least 0.6 of the first fresnel zone must be unobstructed for predicable operation of a Direct Sequence Spread Spectrum radio. The trade-offs are range and the cost of towers to clear obstructions.
- **Path Analysis Tools.** While most tools provide adequate fade margin analysis, many fail in path prediction. Analysis using Federal, 1:50,000 and Ontario 1:10,000 resource maps have been adequate for South Dundas. Of course there is no substitute to traveling the path to insure a tower is in the right location and is high enough. Remember too, the earth is not flat.
- **Distribution.** The most serious drawback of wireless distribution is bandwidth, due to the lack of available spectrum. Point-to-multipoint radios can deliver 10-30 Mbps depending on the band and cost. A typical 2.4 GHz radio can deliver 11-12 Mbps, thus can service about 10 clients, non-blocking. However it has only 3-4 non-overlapping channels. Adding base-stations can increase delivery at the expense of additional in and near-channel radio interference. Clever design of antenna arrays and spacing can mitigate these effects to some degree.
- **Towers.** The height of the base station towers has an important effect on client range. While range can improve with height, the cost is severely affected by height and needed structural rigidity. Experience shows heights of 30-45 metres provide an adequate performance footprint, while minimizing potential interference from adjacent systems, and installed cost.

Perhaps the most important lesson-learned is that microwave radio is not plug-and-play, at least for not serious services suppliers. The South Dundas system has an excellent record for installations and client retention, not possible without thoughtful design consideration, prior to the truck-roll.

4.3 Switching

Switching is considered one of the most important aspects of the network. It affects system performance, flexibility and growth potential in profound ways. Key is the requirement for a low-cost, low-latency solution for delivery of services from any supplier, to any client, at the client's discretion. Gigabit Ethernet switching with bi-directional rate shaping and priority of transmission is the perfect design option. Further, in a

community network concept, it is important to consider a wide range of client types and communications requirements, from that of a single-operator real-estate office, to the large branch office of a major international corporation.

The combination of multiple VLANs with quality of service features allow for tailoring services to the client. Low transmission latency and ease of use are considerable benefits. Other related decisions included UTP based ports connected to 10 & 100 base media converters (UTP to FX) to provide flexibility and lower over-all cost.

In South Dundas, local network specialists were up to the task of programming and maintaining the switching. As well, a single T1 has been employed throughout the start-up period, again with considerable cost benefits. Trials with real clients commenced in February 2001 with the system reaching operational status by June of that year. As of fall, 2003, the system has been transferring over 900,000 one-megabit files per month, with no noticeable performance issues.

5 Expansion

As the initial roll out has been limited to fibre optics in the urban areas, an expansion plan to build a wireless distribution network to serve all the rural areas and residents is under way. In addition, a future fibre-to-the-home plan for the more densely populated areas, where the limited bandwidth of
wireless is insufficient, is in the works.

5.1 Government Grant

This rural wireless expansion required additional funding to purchase the required equipment. A key sustainability issue is the cost of the radios/antennas for rural clients. The equipment would have to be subsidized to attract enough clients. High quality equipment is required to meet the performance goals and thus high retention rates. The initial quantity would have to sustain all follow-on operations.

Industry Canada, an agency of the Canadian Federal government initiated a contribution program to assist rural areas in funding builds of broadband infrastructure. The Township of South Dundas applied for and received business plan development funding in February 2003. A completed plan was filed on June 6, 2003 requesting contribution funding for the rural expansion phase. On October 24, 2003, Industry Canada announced that South Dundas was one of the four Ontario groups eligible for funding under round one. IC would provide $1.696 Million contribution towards the building of the $3.4 Million integrated and expanded network.

5.2 The Plan

The plan involves 6 base stations, 4 new towers, to cover the rural sections of the township, approximately 20 x 30 km. When complete, these towers will offer full coverage of the geographical territory, with an initial design connection speed of 1 Mbps per subscriber. Business subscribers will be offered a higher priority service then residential to ensure their services can be managed adequately.
The towers will be erected quickly and the current core switch at the Morrisburg Point of Presence will be replaced to support the additional client loads due to the expansion.
A marketing campaign will encourage user connections in order to meet the sustainability goals, required for success.

6 Sustainability Design

6.1 Ownership

Ownership is a key sustainability issue, from start-up

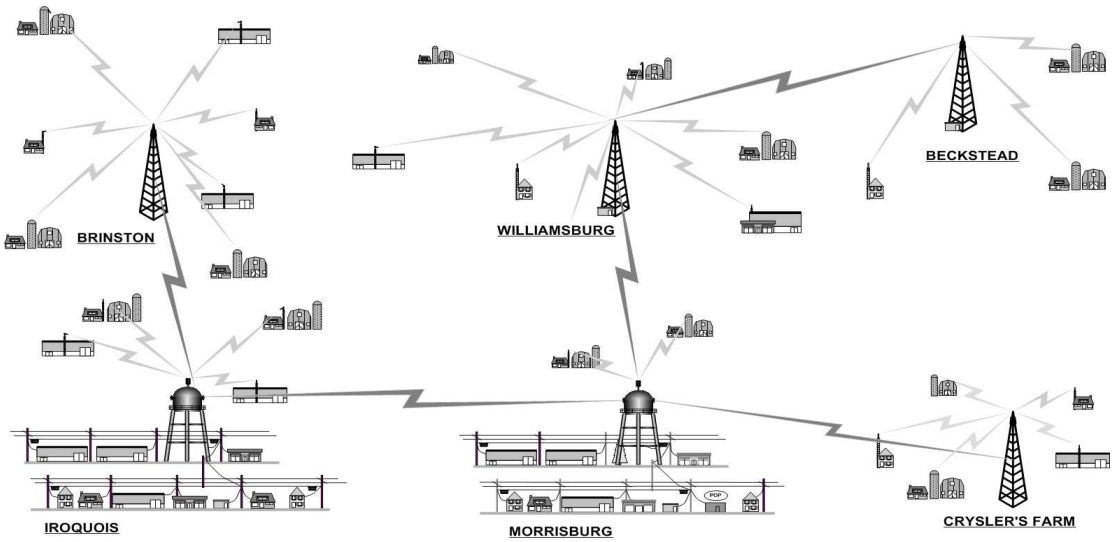

Figure 1: South Dundas Network Concept.

through long-term operations. One can easily accept that low density client base, with long distances between clients, creates a more expensive system while having fewer, and probably less capable, clients to pay for them. Without the subsidy system used by telephone companies to augment revenues of rural telephone cost centres, a rural broadband system has a very narrow range of options. In fact, probably no option at all if not supported by the municipality, at least through the implementation and start-up phases, lasting 4-5 years.

6.2 Network Protocols

After study, including discussions with many network specialists, vendors and stakeholders, South Dundas elected to use the Gigabit Ethernet switching and transmission technology for its system due to its superior overall operational cost/performance features. Factors that support this choice include:

- Highly Scalable. (Easier/Less cost to add ports)
- Much better Price/Performance ratio. (Much lower operational & per port cost)
- Seamless integration with existing Client networks. (Same standard, no extra interface cost)
- Better, cheaper interface options. (10/100/1000 Mbps ports available, standard)
- Similar, Quality of Service (QoS), VLAN and bandwidth control (needed to support a range of clients and services in rural areas)

By choosing Gigabit Ethernet (GigE), South Dundas would capitalize on a wealth of experience within the community at significant savings in start-up and on-going operations. Because the new switching also supported QoS and Rate Shaping, the community can pro-rate services delivery cost across a range of clients, absolutely essential for a sustainable rural system.

6.3 POP Bandwidth

One of the biggest misconceptions is the bandwidth required to adequately service a rural community. Consultants continually suggest a linear aggregation of some perceived need by client, yielding Gbps of requirement, even for small municipalities. A study for a neighbouring town, in year 2000, indicated a start-up need of 155 Mbps (OC-3), to 625 Mbps year 2, followed by a requirement for an astonishing 2400 Mbps the following year.

The South Dundas experience is quite the opposite. South Dundas too flirted with having a T3 or OC-3 connection at $75,000 per month. However they quickly realized that there was no possibility that the community could support such a cost to sustain the system. Thus multiple T1 services, readily available and affordable, would have to do. It has.

Client take-up rates, at 14 percent, the average for all of North America, have been the experience in South Dundas. While this is a reasonable achievement in itself, what is more remarkable, is that one and only one T1, at 1.5 Mbps, full duplex, services all of these clients. As of Dec 2003, with an operational experience in excess of 30 months, the network has grown to transfers of over 900,000 one-megabit files every month. For the most part, clients do not know they are actually sharing the T1. The benefits of low-latency GigE switching in controlling overbooking are substantial. Further:

- Part of the answer is the nature of the Internet itself; often the site visited determines the speed of access.
- The remainder lies in the access service being distributed amongst the clients, in priority such that business users who purchase the lower grade-of-service do not hinder higher value users.

6.4 Logistics

Another problem with networks, particularly wireless, is the issue of equipment compatibility and useful life**.** Equipment is often not compatible with versions of the same product, due to upgrades and new components. In other words, the wireless equipment in the customers' premises (CPE) must be compatible with the base station throughout the system's life cycle, as any changes to either will necessitate changes to all. With a basic technical life expectancy of 8 to 10 year, and upgrades every 2 years or so, a plan and the ability to sustain operations is paramount. In general, requirements for a successful rollout of a wireless system are:

- The sustainable bandwidth delivered to each client must be enough for the entire equipment life period, from start-up to end of life.
- All the CPE must be purchased early while compatible models are available.
- Software upgrades will be necessary and should be able to be done remotely.
- Spares for all radio types will be needed, for the entire system life cycle.
- The network owner will need a sinking fund to completely replace all the electronics at the end of its useful life.

The compatibility and useful life issues are, in general, applicable to all forms of communication where the supplier's equipment acts like a 'base station' to communicate to user end equipment. The most effected are cable, wireless, and passive optical fibre systems. Telco and direct fibre systems are less affected as these systems have a direct communication path to each client. In these systems only, can the service to a particular client be changed or upgraded without affecting the rest.

7.0 Economic Study and Return

The new information age and the associated economic benefits are still basically unavailable in most rural areas. As a result, many rural municipalities have, and continue to, experience a loss of employment opportunities for its citizens.

During the last decade of the twentieth century, the Township of South Dundas experienced a loss of employment opportunities, about 600 positions over the decade prior to 2000. Many of these positions were in the manufacturing sector, as a result of the changing economies in Canada, and in Eastern Ontario in particular. In addition, the municipality had not been able to attract jobs associated with the high technology or communications sector, nor the related high-tech support activities, such as engineering, assembly, component manufacturing or software development, experienced in other centers. Research suggested the key difference between South Dundas and the more successful urban areas were the lack of reasonably priced high-bandwidth communications in general and Internet access in particular.

In 2003, the British Department of Trade and Industry (DTI) contracted a study to determine the economic impact of broadband networks in rural areas. Strategic Networks Group (SNG), of Ottawa, was hired and offered to use the South Dundas experience as a model.

According to the study: [2]
Between June 2001 and April 2003, the following economic effects can be directly attributed to the fibre network in South Dundas:

- • 62.5 new jobs
- • $2.8 million in commercial / industrial expansion
- • $140,000 in increased revenues and decreased costs

The study findings indicated that the overall job growth in the South Dundas between June 2001 and April 2003 was 717. As is expected not all these jobs are in companies that are connected to the fibre system. Rather as companies that are using broadband grow they have indirect impacts on the community, creating jobs in all industry sectors.

The study was able to identify that 50% of all businesses that used broadband internet access (not all were users of the South Dundas fibre system) had experienced job growth. This is compared to a 5.6% job growth for businesses that were not connected to the internet at all.

The study defined impacts as primary and secondary. Primary effects were those that could be correlated directly to the implementation and use of the fibre system. Secondary impacts were the indirect effects that could be measured and were analyzed to have a relationship to the fibre system deployment and use.

An interesting comparison made in the study is that to the price of roads versus the fibre system:
"waste disposal is almost 4 times more expensive and roads are 16 times more expensive than the fibre network to the municipality. Considering the benefits (i.e. direct effects) that South Dundas has realized – and continues to realize – from the fibre network, the ongoing costs of maintaining the fibre network are relatively low as compared to the costs of other municipal infrastructure and services." [2]

Thus in conclusion, the SNG study provides an excellent closing:
"A commitment to the future, the ability to use Internet applications requiring a high bandwidth and a willingness to adopt new business processes are key ingredients which can lead to economic growth. The investment by the municipal government in South Dundas in a fibre network has demonstrated a commitment to the future and a willingness to provide key infrastructure. Broadband access to the Internet has enabled businesses and organizations in South Dundas to realize cost savings, productivity gains and new revenues. Other economic factors being equal, the fibre network in South Dundas has created opportunities for growth. The direct effects identified in this study confirm this growth."

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