KEEWATIN CAREER DEVELOPMENT CORPORATION

Community Broadband Standards

Applications and Infrastructure

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This report summarizes a number of applications of broadband and their bandwidth requirements; introduces a number of broadband access technologies; and examines considerations for community ownership of broadband systems.

Contents

1. Community Broadband Standards Executive Summary

This paper covers several areas. First, it **reviews a number of general internet applications** such as the world wide web, email, file transfer, instant messaging and chat, and videoconferencing . For each application, **a short description of the application and its usefulness and importance** is given. Following this, **a description of the typical bandwidth (speed) requirements for the application** is given.

Second**, specific internet applications are reviewed for a number of sectors**. In some cases, these are more specialized cases of general internet applications such as the world wide web or videoconferencing, while in other cases these are specialized sector-specific applications such as electronic medical records. For each application, a short description of the application and its usefulness and importance is given. Following this, a description of the typical bandwidth (throughput, or speed) requirements for the application is given.

In reviewing the sectoral internet applications, some recommendations for bandwidth requirements are brought forward. For the health sector, **health centres are recommended to have at least 10 megabit / second connections**. Smaller health facilities such as clinics are recommended to have at least 4 megabit / second connections. Health offices are recommended to have at least 1 megabit /second for every four staff. All these recommendations are for symmetrical connections – able to send and receive data at the same rates. For the education sector, **schools and colleges are recommended to have at least 5 megabit / second symmetrical connections, with a target of 10 megabit / second for every hundred students and staff**. For other sectors, **offices and facilities are recommended to have at least 5 megabit /second symmetrical connections** if videoconferencing is or may become a desired application; and least 1 megabit / second symmetrical connections otherwise. **At least 1 megabit / second should be allowed for every four staff or public computers in a facility**. **For residential users**, recreational uses of the internet to access audiovisual resources mandate a recommendation of **at least 5 megabit / second of download capability**, with 10 megabit / second of download capability desirable. **At least 1 megabit / second of upload capability** is desirable to facilitate videoconferencing capabilities for residential access to education.

The third section of this paper **reviews a number of technologies used to deliver internet services in communities**. A brief description is given of each technology, its **capabilities for delivering network throughput** to and from subscribers, its **relative costs**, and factors such as **reliability** that may impact on its effectiveness. For new internet access systems, **the emerging model around the world is fibre optic systems** delivering internet to public sector and private sector offices and facilities; fibre optic systems delivering internet to the home or fibre optic systems delivering internet to a neighbourhood cabinet with either phone lines (DSL) or coax cable from the neighbourhood cabinet to the home**; and 4G cellular wireless systems supplemented by in-building wi-fi wireless** for mobilized internet access through smart phones, tablets, and laptop computers.

The fourth section of this paper reviews a number of considerations to be explored in the process of a community deciding between the model of community ownership and operation of an internet service

provider and the model of having commercial internet service provider invest in and operate a community's internet infrastructure.

This paper should be read with the understanding that it is addressing requirements and capabilities current to the time of writing in 2011. **Planning for any network must take into account potential future growth and unforeseen applications.** One must always remember Parkinson's Law of Bandwidth Absorption: "Network traffic expands to fill the available bandwidth". Nielsen's Law of Internet Bandwidth is also relevant here: "**a high-end user's connection speed grows by 50% per year**". These two growth patterns must be factored into network planning.

2. Applications (Current and prospective)

1. General (all sectors)

1. Web reading - search engines and portals, news sites,

Use of the world-wide web is closely associated in many people's minds with the internet. This service gives access to information in a number of forms – textual, graphical / photographic, audio, and video resources are all available, as are many types of interactive applications. In the most common application of the web, users access information which is primarily textual, often with photographic / graphical elements on the page. The textual content may be enriched by short audiovisual clips, as on many news sites. This type of application requires download bandwidth of approximately 256 kilobit / second per user and upload bandwidth of approximately 32 kilobit / second per user (for submitting requests, usernames / passwords, and user tracking information for the websites). Web usage is a very bursty application – the flow of traffic is not continuous, but peaks as new pages are requested and diminishes as pages are read. This makes it possible for multiple users to share bandwidth effectively.

2. Email

Email is the second application closely associated with the internet. Email has become an essential communications tool for most people in both work and personal environments. The bandwidth requirements of email are dependent on a number of factors. In a work environment, one of the factors is the location of the email server. If the server is within the work location, bandwidth needs will be lower than if the server is hosted outside the work location, as a significant portion of work email is internal. A second factor is the nature of the email and attachments. Attachments with significant audiovisual attachments (photographs, sound files, video files) will require much more bandwidth than email with no attachments or simple office documents(word processing files, spreadsheets, PDF files) as attachments. For the most simple email (straight textual messages), 64 kilobit / second of bandwidth is generally sufficient. However, more typical work email usage with attached photographs and documents requires 256 kilobit / second of bandwidth per user for reasonable performance. Unlike web traffic, email traffic is symmetrical – roughly the same bandwidth is needed in each direction. Like web traffic, email is a very bursty application – traffic flows peak as email is sent to the email server and received from the email server. This allows multiple users to share bandwidth effectively. Because most people

receive more email than they send, bandwidth sharing is even more effective with upload bandwidth (from the user to the email server) than with download bandwidth (from the email server to the user).

3. File transfer / file sharing

A common use of the internet is file sharing. Users often access files such as forms, office documents, photographs, or computer software from sites on the internet. Users may also share these files, either within local area networks or via internet file-sharing sites. Methods of file-sharing include FTP (file transfer protocol), which is often used to distribute files or programs on the internet; SMB (server message block) or CIFS (common internet filesystem), which is used for Windows filesharing; or AFP (Apple Filing Protocol), which is used for Macintosh filesharing; as well as peer-to-peer filesharing systems such as BitTorrent, Limewire, or many others. File transfers will use bandwidth as it is available, so that the principal questions are the size of files to be shared or transferred and the length of time available for the transfer. A one megabyte file (such as a computer printer driver), can be transferred in 2 seconds at 4 megabit / second; in two minutes at 64 kilobit / second; or in two hours at 0.6 kilobit / second.

4. Instant messaging (text eg Windows Live Messenger, Yahoo! Messenger, Google Chat)

An alternative to email which has become popular with many people for short communications is instant messaging. The most basic instant messaging application (sending text messages between people) requires little bandwidth – 32 kilobit / second per user is very sufficient.

5. Computer-based internet phone calls (eg Skype, Google Talk)

Many instant messaging systems have added on voice communications as an advanced feature. In addition, there exist programs to allow internet-based voice communications, either directly between users, or between users and phone systems. Bandwidth requirements for this type of voice application are fairly minimal – about 64 kilobit / second per user, although some systems may increase this to 128 kilobit / second per user for higher voice quality. This bandwidth requirement is symmetrical – the same bandwidth is used in each direction. Internet phone traffic is not bursty – while a call is active, the bandwidth usage is fairly constant. When no call is active, the bandwidth needs drop to next to nothing.

6. Computer-based internet videocalls (eg Skype, Google Talk, Yahoo! Messenger, iChat, FaceTime)

In addition to voice communications, many instant messaging systems have added video communications options using webcams. This type of video chat generally requires at least 384 kilobit / second per user, although some systems may require more. This bandwidth requirement is symmetrical – the same bandwidth is used in each direction. Internet video chat traffic is not bursty – while a call is active, the bandwidth usage is fairly constant. When no call is active, the bandwidth needs drop to next to nothing.

7. Voice over IP (VOIP) phone systems (eg Cisco, Polycom , Nortel)

Voice over IP (VOIP) is a term which can refer to two different types of services. First, this can refer to the use of phone hardware which communicates with the central phone system using internet protocols(IP) across the local area network. This type of phone system can be tied to the regular phone system through the central phone server (often referred to as a PBX, or private branch exchange). The

advantages of this type of phone system are the ease of moving phones within the system, as local extensions are tied to the phone hardware, not to the line; the ability to have additional features like voice mail and call forwarding; and the ability to simplify wiring systems within buildings, as the phone system and the local area network for computers can use the same wiring. The disadvantages are equipment cost and the need for a central phone server, which may involve specialized skills to set up. The bandwidth requirements for this type of phone system are minimal, as the bandwidth used (from 16 kilobit / second up to 128 kilobit / second in each direction) is internal to the local area network. Phone traffic outside the local area network can be routed through the phone company by adapters connecting the local phone server to one or more phone lines, by internet connections to a local phone server in another location (connecting two band offices, for instance), or by internet connections to a VOIP long distance provider. Outside phone calls routed across the internet require bandwidth of approximately 64 kilobit / second in each direction for each phone call being made.

A second use of the term VOIP is to refer to phone systems which allow phones calls to be routed over the internet to minimize long distance charges. Companies such as Vonage or Navigata sell plans which allow users or companies to route their phone traffic through their systems across the internet, in many cases making use of a "local" phone number from another location, so that a Saskatchewan user can have a phone number in Calgary or Toronto. These type of systems often require the use of a hardware adapter to connect a local phone to the VOIP provider's phone server. This requires bandwidth of approximately 64 kilobit / second in each direction for each phone call being made.

8. Videoconferencing / Telepresence

Videoconferencing is generally carried out using specialized hardware called a codec (compressor / decompressor), which includes a high-quality camera and microphone, and which outputs video to one or more television or computer displays. Codecs may have the capability of multiple video inputs, and may also be able to use the video output from a computer as a video input. Many codecs can simultaneously send video from a camera or other video input and a computer output (for a powerpoint presentation or screen-sharing session). Software programs are available which allow a computer with a webcam to communicate with a videoconferencing codec. Some VOIP phones also include cameras to allow them to communicate with a videoconferencing codec. The bandwidth requirements for videoconferencing vary depending on the size of the video picture being transmitted and received, as well as the quality. At CIF (roughly one-quarter the size of a typical television screen), videoconferencing can take place at roughly 300 kilobit / second. At 4CIF (roughly the same as a DVD picture), bandwidth requirements move up to roughly 800 kilobit /second. At 720P high-definition, bandwidth requirements move up to roughly 1500 kilobit / second (1.5 megabit / second). At 1080P high-definition, bandwidth requirements can be up to 4000 kilobit / second (4 megabit / second). Bandwidth requirements may vary depending on whether simultaneous computer content is being sent, the frames per second of the signal (60 frames per second is sufficient to show motion with no perceptible degradation, 30 frames per second will show some minor degradation of motion, while 15 frames per second will show obvious degradation of motion), whether there is a lot of motion in the picture (such as showing an action movie versus watching someone deliver a lecture), and the age and make of the codecs (older codecs

may be less efficient in using bandwidth, as they do not support the newer standards for compressing and decompressing the video signals.)

Telepresence is a term generally used for high-end videoconferencing in which multiple codecs are coordinated to give the impact of the participants being physically present. True telepresence generally makes use of dedicated rooms which are constructed to be physically identical in order to further the illusion of being physically present in the same location. Because of the use of multiple systems operating at their highest quality settings, telepresence can require as much as 25 megabits / second (25,600 kilobits / second) in each direction.

9. Accounting software

Accounting functions are generally carried out now with the assistance of computer software. Most modern accounting software uses a client-server model, in which each user runs a program (the client) which communicates over the local area network with a central server which stores the information. For home use and very small offices, the client and server may be on the same computer; for larger offices, the server is generally on a separate computer. Bandwidth requirements for accounting will vary widely, but 256 kilobit / second per user is a typical data flow. This will normally be within the local area network, so it does not contribute to the internet pipe needs. However, if the accounting server is in another location, this traffic may need to be included in calculating the connection bandwidth for the location.

10. Virtual Private Network (VPN) connections

Virtual Private Networks or VPNs, are connections which allow a worker to access a local area network from a remote location, such as a home computer, a laptop, or a mobile smart phone or tablet. These types of connections are also used to allow traffic to flow between two local area networks in different locations (for example, two band offices in different communities of the same First Nation). The VPN can also allow this traffic to be encrypted so that users on a public wireless network cannot have their traffic intercepted. VPNs do not require much in the way of bandwidth for the VPN connection itself, but they may require a lot of bandwidth for the traffic going across the VPN. If a remote user is accessing a 15 megabyte file on the local area network, the VPN will carry the 15 megabytes as well as 5-10% overhead for the VPN connection. At 128 kilobit / second, this would take over ten minutes; at 1024 kilobit / second (1 megabit / second), this would take just over two minutes; at 50 megabit / second (a typical local area network effective speed), this same file transfer would take just under three seconds. If a VPN is carrying voice or video traffic, it will require the same bandwidth as the traffic being carried as well as 5-10% overhead; thus, a VOIP phone call carried over a VPN requires about 75 kilobit/second in each direction.

11. Remote desktop / terminal services

Remote desktop is a service where a remote user can access his or her computer from another computer and see the screen as if they were looking at their own computer. Terminal services are a similar function where users run a virtual desktop from a central server. Remote desktops have a number of advantages. First, they allow users to continue to work while away from their normal workplace, whether at home or travelling away from the office. Second, they may be used by technical support people to assist users. Third, remote desktops are often useful for performing tasks where large

files need to be accessed remotely. It can be much faster to open the file on a remote desktop and work with it than to wait for the file to be transferred across the VPN or internet. Finally, remote desktops are often useful for minimizing latency (traffic delay) between clients and servers in client-server applications such as accounting programs or GIS (geographic information systems). The use of a remote desktop close to the server means that the data moves quickly over the local area network; only the screen display and keyboard / mouse input must move across the remote connection. Remote desktop connections can vary in bandwidth requirements, but generally this requires 256 kilobit / second for typical activities at a useable quality. This bandwidth is generally higher in the direction going from the computer being accessed, which must send its screen display information (and possibly audio information), than in the direction from the computer doing the accessing, which generally only needs to send its keyboard and mouse inputs.

2. Health

1. Telehealth - patient access to specialists by videoconferencing

Telehealth systems generally involve dedicated videoconferencing codecs in a health centre or clinic setting. These systems are paired with specialized cameras, computer inputs, and microphones to allow doctors to “examine” patients with the assistance of a telehealth facilitator, who may be either a health care worker with special training or a non-medical assistant with special training. Because the quality of the image (both the resolution and the frame rate) is an important factor in both diagnosis and relating effectively to the patient, and because effective diagnosis may require simultaneous transmission of two images (one for interaction and one for diagnostic imagery), telehealth systems generally run at the upper end of the range of bandwidth requirements for basic videoconferencing. For standard-definition telehealth systems, this means from 768 kilobits / second to 1024 kilobits / second (1 megabit / second) in each direction. For high-definition telehealth systems, this means from 2048 kilobits / second (2 megabits / second) to 6144 kilobits / second (6 megabits / second) in each direction. The specialized nature of the telehealth suites means that most primary health facilities will not have more than one suite in operation at a time.

2. Telehealth – health care provider consultation with doctors / specialists by videoconferencing (diagnostic and/or treatment planning)

In addition to being used for direct patient / physician interaction, telehealth systems may be used by health care workers (doctors or nurses) for consultations with other physicians. Because the quality of the image (both the resolution and the frame rate) may be an important factor in both diagnosis and supporting effective consultation, and because effective diagnosis may require simultaneous transmission of two images (one for interaction and one for diagnostic imagery), telehealth systems generally run at the upper end of the range of bandwidth requirements for basic videoconferencing. For standard-definition telehealth systems, this means from 768 kilobits / second to 1024 kilobits / second (1 megabit / second) in each direction. For high-definition telehealth systems, this means from 2048 kilobits / second (2 megabits / second) to 6144 kilobits / second (6 megabits / second) in each direction. The specialized nature of the telehealth suites means that most primary health facilities will not have more than one suite in operation at a time.

3. Telehealth – health care provider professional development by videoconferencing

Professional development by videoconferencing may make use of a dedicated telehealth suite or a secondary videoconferencing codec. This type of use scenario does not require the same range of specialized medical accessories, and may be less demanding in terms of image quality, allowing it to be run at a lower bandwidth, although in practice connections will often be made at the same high-quality levels used in diagnostic or consultative applications. For standard-definition telehealth systems, this means from 512 kilobits / second to 1024 kilobits / second (1 megabit / second) in each direction. For high-definition telehealth systems, this means from 1536 kilobits / second (1.5 megabits / second) to 6144 kilobits / second (6 megabits / second) in each direction. This type of professional development role may lend itself to ultilization of a second codec, leaving the telehealth suite free for medical use. For further information on professional development possibilities, also see the educational applications below.

4. Telehealth – patient and/or public education by videoconferencing

Patient or public education by videoconferencing may make use of a dedicated telehealth suite or a secondary videoconferencing codec to offer specialized instruction in areas such as diabetes prevention and management. This type of use scenario does not require the same range of specialized medical accessories, and may be less demanding in terms of image quality, allowing it to be run at a lower bandwidth, although in practice connections will often be made at the same high-quality levels used in diagnostic or consultative applications. For standard-definition telehealth systems, this means from 512 kilobits / second to 1024 kilobits / second (1 megabit / second) in each direction. For high-definition telehealth systems, this means from 1536 kilobits / second (1.5 megabits / second) to 6144 kilobits / second (6 megabits / second) in each direction. This type of professional development role may lend itself to ultilization of a second codec, leaving the telehealth suite free for medical use. Space usage and mobility of equipment may also be factors here, as public sessions necessarily require larger spaces than rooms for patient-doctor interaction. For further information on patient and public education possibilities, also see the educational applications below.

5. Remote interpreter services

Effective interaction with patients with limited English language skills may require the use of an interpreter. While this role is often played by an accompanying family member, there may be circumstances in which an experienced interpreter needs to be consulted. Telehealth suites offer an avenue for this to be done in a way which allows a patient, health care provider, and interpreter to interact effectively. Bandwidth requirements for this type of usage would be similar to doctor / patient consultations. For standard-definition telehealth systems, this means from 768 kilobits / second to 1024 kilobits / second (1 megabit / second) in each direction. For high-definition telehealth systems, this means from 2048 kilobits / second (2 megabits / second) to 6144 kilobits / second (6 megabits / second) in each direction.

6. Patient monitoring – vital signs (blood pressure, blood sugars, pulse, obstetrical fetal monitoring)

New developments in home medical equipment offer the possibility of monitoring vital signs such as blood pressure, blood sugar, pulse, or fetal health using home equipment which is able to report

results to a physician or nurse to allow better ongoing monitoring of health. This will allow health care providers to be more proactive in treating ongoing health issues. The bandwidth needs for these applications are fairly limited, as the results would only be reported on a periodic basis, rather than continuously, and the results would generally consist of small amounts of data. Bandwidth of 64 kilobits / second in each direction would likely suffice for this type of application.

7. Patient monitoring and consultation – chronic conditions

Other jurisdictions, such as Ontario, are currently experimenting with use of equipment to allow patients with chronic conditions such as congestive health failure or chronic obstructive pulmonary disorder to consult with health care providers from home. In Ontario's trials, this allowed significant reductions in hospital stays, emergency room visits, and clinic visits. Bandwidth needs for this type of application would be similar to that for general videoconferencing: roughly 256 kilobits / second to 512 kilobits / second in each direction.

8. Patient monitoring – medication compliance

One of the significant issues in health care is ensuring patient compliance in taking medications. One approach currently being used is reminders delivered automatically to a patient via email and/or text messaging on a cellular phone. Patient compliance can be monitored by requiring responses confirming that the medication has been taken. This type of application requires minimal bandwidth, but does require mobile bandwidth (cellular internet service).

9. Home delivery of medical services with telesupport

There are a number of medical services which are typically delivered in health centres, but may be delivered at home. Dialysis for patients suffering renal failure is one example. In countries such as Australia , over 10% of dialysis is done in patients' homes. Support for this type of service may include videoconferencing between health care providers and the patients, using relatively inexpensive (under $500) videophones in the home to allow the health care providers to see what the patients are doing. Bandwidth requirements for this type of application are in the range of 256 kilobits / second to 512 kilobits / second in each direction, as this type of technology tends to produce a lower-resolution image which is less bandwidth-intensive.

10. Electronic health records / patient charts

One area in which Canada is currently making a significant investment is the transition from paper-based patient charts and records to electronic health records. Mobilizing access to these records allows health care workers to quickly access records for patients, whether for routine consultations or for emergency treatments. This access may be through laptops, tablets, or hand-held smartphone devices. In order to be readily available as patients move around, the electronic health records will need to be both locally and centrally stored, with secure arrangements for updating and accessing central records as needed. This means that access will require bandwidth both within a health facility (for storage of local patient records) and outside the facility (for access to non-local patient records). Bandwidth requirement are likely to be in the range of 256 kilobits / second to allow timely delivery of patient records.

11. Personal access to medical records via internet

As electronic health records become prevalent, there will be growing interest in patients having access to their own medical records, in order to review prescriptions and medical advise, research conditions, and ensure accuracy of records. Providing this access will likely take the form of a web-based service. Individual access bandwidth requirements are likely to be in the range of 256 kilobits / second. The central service requirements will be much larger, and will depend largely on the number of patient records being stored and the expected frequency of access. For local medical centres, bandwidth requirements could be as low as 1024 kilobits / second (1 megabit / second) to serve demand for up to four simultaneous requests.

12. Electronic prescriptions

Along with electronic health records comes a change from paper-based drug prescriptions to electronic drug prescriptions. This will reduce the risks of prescription mistakes and patient abuse of multiple prescriptions. To be effective, electronic prescriptions will require a centralized prescription service, with access to it by doctors and pharmacists through some form of web service or application running on a desktop computer, a laptop computer, a tablet, or a handheld device. Bandwidth requirements for this application will be similar to other web-based services, from 64 kilobits / second to 256 kilobits / second.

13. Diagnostic imagery (including X-Rays and other radiological imagery, Ultrasound imagery, ECG traces, EEG traces)

The broad trend in the medical community over the last few years has been to electronic transmission and examination of diagnostic imagery such as X-rays, MRIs, and CAT scans. In many cases, imagery is produced at a local health centre and interpreted or reviewed by specialists in a tertiary care centre. To allow the quality necessary for diagnostic examination, imagery must be stored at a very high resolution and quality. Medical diagnostic imagery files also must meet the DICOM (digital imaging and communications in medicine) requirements to have additional information such as patient name and identification numbers embedded into the file. These requirements lead to large filesize. For example, a digital X-Ray file can hit 5 to 20 megabytes. Transmission of such a files in a timely fashion requires significant bandwidth – limiting the transmission time to 1 minute requires 1536 kilobit / second (1.5 megabit / second) of bandwidth. More advanced imagery files, such as an MRI scan or ultrasonographs, can hit filesizes over 100 megabytes (although compression techniques may reduce filesizes for some types of diagnostic imagery, such as sonographs). To transmit such files quickly, a 10 megabit / second connection is required.

14. Digital lab reporting

As with diagnostic imagery, there is a trend in the medical world towards electronic reporting of lab results. This is often tied together with electronic health records. Reporting of results may be through the same web-based systems used for electronic medical records, either through manual entering by lab staff or by automated processes. Bandwidth requirements would be similar to those for electronic medical records, at about 250 kilobits / second.

15. Telesurgery

Telesurgery (the use of videoconferencing combined with remote-control apparatus to manipulate surgical instruments) is currently being experimented with, with some success. However, a more limited form of telesurgery, in which a remote surgeon would guide a local doctor or nurse in performing emergency surgery with the assistance of videoconferencing technology, is more likely to be used in the foreseeable future. Bandwidth requirements for such an application would be on the order of 768 kilobit / second to 4096 kilobit / second in each direction, depending on the available videoconferencing technology.

16. Remote access to diagnostic manuals / medical journals / medical research databases / pharmaceutical manuals

Many medical professionals are now making use of the growing resource base available through the internet. This includes many specialized websites / web-based services, as well as downloadable apps and ebooks for portable devices. While downloadable ebooks require no bandwidth for operation once they have been downloaded, apps and websites require bandwidth of about 250 kilobits / second for effective transfer of images and text. If video clips are available, the bandwidth demands increase to about 500 kilobits / second.

17. Billing / reporting applications

Medical billing is an important aspect of medicine, even where the billing is primarily to the provincial health department or federal government. While models vary, billing and reporting applications may require bandwidth in order to transmit electronic reports to funding agencies (such as INAC or the provincial health department). Bandwidth may also be required where billing and reporting is centralized for a group of medical centres, such as a multi-community First Nation or a tribal council, rather than hosted within the health centre or clinic. Bandwidth needs for these remote billing and reporting applications would be similar to web-based internet needs, at about 250 kilobits / second.

Given these health applications, some general recommendations for bandwidth can be offered. Larger health facilities should have at least 10 megabits / second to facilitate transfer of diagnostic imagery. Smaller facilities such as clinics may want to aim for this bandwidth level as well, but if diagnostic imagery is not required, bandwidth levels of 4 megabits / second should be planned for to allow for use of high-definition videoconferencing and to give adequate bandwidth for other applications. Minimally adequate levels of bandwidth would be 1 megabit / second for every four staff.

3. Education

1. Internet-delivered public audiovisual learning resources

The last few years have seen an explosion in the availability of video content on the internet, most notably at Youtube, but also at a number of lesser-known sites. These sites include a significant number of videos which can be used as educational resources in curriculum areas ranging from science, mathematics, and geography to English, history, and arts. Access to these videos requires at least 300 kilobits / second, and may be significantly higher for high-definition videos – as much as 5 megabits / second for the highest-quality high-definition video. This bandwidth is primarily download bandwidth

(coming from the web server to the viewer). Because most of these video resources utilize a download and play system, it is possible to download them ahead of time so that no bandwidth is required at the time of viewing – this also allows high-definition videos to be loaded on lower bandwidth connections for later viewing.

2. Internet-delivered subscription audiovisual learning resources

In addition to public video resources, there are a number of subscription-based services which offer audiovisual content tailored to curriculum. One example, Access Learning, claims over 3,500 full-length educational programs and over 40,000 educational short video clips, while Discovery Education claims over 150,000 digital learning objects. Bandwidth requirements to access services such as these will be similar to those for public sites, requiring at least 300 kilobits / second and as much as 5 megabits / second (5120 kilobits / second). In many cases, these resources will be downloaded ahead of time, so that bandwidth demands can be shifted after hours when the school's connectivity has fewer demands on it.

3. Internet-delivered learning objects

As well as audiovisual resources, there are many interactive educational resources available on the internet, using technologies such as Adobe Flash, Java, or Web 2.0 javascript to deliver interactive applications to learners. These can include things such as physics or chemistry lab simulators, mathematical graphing calculators, or Google Earth mapping, to name but a few. These resources may be designed to have their interactivity dependent on the web browser or local computer only (many lab simulators) or to require ongoing communication (Google Earth). Bandwidth demands will vary depending on the need for ongoing communication to the server, but generally will fit into the same profile as general web browsing at 250 kilobits / second.

4. Internet-delivered textual / graphic learning resources (Wikipedia, etc)

In the last few years, Wikipedia has largely replaced traditional printed encyclopedia as a first reference point for classroom and homework research. In addition to Wikipedia, there are a significant number of knowledge resources available on the internet for articles on many areas of interest in a school setting. Typical page sizes suggest that bandwidth of 250 kilobit / second will allow pages to be loaded within 5 to 10 seconds.

5. Synchronous (live) e-learning

Synchronous learning refers to education in which the learners are able to view and/or hear the instructor or presenter as they teach and to communicate questions or comments . Technologies which can be used include videoconferencing through dedicated equipment or software codecs, use of specialized learning services such as Wimba Collaboration Suite, use of generalized web conference services such as Adobe Connect, Webex, or GoToMeeting, or use of video chat programs such as Skype. Use of videoconferencing generally requires from 512 kilobits / second to 1024 kilobits / second (1 megabit / second) to allow a high enough resolution and framerate to achieve educational purposes, although in some cases lower bandwidth requirements down to 256 kilobits / second may be sufficient. As videoconferencing shifts to high definition, bandwidth requirements may increase to up to 4 megabits / second (4096 kilobits / second). Use of learning services or web conference services will

generally require 512 kilobits / second (half a megabit / second), while video chat programs will require at least 300 kilobits / second. All of these types of services allow full interaction between the participants, and bandwidth demands are similar for both upload and download. One further form of synchronous learning is the webcast, in which an instructor or presenter can be seen and/or heard by learners, but they can not be seen or heard by the instructor. This type of learning application requires download bandwith of 256 kilobits / second to 512 kilobits / second, but little upload bandwidth.

Synchronous e-learning encompasses a number of different scenarios. These include:

1. *Remote courses*

Many schools lack the resources to deliver a full range of classes. This may be due to smaller student populations or to difficulty in recruiting teachers with specialized skills. To address this, some schools share resources by working with other schools to offer courses to their students through synchronous e-learning. This may involve a single student joining a remotely taught course, a group of students joining a remotely taught course, or a local instructor teaching a course which includes remote students.

2. *Class enrichment opportunities*

There exist a number of opportunities for classes to take advantage of educational enrichment. Many public institutions such as museums, art galleries, and research institutions offer programming for schools in which students can interact with curators, scientists, or educators. This programming can include virtual tours as well as specialized presentations.

3. *Classroom interaction opportunities*

One form of classroom enrichment experience has been the opportunity for classes to create relationships with classes in other places. These may be one-time special events, such as the annual "Read Around the Planet" series or ongoing relationships ("twinning" of classrooms).

4. *Extracurricular or public education courses*

The education system often assists in the delivery of extracurricular courses which benefit students or members of the public. This can include such courses as babysitter training, firearms training, snowmobile safety, watercraft operator training, public health courses, and many others.

5. *Professional development*

Staff often have the opportunity to participate in workshops for professional development, or to take continuing education courses. These workshops and courses can be delivered through synchronous e-learning.

6. Asynchronous (delayed) e-learning

Asynchronous learning refers to education in which the learners access course content on their own schedule. The content can include recorded audiovisual presentations, recorded web conferences, web pages, or office documents such as word processing, spreadsheets, or powerpoint presentations. Communication between instructors and students may be through email, chat, private messaging systems, or through class forums, as well as through traditional communication tools such as phone, fax, or mail. Learning may be structured to be purely asynchronous (no live teaching and interaction) or may

be primarily synchronous (live teaching and interaction) with recordings available for students who cannot participate at the scheduled time.

The bandwidth requirements for asynchronous learning can be similar to those for synchronous learning, but with lower upload requirements. Accessing recorded videoconferences or web conference sessions will require the same download bandwidth as viewing the same sessions live – from 256 kilobits / second to 512 kilobits / second at the low end up to 4 megabits / second for high definition recordings. Accessing other types of content will generally require the same bandwidth as general web browsing – 256 kilobits / second.

Asynchronous e-learning lends itself to a number of scenarios:

1. Remote courses

Many schools lack the resources to deliver a full range of classes. This may be due to smaller student populations or to difficulty in recruiting teachers with specialized skills. To address this, some schools share resources by working with other schools to offer courses to their students through asynchronous e-learning. This may involve one or more students participating in a remotely taught course, or a local instructor teaching a course which includes remote students.

2. Extracurricular or public education courses

The education system often assists in the delivery of extracurricular courses which benefit students or members of the public. This can include such courses as babysitter training, firearms training, snowmobile safety, watercraft operator training, public health courses, and many others.

3. Professional development

Professionals such as teachers often have the opportunity to participate in workshops for professional development, or to take continuing education courses. These workshops and courses can often be delivered through asynchronous e-learning.

7. Learning portals for enrichment of live classes (Moodle, Blackboard, etc)

One educational tool often used by schools is the learning portal. This is a specialized website which holds content and activities for a course as well as communication tools such as forums and private messaging systems to facilitate interaction between students and teachers or between groups of students. These portals may be hosted within a school or may be hosted outside a school as part of a central office serving a first nation, tribal council, or provincial group. Bandwidth requirements for locally hosted learning portals are minimal when accessed from within a school, but the desire for students, teachers, and potentially parents to be able to access the systems from home may require bandwidth. The bandwidth demands will be dependent on the number of simultaneous users to be supported, but 512 kilobits / second of upload bandwidth is likely a minimum for hosting a learning portal to be accessed from outside a school. If a learning portal is hosted outside a school, bandwidth will be required for students and teachers to be able to access it from within the school. Like any other web-based resource, bandwidth needs will be about 256 kilobits / second per user, but requirements may be much higher if audiovisual content is being hosted on the learning portal.

8. Student management systems (registration, attendance, grading, etc.)

One administrative application which is commonly used in schools is a student management system, which incorporates functions such as student registration, attendance tracking, assignment grading, and report cards. These systems generally are accessed using a web browser, and the bandwidth requirements are similar to other websites. If the system is hosted within the school, much of the traffic will be local to the school, but access may be needed from outside the school for teachers working from home or for parents to access student reports. The bandwidth demands will be dependent on the number of simultaneous users to be supported, but 256 kilobits / second of upload bandwidth is likely a minimum for hosting a student management system to be accessed from outside a school. If a student management system is centrally hosted for a first nation, tribal council, or other larger group, then bandwidth will be required for accessing it in the school. As content tends to be primarily text-based, bandwidth of 128 kilobits / second per user is likely to be adequate for effective use.

9. Social media for educational purposes

Social media websites such as Facebook, MySpace, or Twitter can find legitimate educational applications, especially in class enrichment scenarios such as twinning classes with other schools or for social studies classes. Bandwidth requirements for these uses are at least 256 kilobits / second.

10. Social media for recreational purposes

Social media websites such as Facebook, Myspace, Twitter, and Youtube are popular with students as recreational activities. This can create challenges for educators in terms of distraction from studying, in terms of potential for inappropriate communications to or from students (cyber-bullying and/or cyber-stalking), and in terms of bandwidth demand, as these sites can be bandwidth intensive, particularly Youtube. These challenges often lead schools to partially or completely ban these sites. Where they are allowed, bandwidth requirements can range from 128 kilobits / second (for Twitter, which is primarily short texts) to 300 kilobits / second for basic Youtube videos.

Overall school bandwidth requirements are dependent on a number of factors, including the school's policies toward recreational use of social media, the size of the school, the number of computers available to students, and the applications in use. However, some general guidelines are available. INAC has set a goal of 10 megabit / second symmetrical connections for all federally-funded schools in the First Nations SchoolNet program. The US government has a recommendation of 50 megabit / second to 100 megabit / second available for every thousand students in a school. This translates to 5 megabit /second to 10 megabit / second per hundred students.

4. Justice / Public Safety

1. Mobile access to criminal records (CPIC) for police

Currently, police wishing to check for warrants, criminal records, or other information on individuals while out of the office rely on voice communications with a police operator, who searches for the information and relays it to the officer. It is now possible to equip police with mobile handsets, laptops, or tablets which will allow them to access this same information through secure web interfaces

or specialized applications. Bandwidth requirements for this type of application are fairly light, as there is no need for audio or video, and little need for graphics or photographs beyond simple identification photographs. Connections of 128 kilobit / second would likely suffice, which is possible using cellular data access technology. The secure server at the police station would require upload bandwidth of 512 kilobit / second to support multiple accesses.

2. Mobile access to driver registrations / vehicle registrations / stolen property registrations for police

As with criminal record access, it is now possible to equip police with mobile handsets, laptops, or tablets which will allow them to access this type of information through secure web interfaces or specialized applications. Bandwidth requirements are similar to criminal records access, but may require greater use of photographs, slightly increasing bandwidth requirements. Connections of 256 kilobit / second would likely suffice, which is possible using 3G or 4G cellular data access technology. The secure server at the police station would require upload bandwidth of 1 megabit / second to support multiple accesses.

3. Mobile access to case files for report entry

By equipping police with mobile laptops or tablets, it becomes possible for more case notes to be entered from the field, rather than after returning to the office. This can help to ensure details are correct in the case notes. This application requires fairly low bandwidth for note entry, but may require more bandwidth if digital photographs are to be included with case notes. Connections of 256 kilobit / second upload would be adequate for all reports with significant photographic attachments. This type of bandwidth is possible using 3G or 4G cellular data access technology to support the mobility requirements. The fileservers at the police station would require bandwidth of 1 megabit / second in both directions to facilitate multiple accesses.

4. GPS / GIS mapping support for police / fire / EMS response

One challenge for police or emergency responders can be to know the location of the emergency. GPS mapping technology can be an advantage in giving directions to known addresses. For many first nations, residences and businesses may be lacking street addresses for GPS units. In these cases, GIS mapping which ties together phone numbers with detailed maps of the community may be of assistance to responders. Mobile access to the maps through a secure web interface would require bandwidth of 256 kilobit / second, which is possible using 3G or 4G cellular data access technology to support the mobility requirements. The secure web server would require upload bandwidth of 1 megabit / second to ensure sufficient bandwidth to support multiple clients.

5. GIS profiling for crime

GIS (geographic information system) is a technology used for combining maps with data relating to the maps. Police departments often use GIS systems to track locations of criminal activity, both for reporting and predictive purposes. This application does not require bandwidth if the GIS information is limited to the station or office. However, if this information is hosted on systems outside the local station (a departmental or regional headquarters, for example), bandwidth may be required to transmit

data. GIS applications tend to be bandwidth intensive, as both data and map graphics must move both ways. Bandwidth of 1 megabit / second per user may be required to support this application.

6. Web-based crime reporting / tips

Organizations such as Crimestoppers allow the public to report criminal activity, suspicious activity or information about missing persons to the police. This may be done through the use of a web page, as well as through phone tips or email tips. Bandwidth for the users is fairly low, with a 128 kilobit / second connection likely sufficient for this web application. The organization hosting the server will need more bandwidth to support multiple users, with 512 kilobit/ second of upload and download bandwidth needed for a smaller local system, and 1 megabit / second of upload and download bandwidth needed for a larger regional system.

7. Offender electronic monitoring (ankle bracelets)

There are two major applications for offender monitoring. The first application uses radio signals from a bracelet (often worn on the ankle) to transmit location data to a receiver. This may involve GPS technologies, cell phone data transmission, or the use of a signal to a fixed-location receiver to indicate that the offender is within range of the receiver. These technologies allow police to ensure offenders are in designated locations at specified times (house arrest curfews, etc). A second application uses a bracelet to monitor alcohol levels through perspiration, thereby verifying compliance with orders to abstain from alcohol. Neither of these technologies involve significant bandwidth, as the data transmitted is minimal and sporadic. Cellular data transmission technologies are capable of handling the bandwidth requirements for the offenders. The receiving station at the police station may require a small amount of bandwidth to receive data from multiple offenders. 256 kilobit / second would be more than adequate for this application.

8. Internet access to surveillance / recording systems – also applies to health, education, etc.

Many public facilities and areas are now covered by surveillance cameras to allow police to identify vandals and/or thieves. Cameras may be directly available through the internet, or multiple cameras in and around a facility may be connected to a surveillance video recorder system, which may be accessible through the internet. Bandwidth requirements for this application may vary widely; a typical camera may require up to 10 megabit / second of upload bandwidth for remote viewing at full quality, but many cameras support lower-bandwidth options for remote viewing, either using better codecs for compression of the video signal, lower resolutions, or fewer frames per second. At minimal resolution and frame rate, 256 kilobit / second of upload bandwidth may be sufficient to transmit a video signal for remote viewing.

9. GIS support for emergency planning (fire / flooding / storm vulnerabilities, etc)

GIS (geographic information systems) mapping technologies may be used in planning for emergencies. Data which can be linked to the maps can include water level predictions, fire fuel sources, and other factors which may be important in planning. The GIS systems may support planning evacuation routes or planning for levee or firebreak construction. Bandwidth for GIS applications can be high, especially if there is a need to transmit data between a server in one location and a GIS application

user in another location. For this type of application, bandwidth of at least 1 megabit / user in both directions is recommended.

10. Emergency communications

One common feature of emergency situations is disruption of communications due to damage to infrastructure. Wireless communications may be an alternative where wired infrastructure has been damaged. This may involve shifting from phonelines to cellular phones, installing wireless network equipment to fill in for damaged landlines, or using IP-based communications running over undamaged network infrastructure. Voice communication is a low-bandwidth application, requiring about 64 kilobit / second in each direction for a call, meaning that wireless or satellite network connections may be a viable alternative where wired communications and cellular service are unavailable.

11. Telecourt

Many First Nations communities are distant from court systems, which can create obstacles for offenders, victims, witnesses or plaintiffs needing to make court appearances. One approach to easing this burden is the use of videoconferencing for court appearances. This is generally done with the highest quality possible, meaning that bandwidth requirements can be 2 to 4 megabit / second in each direction for both the courthouse and the local site linked to the court.

12. Videoconferencing access to legal aid / legal representation

Just as First Nations communities are distant from court systems, they are often distant from legal aid offices and law offices. This can pose a barrier to individuals seeking legal representation. Use of videoconferencing to link these individuals with legal aid or law offices can help solve this problem. For this application, lower quality connections are more acceptable, meaning that bandwidth requirements can be as little as 512 kilobit / second in each direction.

13. Family / community support for incarcerated offenders by videoconference

One challenge facing many incarcerated First Nations offenders is that the prisons or jails are distant from their families. As a result, visits from family or community members are rare. This problem can be a alleviated to a degree through the use of videoconferencing to allow virtual face-to-face visits between prisoners and their families or friends. This application does not require the highest possible video quality, meaning that bandwidth requirements can be as little as 512 kilobit / second in each direction.

5. Social Services

1. Mobilized access to case management databases for social workers

Social workers are required to keep records on interactions with clients. This information may be made available for access and for updating through mobile laptops or tablets. This then makes it possible for more case notes to be entered from the field, rather than after returning to the office. This can help to ensure details are correct in the case notes. This application requires fairly low bandwidth for note entry, but may require more bandwidth if digital media such as photographs or interview recordings are to be included with case notes. Connections of 256 kilobit / second upload would be adequate for all reports without significant photographic attachments. This type of bandwidth is

possible using 3G or 4G cellular data access technology to support the mobility requirements. The fileservers at the office would require bandwidth of 1 megabit / second in both directions to facilitate multiple accesses.

2. Web-based applications for employment insurance, social assistance, etc.

Many routine forms for social services clients are now available as electronic forms, which can either be downloaded and printed out or filled out online. In many cases, social services offices are assisting clients to fill out these forms electronically at a public access computer in the social services office. This type of application requires a server hosting the forms and form processing software. This can be hosted either in the local office or in a central office or datacentre. Where the hosting is not local, bandwidth to access this service will be low, with a 256 kilobit / second connection sufficient for most forms. However, if an office is hosting multiple workstations accessing remote forms, the bandwidth requirements will need to reflect the possibility of multiple accesses. Where the hosting is local to the office, additional bandwidth will be needed to ensure that multiple clients can access the service. 1 megabit / second would be recommended for this type of application.

3. Web-based reporting of child abuse / neglect or domestic abuse

Just as it has become possible to report actual or suspected criminal activities online, so it is possible to allow reporting of suspected or actual abuse or neglect online. This may be done through the use of a web page, as well as through phone tips or email tips. Bandwidth for the users is fairly low, with a 128 kilobit / second connection likely sufficient for this web application. The organization hosting the server will need more bandwidth to support multiple users, with 512 kilobit/ second of upload and download bandwidth needed for a smaller local system, and 1 megabit / second of upload and download bandwidth needed for a larger regional system.

4. Videoconferencing sign-language translation services for deaf individuals

Deaf individuals are often taught and communicate via sign language, as well as written communications. Just as translation services are often required for non-English-speaking individuals, sign language translation services are often required for deaf individuals in order to effectively communicate. Videoconferencing technology allows sign language translators to work with a deaf individual, as the translator can both hear and speak to a non-deaf individual or group, and sign with a deaf individual or group. This application, does not require the highest quality of videoconferencing, meaning that bandwidth requirements can be as little as 512 kilobit / second in each direction.

5. Videoconferencing access to counselling

Counselling services often straddle the line between health and social services. Counselling in a number of areas, including mental health, addictions, and financial counselling, may be a service required by social services clients, yet not readily available locally. Videoconferencing may allow local social services clients to access counselling services in larger centres. The nature of the counselling may affect the bandwidth requirements – a financial counsellor showing presentations may need more bandwidth than a counsellor having a face-to-face conversation with a client. In general, bandwidth needs for this application would range from 256 kilobit / second to 1 megabit /second in each direction.

6. Electronic banking / fund transfers for assistance recipients

Social services organizations are often required to provide funds to clients needing assistance. This often involves electronic banking and funds transfers. This is a fairly low bandwidth application, with 256 kilobit / second being more than sufficient to transfer the necessary information for even large groups of funds transfers.

7. Web-based information for clientele and the public

There is a wealth of information available on the internet, and many social services recipients will find helpful information in areas as diverse as employability skills, job search skills, parenting, dealing with handicaps, dealing with addictions, and many others. Social services staff may use public internet access stations to assist clients in accessing some of these resources. Providing access in-office is a relatively low-bandwidth application, requiring 256 kilobit / second for each computer.

8. Web-based employment searching (Saskjobs.ca, Monster Jobs, etc)

In the past decade, employment opportunities listings have largely moved to on-line databases, whether government-run websites such as Saskjobs.ca or privately owned companies such as Monster.ca. Social services staff may use public internet access stations to assist clients in accessing some of these resources. Providing access in-office is a relatively low-bandwidth application, requiring 256 kilobit / second for each computer.

6. Public Works

1. GIS support for planning / documenting infrastructure

Many First Nations, local, and regional governments use GIS (geographic information systems) to document and plan infrastructure such as water systems, sewer systems, natural gas pipelines, electrical utilities, telecommunications utilities, transportation routes, and housing. The GIS systems allow the combination of detailed maps with database information such as residential occupancy. Bandwidth for GIS applications can be high, especially if there is a need to transmit data between a server in one location and a GIS application user in another location. For this type of application, bandwidth of at least 1 megabit / user in both directions is recommended.

2. Remote monitoring for water / sewer treatment facilities

Water and sewer treatment facilities require ongoing monitoring to ensure health and environmental standards are being met. Equipment within these facilities often has the capability to provide information on current operating parameters and testing results remotely, to facilitate review by equipment providers and/or standards enforcement officials. This is a fairly low-bandwidth application, as the data being transmitted is limited. 128 kilobit / second of upload bandwidth is likely to be sufficient for this application.

3. Professional development for water / sewer treatment operators

Water and sewer treatment operators require ongoing professional development in order to maintain certification. This may involve sending operators to centralized training courses. However, some of the training may be conducted through videoconferencing or other internet-based approaches. Bandwidth for this application is likely to require at least 512 kilobit / second in each direction.

4. Remote monitoring / control for building HVAC systems

Many institutional buildings include centralized HVAC (heating, ventilation, and air conditioning) systems which are controlled through computerized systems. These systems are frequently made available remotely for support by the manufacturer's service representatives or the installation company. This is a fairly low-bandwidth application, as the data being transmitted is limited. 128 kilobit / second of upload and download bandwidth is likely to be sufficient for this application.

5. Delivery of information to residents (garbage pickup schedules, snow removal schedules, service disruption announcements, etc)

Many First Nations, local, and regional governments have the need to communicate to their residents about scheduled infrastructure maintenance and regular public services, including such items as garbage pickup schedules, snow removal schedules, scheduled maintenance outages for water or sewer, and planned road maintenance. Emergency notices such as flood warnings, fire evacuation notices, or boil water advisories also need to be communicated to residents. One channel for communicating these types of informational items is a government website. The bandwidth for this application will depend on the expected frequency of usage, but can be expected to require 500 kilobit / second to 1 megabit / second of upload bandwidth at the webserver location. For this type of application, it is common to arrange to have the webserver located in an internet service provider datacentre, rather than on the local office.

7. Governance

1. Videoconferencing for government-to-government meetings (INAC, etc)

Local-level governments such as First Nations band councils often require meetings with provincial or federal government politicians or civil servants. These types of meetings may often be held by videoconferencing in order to reduce travel costs. Bandwidth requirements for this application are generally from 512 kilobit / second to 2 megabit / second in each direction as discussed earlier.

2. Videoconferencing for community consultations

Many First Nations have multiple communities, as do all tribal councils. Community consultations therefore often require significant travel. Some of this travel can be eliminated by holding consultations by videoconferencing. Bandwidth requirements for this application are generally from 512 kilobit / second to 2 megabit / second in each direction as discussed earlier.

3. Electronic data reporting for funding agencies (INAC, etc)

Local-level governments such as First Nations and their departments often work with other levels of government to fund operations and infrastructure projects, whether through INAC, Health Canada, Service Canada, or other federal departments or provincial ministries. Many of these funding arrangements require reporting of activities and data to the funding agency. Much of this reporting is now done electronically. Bandwidth requirements for this application are generally low, as most of the data being transmitted is textual or numerical, rather than audiovisual. Connections of 128 kilobit / second in each direction are likely to be adequate for this application.

4. GIS for traditional land use / resource management

Many First Nations have landbases with resources available. Planning for use of these resources generally must take into account traditional land uses. Documenting these traditional land uses is often performed through the use of GIS (geographic information systems), which combine mapping capabilities with database information such as resource estimates, names of traditional land users, and leaseholders. Bandwidth for GIS applications can be high, especially if there is a need to transmit data between a server in one location and a GIS application user in another location. For this type of application, bandwidth of at least 1 megabit / user in both directions is recommended.

5. Web presence for information to stakeholders and public

Governments must communicate information to their citizens and to the neighbouring public. This information can include items such as council meeting schedules and agendas, Band Council minutes and resolutions, election candidates, election results, and contact information for elected and appointed officials. One channel for communicating these types of informational items is a government website. The bandwidth for this application will depend on the expected frequency of usage, but can be expected to require 500 kilobit / second to 1 megabit / second of upload bandwidth at the webserver location. For this type of application, it is common to arrange to have the webserver located in an internet service provider datacentre, rather than on the local office.

8. Administration

1. Employment / Human resources recruitment via internet

Most employers are now using the internet as a recruitment tool, whether through the use of career / jobsites such as saskjobs.ca or monster.ca, through their own websites, or both. This application does not require significant bandwidth, as much of the information is delivered through servers outside the local office. A connection of 128 kilobit / second is sufficient to update this type of information so that it can be delivered to the public users. For employment information on a locally hosted web server, a connection of 512 kilobit / second to 1 megabit / second is generally sufficient.

2. Human resource management

Many organizations now have staff websites providing employees access to employment policies, forms (for leave requests, expense reimbursement, purchase authorizations, etc), calendars, and other resources. Operating such a staff website is usually done from a central office server, although it is also possible to host this through an internet service provider. Bandwidth for such a server will require 500 kilobit / second to 1 megabit / second, depending on the size of the organization and the amount of information being distributed.

9. Economic Development / Commercial

1. Promotion via web / internet

Many communities and First Nations wish to promote themselves to attract tourism, to attract investment and employment opportunities, and to promote businesses owned by the community. These types of promotions typically include a presence on the world wide web. Because promotional sites often rely heavily on audiovisual elements, the bandwidth requirements for such websites are higher

than for more informational sites. Bandwidth of 1 megabit / second is typically required to ensure availability to visitors. This bandwidth is often achieved through hosting a website at an internet service provider facility, either by renting space on an ISP server or by collocating a server in the ISP facility.

2. Sales via web / internet

Many smaller businesses are able to use the internet to find a wider market for selling their goods. This can be done using sales marketplace websites such as EBay, Craigslist, Kijiji, or Amazon Marketplaces; or can be done through setting up a website for the business. Business websites can act as catalogues, with sales taking place by phone or email; or business websites can have full sales capabilities, where buyers can actually order and pay through the website. To use a sales marketplace website for selling requires only a moderate bandwidth unless extensive photographs are being sent to the website. Bandwidth of 256 kilobit / second to 512 kilobit / second is sufficient for this application. Hosting a business website may require more bandwidth if the site is hosted locally rather than through an ISP facility. For this type of application, at least 1 megabit / second should be in place to be able to support moderate traffic to the website.

3. Services via web / internet

Many businesses are now coming into existence providing services to remote clients using the internet. There is a vast range of possibilities, including business bookkeeping and accounting services, writing services, design services, computer programming services, marketing services, and many others. The bandwidth required for this application will be very dependent on the type of service and the communication needs between the business and the client(s). To be able to send files quickly and easily, bandwidth of at least 1 megabit / second would be advisable.

4. Purchasing via web / internet

Many businesses and organizations are now able to lower costs by using the internet to compare prices and order goods and supplies. In many cases, goods and supplies that can be ordered online would not otherwise be locally available, or would be significantly more costly. This application does not require significant bandwidth; a connection of 256 kilobit / second is sufficient for effective use.

5. Government to business services via web / internet (forms, communications, etc)

Economic development often requires communicating with both public and private sector funding organizations to arrange financing. Much of the funding research and application process can now be performed through the internet. This application does not require significant bandwidth; a connection of 256 kilobit / second is sufficient for effective use.

6. Videoconferencing for connections with funding agencies

Economic development and business financing may require meetings with public and private sector funding organizations and investors. Many of these meetings require travel by one or more participants. Videoconferencing offers the possibility or reducing the travel requirements. This application does require greater bandwidth of from 512 kilobit / second to 2 megabit / second in each direction.

10. Recreational

1. Community recreational schedules and information

Many communities have recreational programs for their members. Information such as schedules, results, and announcements can be effectively communicated using the internet, via a community website and/or by email. Bandwidth of 256 kilobit / second to 512 kilobit / second is sufficient for this application when the website is hosted through an internet service provider. Hosting a community website may require more bandwidth if the site is hosted locally rather than through an ISP facility. For this type of application, at least 1 megabit / second should be in place to be able to support moderate traffic to the website.

2. Community recreational fees payments

Many community recreational groups and programs have begun using the internet to accept payments for fees and dues. This may be done through services such as Paypal, through Interac money transfers, or by setting up a merchant services account to allow accepting credit card payments through a website. Bandwidth of 256 kilobit / second to 512 kilobit / second is sufficient for this application when the website is hosted through an internet service provider. Hosting a community website may require more bandwidth if the site is hosted locally rather than through an ISP facility. For this type of application, at least 1 megabit / second should be in place to be able to support moderate traffic to the website.

3. Online streaming video

The internet both supports recreation and functions as a source of recreation for many people. One recreational application used by many people is watching video online. This can include live video from local, regional, or national sports, locally produced video, commercial movies through services such as Netflix, video from television shows through television network websites or internet television services such as SaskTel Max, or amateur video from sites such as Youtube. The bandwidth required for streaming video varies depending on the quality of the video, but generally requires at least 300 kilobit / second for each viewer. For full high-definition video streams from an internet television service, bandwidth requirements may jump to as much as 10 megabit / second per stream.

4. Online video download (Itunes, etc)

Just as live video can be watched over the internet, video can be downloaded for later viewing. Services such as Apple's Itunes Store allow purchase of commercial movies for downloading and watching on a computer, tablet, or media player. Bandwidth for this application is dependent on the time constraints for the download. To download a full-length (2 hour) compressed DVD-quality video in less than the 2 hours it would take to watch it would require a connection of approximately 3 megabits / second. To download a full DVD in less than 2 hours would require a connection of approximately 5 megabit / second.

5. Online streaming audio (Itunes, online radio, etc)

A second major recreational application of the internet is listening to live or recorded online audio, whether music or radio. Thousands of radio stations stream audio onto the internet. Audio is a

much less demanding application than video. Listening to an internet audio stream typically requires 64 kilobit / second, with the highest quality streams typically requiring 128 kilobit / second.

6. Online audio download (Itunes, etc)

As with video, audio on the internet can either be streamed (live) or downloaded for later listening. Apple's Itunes store and Amazon both sell music online, as well as many smaller independent sites. In addition, many websites such as radio stations offer podcasts of programs for listeners. A typical 1 hour album or podcast can be downloaded on a 1 megabit / second connection in under 4 minutes.

7. Online gaming (World of Warcraft, Steam online game downloads, flash games, etc)

Computer games have become an extremely popular recreational pastime. Many games can be purchased and installed through the internet, using services such as Valve's Steam. As modern computer games contain many audiovisual resources, the file sizes for these games are very large. Downloading a typical game on a 5 megabit / second connection can take over four hours.
As well as full-scale computer games, many users enjoy using smaller games found on websites, often using Adobe Flash. This requires much less bandwidth. A 256 kilobit / second connection is generally sufficient to play one of these games.

8. Blogging - online journaling

Many internet users enjoy reading or writing blogs (web logs), which can be personal journals or commentaries. These blogs are generally hosted on blogging services such as Google's Blogger, LiveType's TypePad, or WordPress, but can also be hosted through private websites. Many blogsites include photographs or audiovisual elements, so that bandwidth requirements can vary. A 256 kilobit / second connection is generally sufficient to view or author a blog, but blogs that are heavy in photography or audio may require a higher-bandwidth connection.

11. Social

1. Social web

The internet has served to reduce distance for many people, allowing the maintenance of relationships among people who have become geographically separated. The internet also allows people to come together with others who share their specialized interests. These two capabilities are exhibited in social web services such as Facebook or Myspace, as well as in thousands of specialized websites where large or small interest groups use forums to discuss their hobbies and passions. This basic application does not require high bandwidth; a 256 kilobit / second connection is generally adequate to participate in social websites or forums.

2. Online dating services

Many people have found that the internet allows people to find others who have compatible values and interests for romantic relationships. In some cases, this happens through the social web, as people connect while pursuing mutual interests. In other cases, people utilize online dating services such as Match.com, EHarmony, or many specialized services to connect them with others searching for relationships. The basic requirements of this application are not high; a 256 kilobit / second connection is sufficient to participate in such activities. However, connecting with others may involve audio or video

communications, as well as sharing photographs. These activities may require greater bandwidth, so that a 1 megabit / second connection may be required.

3. Photo / video sharing

One aspect of the social internet is the desire to share photographs or videos with friends or family. In some cases, this focuses on the artistry or skill of the photographer or videographer, while in others the focus in on the people being portrayed in the photograph or video. Sites such as Flicker, Picasa, Facebook, and Youtube facilitate sharing these photographs and videos, either with a restricted group of friends and family, or with anyone who may have an interest. Because both photographs and video produce large filesizes, participating in these sharing sites requires a significant bandwidth. A 1 megabit / second connection is adequate for sharing photographs or short video clips; for longer videos, a higher-bandwidth connection may be advisable to avoid extremely long file transfer times.

3. Local Access Technologies

1. Wired

Internet access within a community can rely on either wired or wireless technologies. Wired technologies are more costly to install, but are generally more reliable and capable of higher bandwidth than wireless technologies. Note that equipment cost estimates in the following section refer only to the access technology equipment costs (central office modems and end user modems), not to cable costs, installation costs, or central office router costs.

1. DSL Copper phone lines

DSL (digital subscriber line) is a set of technologies for transmitting high-speed data over copper phone lines. This has a number of advantages. Phone lines are in place to most offices, schools, businesses, and residences. This means that an internet distribution system can be set up without the need to install new cable. This saves both time and money in establishing an internet access system for a community.

1. ADSL

ADSL is asymmetrical digital subscriber line. Asymmetrical refers to the fact that the download bandwidth available to the subscriber is much higher than the upload bandwidth. ADSL is limited by the length of the phone line between the central office and the subscriber. At distances of up to 2 km, ADSL can offer up to 12 megabit / second of download, but only 1 megabit / second of upload. Beyond 2 km, ADSL performance can be variable. Basic equipment costs are in the neighbourhood of $100 / subscriber.

2. VDSL

VDSL is very high speed digital subscriber line. This is a new technology in which download bandwidth of up to 50 megabit / second can be offered if the line length is less than 1 km. At 2 km, this drops to 20 megabits / second. At 3 km, this drops to 8 megabits / second. At 5 km, this drops to 4 megabit / second. Upload bandwidth will also vary by distance, but 1 megabit / second is common at medium distances. One common use of VDSL is in “fibre-to-the-node” deployments, in which phone

lines are routed to local cabinets housing DSLAMs (DSL access modules). The DSLAMs are connected by fibre optics to the central phone office. This model is used in SaskTel's Next Generation Access Infrastructure project in major cities. Basic equipment costs are in the neighbourhood of $100 / subscriber.

3. HDSL

HDSL is high data rate digital subscriber line. This is a technology often used for delivery of T1 (1.5 megabit / second symmetrical) internet services. This technology can be used with lines of up to 20 km through the use of repeaters on the line.

2. Coax Cable lines (DOCSIS 3.0)

Coax cable is used by cable television service providers to transmit television signals. It can also be used to transmit internet data. The most recent standard for internet service over coax cable is DOCSIS (Data over Cable Service Interface Specification) version 3.0, which supports download bandwidth of up to 400 megabit / second and upload bandwidth of up to 100 megabit / second, although because bandwidth is shared among subscribers, actual delivered bandwidth may not reach these levels.

Costs for DOCSIS 3 equipment are estimated at approximately $70 / subscriber, assuming that a cable system for television is already in place.

3. Fiber Optic lines

1. Active (dedicated) fibre (Ethernet)

Active fibre optics involve one pair of fibres being dedicated to the connection between the central office or remote cabinet and the subscriber. This pair of fibres is used to plug in to a switch fibre module at the head office / remote cabinet and either a switch fibre module or a media converter at the subscriber location. Using single mode fibre, an active fibre connection can support a gigabit / second (1024 megabit / second) symmetrical connection, or with more expense switch hardware, a 10 gigabit / second symmetrical connection. If a remote cabinet is utilized, it must have power for the switch which aggregates the traffic onto one fibre pair going to the central office. Costs for gigabit fibre equipment would be approximately $600 / subscriber.

2. Passive (shared) fibre (EPON)

Passive fibre optics involve one pair of fibres being shared among a number of subscribers through the use of fiber splitters. Because these fibre splitters do not require power, remote cabinets can be set up for splitters without requiring power. EPON is Ethernet passive optical network, one of the two major standards for passive fibre optics distribution systems. EPON systems offer over 1 gigabit / second in both download and upload bandwidth, but this bandwidth is shared among a number of subscribers (up to 32 subscribers). In the best case (little to no traffic from other subscribers), an individual subscriber could access a gigabit / second symmetrical connection. In the worst case (the maximum number of subscribers on a shared connection, all using the maximum possible bandwidth), an individual subscriber might drop to 40 megabit / second in each direction. Typically, EPON systems offer 100 megabit / second in each direction to each subscriber. EPON systems generally are limited to

cable lengths of 10 kilometers. Costs for EPON fibre equipment would be approximately $160 / subscriber.

3. Passive (shared) fibre (GPON)

GPON is gigabit passive optical network, the second major standard for passive fibre optics distribution systems. GPON systems offer up to 2.5 gigabit / second of download and up to 1.25 gigabit / second of upload bandwidth shared among up to 64 subscribers. In the best case (little to no traffic from other subscribers), an individual subscriber could access a gigabit / second symmetrical connection. In the worst case (the maximum number of subscribers on a shared connection, all using the maximum possible bandwidth), an individual subscriber might drop to 40 megabit / second of download bandwidth and 20 megabit / second of upload bandwidth. Typically, GPON systems offer 100 megabit / second in each direction to each subscriber. GPON systems generally are limited to cable lengths of 10 kilometers. Costs for GPON equipment would be approximately $130 / subscriber.

2. Wireless (Unlicensed Microwave)

Wireless internet access relies on either radio (microwave) transmissions or light transmissions (free space optical systems). Microwave radio can utilize different frequencies, or spectrum. Radio spectrum is regulated by Industry Canada. Many areas of the spectrum require a license from Industry Canada in order to be used. A number of spectrum areas are set aside for use without license requirements. As a tradeoff, equipment designed to work in unlicensed frequencies is much more limited in the amount of power that it is allowed to broadcast than is equipment designed to work in a licensed frequency, giving it a lower range in distance. The spectrum areas set aside for unlicensed use include the 902-928 MHz range, the 2.4- 2.5 GHz range, and the 5.15-5.8 GHz range. Higher frequency spectrum allows more data throughput per channel, but at a cost of reduced range. Because unlicensed spectrum is open to anyone to use, interference between signals is always possible.

1. Unlicensed WiFi

WiFi refers to a family of standards for the use of digital microwave radio transmission of network data over unlicensed spectrum. WiFi wireless signals may face interference between multiple systems attempting to use the same spectrum, or between other sources of electromagnetic radiation on the same spectrum (such as produced by microwave ovens, cordless phones, or other non-networking equipment). WiFi has several variants, with one of the distinguishing features being the choice of which microwave spectrum is used. The two major choices are the 2.4GHz bands or the 5 GHz bands, which offers more available channels and fewer sources of interference. WiFi is designed for use in a home or office, but the equipment may be adapted for outdoor use to transmit internet within a community. This generally requires a central high point or tower with one or more antennas connecting to permanently mounted antenna on subscriber premises. Clear line of sight between the subscriber antenna and the central antenna is a requirement for wireless access, meaning that areas in valleys or behind trees may not be able to be served by wireless access without the use of towers. In some cases, both a central tower and a subscriber tower may be required in order to obtain a clear line of sight. WiFi can offer up to 150 megabit / second of bandwidth, but this bandwidth is shared among all the subscribers and is also shared between upload and download, so actual delivered bandwidth is likely to be considerably lower. With appropriate equipment, WiFi can transmit information up to 60 kilometres,

although 15 kilometers is more typical for wireless internet scenarios. Costs for equipment will vary depending on the distance to the central tower, but client equipment can be as low as $160 per subscriber (this does not include the cost of the central tower or its radios).

2. Unlicensed WiMax

WiMax (Worldwide Interoperability for Microwave Access) is a similar technology to WiFi, but where WiFi was designed for local premise use, WiMax was designed for community or neighbourhood access. WiMax is used for both internet distribution and cell phone service, and is often referred to as a 4G (4^{th} generation) cell phone technology. WiMax may be used on either licensed spectrum (requiring a federal license) or unlicensed spectrum (usable by anyone without licenses required). Most WiMax equipment is designed for licensed use, but some vendors offer unlicensed equipment in the 5.2 to 5.8 GHz spectrum. This equipment is not capable of supporting WiMax to mobile equipment like cell phones, but is effective for supporting internet access to buildings such as schools, clinics, offices, or homes. Unlicensed WiMax can cover ranges of 5 km with some ability to penetrate through trees or walls; with direct line of sight between a central tower and a building's antenna, ranges may go over 10 km. WiMax can support connections of up to 75 megabit / second per channel, although this bandwidth may be shared among subscribers and between upload and download, so actual delivered bandwidth may be considerably less. 5 megabits of download bandwidth per subscriber is common performance for WiMax systems; small community systems may achieve better results. Customer equipment costs approximate $450 per subscriber (this does not include the cost of the central tower or its radios).

3. Unlicensed proprietary

Besides WiFi and WiMax, which are interoperable standards supported by a number of equipment manufacturers, there are a large number of manufacturers utilizing their own proprietary systems for wireless internet access. One of the better known products is the Motorola Canopy system, which can operate in the 900 MHz unlicensed spectrum. This spectrum allows greater range and penetration at the cost of lower bandwidth availability. Bandwidth on this system is limited to 10 megabit / second shared among all subscribers on a central antenna (the system is designed to allow 6 sectoral antennas on the central tower). Other proprietary wireless systems may be designed for point-to-point applications (linking one location to another), and may achieve up to 100 megabit / second in each direction at a distance of up to 120 km in this type of link, or up to gigabit / second in each direction at a distance of up to 2.5 km. Costs will vary widely based on the manufacturer, type of application (point-to-point link or point-to-multipoint internet service provision), and bandwidth requirements, but 100 megabit / second point-to-point solutions can be created for approximately $10,000.

3. Wireless (Licensed Microwave)

The use of licensed spectrum imposes a number of constraints. First, a license must be obtained from Industry Canada for use of the spectrum. This license will spell out the spectrum usable, the allowed transmission power levels, and the geographic limitations of the spectrum usage. Desirable spectrum may or may not be available in a given geographic area, depending on the existing licenses. Annual license fees must be paid to Industry Canada. For use of certain spectrum with wireless internet, reports must be filed with Industry Canada on the equipment used, and operators may be required to

coordinate operations with satellite earth stations which may use the same spectrum. All equipment used in licensed applications must be certified by Industry Canada for use.

1. Licensed WiMax

Unlike WiFi, which is only designed for use in unlicensed spectrum, WiMax is primarily designed for use in licensed spectrum. WiMax equipment is frequently available in the 3.5 GHz spectrum, which is licensed by Industry Canada for use in Wireless Broadband Systems on a local regional basis (the province of Saskatchewan is divided into 11 local regions for licensing purposes). Wimax equipment may also be available in other spectrum ranges requiring specific licensing from Industry Canada. Licensed WiMax equipment is generally certified for use with both fixed wireless systems (antennas mounted permanently to a building) and mobile wireless systems (such as cell phones, tablets, or computer wireless modems). Bandwidth for WiMax is dependent on distance from the central station, with bandwidth of 50 megabit / second possible at distances of under 1 km, and typical bandwidth of up to 4 megabit / second at the edge of coverage (up to 30 km).

2. Licensed proprietary (eg Motorola Canopy)

There are a number of systems available for wireless internet distribution which are proprietary to a single vendor, rather than being standardized and interoperable. While multipoint distribution systems generally favour the unlicensed spectrum, some vendors also provide systems using licensed spectrum, which is less susceptible to interference. The Motorola Canopy system is one example of a proprietary system which is available in both unlicensed and licensed spectrum models. In addition to multipoint distribution systems, many wireless equipment manufacturers produce point-to-point solutions for linking two sites together. These licensed systems may offer bandwidth as high as gigabit / second in both download and upload capabilities. Costs in this sector are extremely variable depending on the manufacturer, the bandwidth requirements, and the spectrum requirements.

3. Licensed MCS / BRS

In Canada, the 2500 MHz - 2690 MHz spectrum is assigned to multipoint communication systems (MCS). In the United States, this same spectrum is assigned for Broadband Radio Service (BRS). In Saskatchewan, this spectrum was licensed to SaskTel; elsewhere in Canada, this spectrum was licensed to Inukshuk Wireless Inc. In Saskatchewan, SaskTel uses this spectrum to deliver wireless broadband using equipment based on a wireless modification of the DOCSIS cable internet standard. This equipment can deliver up to 3 megabit / second of download bandwidth and up to 640 kilobit / second of upload bandwidth to subscribers, although bandwidth may be limited by distance from the tower. Because of the nature of the spectrum licensing, this type of internet distribution is limited to existing licensees.

4. Licensed Cellular 2G / 3G (CDMA EV-DO)

The second generation of cellular phone systems moved from transmitting voice signals as radio transmissions to transmitting voice signals in digital form. The same infrastructure that allows transmitting voice signals in digital form can be adapted to transmit internet traffic. The version of digital cellular system originally adopted by SaskTel in Saskatchewan is known as CDMA (code division multiple access). Early CDMA systems were very limited in bandwidth, allowing up to 144 kilobit /

second of download bandwidth. More recent versions are known as EV-DO (evolution data optimized). EV-DO revision A is considered a third generation cellular phone system because of the increased bandwidth it allows. EV-DO can support internet access through using smart phones as modems or through the use of internet sticks. Bandwidth on EV-DO revision A allows up to 3.1 megabit / second of download and up to 1.8 megabit / second of upload bandwidth, although this is shared among all the users on a tower base station, meaning that actual performance is significantly lower.

5. Licensed Cellular 2G / 3G / 4G (GMS / HSPA)

The second major worldwide system for digital cellular service is known as GSM (global system for mobile communications), which is the system used by Rogers wireless. The early 2G versions of GSM for internet data could provide data bandwidth of 56 kilobit / second to 115 kilobit / second. A later upgraded version called EDGE (Enhanced Data Rates for GSM Evolution) increased this to up to 236 kilobit / second. The 3G versions are known as HSPA (High Speed Packet Access), which can reach up to 14 megabit / second of download bandwidth and up to 5.8 megabit / second of upload bandwidth, while the 4G version is known as HSPA+ (Evolved High Speed Packet Access), which can reach up to 28 megabit / second of download bandwidth and up to 11 megabit / second of upload bandwidth. Since 2010, SaskTel has been adding HSPA+ service to its cellular network in cooperation with Telus and Bell Mobility, meaning that this service is widely available in Saskatchewan. As bandwidth is shared among all active subscribers on a cell base station, actual bandwidth results are significantly lower, with SaskTel advertising “up to 21 megabits / second” on their 4G (HSPA+) service, and typical bandwidth being in the range of 4 to 6 megabit / second download and 2 to 4 megabit / second upload. This level of performance makes cellular a viable option for small offices or homes and an excellent option for mobilized applications.

6. Licensed Cellular 4G (LTE)

For future cellular networks, the two major competitors are WiMax and LTE (long term evolution). LTE networks are being deployed in many countries, and are being tested in Canada. As of March 2011, no timeline has been announced for deployment in Saskatchewan. LTE can offer download bandwidth of up to 100 megabit / second and upload bandwidth of up to 50 megabit / second, with the future LTE advance version expected to offer download bandwidth of up to 1 gigabit / second and upload bandwidth of up to 500 megabit / second.

7. Microcell base stations

Cellular technologies require a base station, which phones or “internet sticks” communicate with. One developing trend in the telecommunications industry is the use of microcells, which are small-scale base stations. These base stations can serve a neighbourhood, an office building, or a home, and are connected to the phone system through existing network connections such as internet. Microcells generally have a signal range of up to 2km; smaller microcells with a signal range up to 200m are often referred to as picocells, while microcells with a signal range up to 10m are often referred to as femtocells. Femtocell base stations are available for costs of around $150, while larger microcell base stations may cost up to $20,000. In the near future, costs on a microcell base station may drop to approximately $2,000. These technologies offer a solution to the problems of poor or non-existent cellular service for phones, smartphones, tablets, and cellular internet modems.

4. Free Space optical

While fibre optic networking makes use of lasers to transmit light through specially designed glass or plastic fibres, free space optical network makes use of lasers or LEDs to transmit signals through the open air. This requires clear line of site between the transmitters / receivers on each end of the link. Unlike wireless microwave systems, free space optical systems can only be used for point-to-point applications. Bandwidth of up to gigabit / second (1000 megabit / second) can be achieved at a distance of up to several kilometers. However, the impact of bad weather (fog, rain, or snow) can reduce the effectiveness of free space optical solutions at ranges over 200 m. Costs will vary by the required bandwidth, the required range, and the need for a fall-back solution to deal with bad weather (hybrid equipment can include both laser and microwave radio links), but a 100 megabit / second point-to-point link for up to 500 m can be created for approximately $5,000.

5. Satellite

Satellite internet relies on a geostationary (fixed-position orbit) satellite and a ground antenna pointed at it. Geostationary orbits require high altitudes, so that transmission delays at the speed of light account for up to 240 milliseconds (about one-quarter of a second). This can have noticeable impacts on real-time communications, and can also limit file transfers; the design of the internet's transmission control procotol (TCP) requires regular acknowledgements of packet receipt, and the delay in transmitting these acknowledgements puts a limit on the flow of data. Many satellite internet systems have workarounds to mitigate the TCP delays, but real-time communications impacts are unavoidable. Satellite systems require careful alignment of the satellite dishes to ensure precise pointing at the satellite; for this reason, even subtle changes in the dish alignment caused by extreme weather, structural shifting, or vandalism can be disruptive to connectivity, and may require maintenance by a trained satellite installer with the proper specialized equipment. This is a significant reliability issue for satellite internet systems.

The significant capital costs of a geostationary communications satellite and the limited amount of spectrum available for data transmission means that internet bandwidth will always be significantly more expensive when provisioned by satellite than when provisioned through terrestrial connections.

1. Ka-band Satellite internet

The Ka-band is the highest frequency of satellite spectrum, from 26.5 to 40 GHz. Because of the high frequency, much smaller dishes can be used on the antennas. Typically, Ka-band dishes in Canada are 74 cm or 98 cm in size. However, the higher frequency also makes the signal more susceptible to weakening due to rain or snow. Newer satellites launched in the last few years have deployed spot-beams for Ka-band internet, allowing the bandwidth available to be divided among fewer customers in a region, and thereby allowing higher bandwidth to subscribers.

2. Ku-band Satellite internet

The Ku-band sits between the Ka-band and the C-band on the spectrum chart, from 12 to 18 GHz. Because the frequency is lower than Ka-band, larger dishes are required on the antennas. Typically, Ku-band dishes in Canada are from 74 cm to 2.4 m in diameter. Ku-band frequencies are less susceptible

to weakening in rain or snow than Ka-band, but more susceptible to weakening in rain or snow than C-band.

3. C-band Satellite internet

The C-band is the lowest frequency used for satellite data transmission, from 4 to 8 GHz. The lower frequency requires larger dishes on the antennas, with typical sizes being from 2.5 m to 3.5 m in diameter. There are fewer transponders used for internet communications in the C bands, as the antenna sizes have tended to favour Ku-band or Ka-band systems for this purpose. Some community-based systems use C band, taking advantage of subsidized C band transponders. Bandwidth availability is limited by the transponder load, but commercial satellite internet tends to have high end ranges of 4 megabit / second download and 1 megabit / second upload.

Ground equipment for C-band can be quite costly, partly due to the antenna size making transportation and installation difficult, and partly due to the fact that C-band equipment is more specialized.

4. Community ISP decision factors

One question which is faced by many communities when looking to establish or expand local internet services is whether to own and operate the internet service provider (ISP) or to persuade a commercial ISP to begin offering service. There are a number of factors which need to be considered in making this choice.

1. Plant costs (wiring and/or towers / antennas)

To distribute internet bandwidth within a community, there needs to be a distribution infrastructure. This may take the form of cabling (twisted-pair copper phone lines, coax copper lines, or fibre optic lines) or it may take the form of wireless antennae on towers. If a commercial ISP such as a telephone company or cable company already owns distribution infrastructure, it may be significantly less expensive to add the equipment to make use of this infrastructure than to build new infrastructure. To make use of this existing infrastructure, the community will either need to have the ISP owned and run by the infrastructure owner, enter into a partnership agreement with the infrastructure owner, or arrange to have a community-owned ISP rent the distribution infrastructure. If none of these options are viable, or if the existing infrastructure is inadequate for the bandwidth requirements of the community, then investment in new distribution infrastructure will be required. These costs can be very considerable . Fibre optic cabling (the current first choice for new distribution) can run $6,000 / km for cable installed on power poles, and can start at $18,000 / km for trenched cabling. Distribution infrastructure will also include costs such as remote cabinets for housing optical splitters or DSLAMs; as well as fibre switches, fibre splitters, cable amplifiers, or DSL repeaters. Maintenance of distribution infrastructure may require purchase or rental of specialized equipment such as fibre optics splicers, hoists, or trenchers.

2. Central office costs

In addition to distribution plant costs, to establish an ISP, a central office is needed. This must have sufficient space to house the necessary equipment; power systems including uninterruptible power supplies and backup generators to ensure continuity of power; heating and cooling to ensure optimum operating temperatures for the equipment; racks for storing the equipment; central office distribution equipment such as fibre optic switches, fibre optic optical line terminals (OLTs), cable modem termination systems (CMTS), digital subscriber line access multiplexer (DSLAM), wireless base station controllers; core internet service provision equipment such as routers, switches, email servers, web servers, network monitoring servers, traffic management appliances, network security appliances; and systems for managing subscribers and billing. The central office will need to be provisioned with connectivity to the internet. Ideally, this would take the form of two connections to two different Tier 1 or Tier 2 internet service providers, but in many cases only a single connection will be possible. The backbone connection(s) will need to have high throughput capacity, and will likely require either a fibre optic connection or a dedicated point-to-point wireless link with multi-megabit bandwidth (10-100 megabit / second or more).

3. Staffing and expertise issues

To operate a local internet service provider requires staff with a range of specialized skills. These include line installation and maintenance (fibre optic splicing or copper cable splicing) and/or antenna installation and alignment, equipment installation and maintenance, help desk support, advance router and network configuration and maintenance skills (including expertise in BGP routing and MPLS private networks), email and web server management, and network security. Many of these areas are extremely specialized and skilled staff are difficult to recruit. Smaller ISPs may find it necessary to contract work, as they will have neither the resources nor the workload to support full-time staff for all of these areas. ISPs providing services to certain sectors, such as health services, may find it necessary to have help desk and/or maintenance staff on call 24/7, which further complicates staffing issues.

4. Management and financial issues

In addition to the technical requirements of operating an internet service provider, there are a number of administrative and financial requirements. A community-operated ISP may function in one of two models. First, the services may be provided for free as part of the normal budget of the community. This has the advantage of eliminating the need for billing and collections, but the disadvantage of becoming a significant financial burden upon the community. The second model is to operate the ISP as a revenue-generating business. In this case, the ISP will need to have systems and staff for advertising and promotions, for connecting and disconnecting subscribers, and for billing and collections. Depending on the service billing model, there may be a need to monitor usage levels and to connect this to the billing system. There will need to be financial analysis in order to ensure that billing levels are appropriate to the competing needs of retaining subscribers and generating revenue sufficient to meet expenses including distribution network costs and depreciation, equipment costs and depreciation, connectivity costs, staffing costs, and potentially a profit margin for the community ownership.

5. Business planning

Given the major factors described above, preparation of a detailed business plan is essential for any community considering establishment or expansion of an internet service provider operation. This business plan must consider both the financial costs and benefits as well as the social costs and benefits of the operation, including the opportunities for local training and employment. Preparation of the business plan will include more detailed analysis of distribution infrastructure needs and costs, including materials and installation costs, as well as projections for maintenance and upgrade costs.

Outline	Sector	Application	Facility / Users	Bandwidth (Mb/s) Typical	Multiplier	Aggregate Bandwidth Required to Facility for app
2.1.1	General	Web reading	various	256 kilobit / second / user	4	1 megabit / second
2.1.2	General	Email	various	256 kilobit / second / user	2	0.5 megabit / second
2.1.3	General	File transfer / file sharing	various	128 kilobit / second / user	4	0.5 megabit / second
2.1.4	General	Instant messaging (text)	various	32 kilobit / second / user	4	0.125 megabit / second
2.1.5	General	Voice chat / internet phone	various	64 kilobit / second / user	2	0.125 megabit / second
2.1.6	General	Video Chat	various	384 kilobit / second / user	1	0.375 megabit / second
2.1.7	General	Voice over Internet phone	various	64 kilobit / second / user	2	0.125 megabit / second
2.1.8	General	Videoconferencing / telepresence	various	1 megabit / second / user	1	1 megabit / second
2.1.9	General	Accounting software	various	256 kilobit / second / user	1	0.25 megabit / second
2.1.10	General	Virtual Private Network	various	128 kilobit / second / user	1	0.125 megabit / second
2.1.11	General	Remote desktop / terminal services	various	128 kilobit / second / user	1	0.125 megabit / second

2.2.1	Health	Telehealth - patient access to specialists by videoconferencing	Health Care Centre / Clinic	2 megabit / second / session	1	2 megabit / second
2.2.2	Health	Telehealth - health care provider consultation with doctors / specialists by videoconferencing (diagnostic and/or treatment planning)	Health Care Centre / Clinic	2 megabit / second / session	1	2 megabit / second
2.2.3	Health	Telehealth - health care provider professional development by videoconferencing	Health Care Centre / Clinic	1 megabit / second / session	1	1 megabit / second
2.2.4	Health	Telehealth - patient and/or public education by videoconferencing	Health Care Centre / Clinic	1 megabit / second / session	1	1 megabit / second
2.2.5	Health	Remote interpreter services	Health Care Centre / Clinic	1 megabit / second / session	1	1 megabit / second
2.2.6	Health	Patient monitoring - vital signs (blood pressure, blood sugars, pulse, obstetrical fetal monitoring)	Health Care Centre / Clinic / Long Term Care / Residences	64 kilobit / second / user	2	0.125 megabit / second
2.2.7	Health	Patient monitoring and consultation - chronic conditions	Health Care Centre / Clinic / Long Term Care / Residences	512 kilobit / second / user	1	0.5 megabit / second
2.2.8	Health	Patient monitoring - medication compliance	Health Care Centre / Clinic / Long Term Care / Residences	64 kilobit / second / user	2	0.125 megabit / second
2.2.9	Health	Home delivery of medical services with telesupport (home dialysis)	Health Care Centre / Clinic / Long Term Care / Residences	512 kilobit / second / user	1	0.5 megabit / second
2.2.10	Health	Electronic health records / patient charts	Health Care Centre / Clinic / Long Term Care / Residences	256 kilobit / second / user	4	1 megabit / second

2.2.11	Health	Personal access to medical records via internet	Health Care Centre / Clinic / Long Term Care / Residences	256 kilobit / second / user	4	1 megabit / second
2.2.12	Health	Electronic prescriptions	Health Care Centre / Clinic / Long Term Care / Pharmacies	256 kilobit / second / user	1	0.25 megabit / second
2.2.13	Health	Diagnostic imagery (including X-Rays and other radiological imagery, Ultrasound imagery, ECG traces, EEG traces)	Health Care Centres	10 megabit / second / user	1	10 megabit / second
2.2.14	Health	Digital lab reporting	Health Care Centres / Clinics / Labs	256 kilobit / second / user	1	0.25 megabit / second
2.2.15	Health	Telesurgery	Health Care Centres	2 megabit / second / user	1	2 megabit / second
2.2.16	Health	Remote access to diagnostic manuals / medical journals / medical research databases / pharmaceutical manuals	Health Care Centres / Clinics / Pharmacies	256 kilobit / second / user	4	1 megabit / second
2.2.17	Health	Billing / reporting applications	Health Care Centres / Clinics / Health Departments	256 kilobit / second / user	4	1 megabit / second

2.3.1	Education	Internet-delivered public audiovisual learning resources (Youtube, etc)	School / Learning Centre	256 kilobit / second / user	25	6.25 megabit / second
2.3.2	Education	Internet-delivered subscription audiovisual learning resources (Access Learning, etc)	School / Learning Centre	320 kilobit / second / user	4	1.25 megabit / second
2.3.3	Education	Internet-delivered learning objects (lab simulators, etc)	School / Learning Centre	320 kilobit / second / user	4	1.25 megabit / second
2.3.4	Education	Internet-delivered textual / graphic learning resources (Wikipedia, etc)	School / Learning Centre	256 kilobit / second / user	4	1 megabit / second
2.3.5	Education	Synchronous (live) e-learning	School / Learning Centre	512 kilobit / second / user	2	1 megabit / second
2.3.6	Education	Asynchronous (delayed) e-learning	School / Learning Centre	256 kilobit / second / user	6	1.5 megabit / second
2.3.7	Education	Learning portals for enrichment of live classes (Moodle, Blackboard, etc)	School / Learning Centre	256 kilobit / second / user	4	1 megabit / second
2.3.8	Education	Student Management systems (registration, attendance, grading, etc)	School / Learning Centre	256 kilobit / second / user	4	1 megabit / second
2.3.9	Education	Social media for educational purposes (facebook, twitter, youtube, etc)	School / Learning Centre	256 kilobit / second / user	4	1 megabit / second
2.3.10	Education	Social media for recreational purposes (facebook, twitter, youtube, etc)	School / Learning Centre	256 kilobit / second / user	4	1 megabit / second

2.4.1	Justice / Public Safety	Mobile access to criminal records (CPIC) for police	Police station / Individual	128 kilobit / second / user	4	512 kilobit / second
2.4.2	Justice / Public Safety	Mobile access to driver registrations / vehicle registrations / stolen property registrations for police	Police station / Individual	256 kilobit / second / user	4	1 megabit / second
2.4.3	Justice / Public Safety	Mobile access to case files for report entry	Police station / Individual	256 kilobit / second / user	4	1 megabit / second
2.4.4	Justice / Public Safety	GPS / GIS mapping support for police / fire / EMS response	Office / individual	256 kilobit / second / user	4	1 megabit / second
2.4.5	Justice / Public Safety	GIS profiling for crime	Police station / office	1 megabit / second / user	1	1 megabit / second
2.4.6	Justice / Public Safety	Web-based crime reporting / tips	Individual / Police station	128 kilobit / second / user	4	512 kilobit / second
2.4.7	Justice / Public Safety	Offender electronic monitoring (ankle bracelets)	Individual / Police station	64 kilobit / second / user	4	256 kilobit / second
2.4.8	Justice / Public Safety	Internet access to surveillance / recording systems --also applies to health, education, etc.	Office / individual	256 kilobit / second / user	1	256 kilobit / second
2.4.9	Justice / Public Safety	GIS support for emergency planning (fire / flooding / storm vulnerabilities, etc)	Office	1 megabit / second / user	1	1 megabit / second
2.4.10	Justice / Public Safety	Emergency communications	Office / residence / individual	64 kilobit / second / user	10	640 kilobit / second
2.4.11	Justice / Public Safety	Telecourt - videoconferencing for court appearances, pre-trial hearings	Court / Community Office	2 megabit / second / user	1	2 megabit / second
2.4.12	Justice / Public Safety	Videoconferencing access to legal aid / legal representation	Law Office / Community Office	512 kilobit / second / user	1	512 kilobit / second

2.4.13	Justice / Public Safety	Family / community support for incarcerated offenders by videoconference	Prison / Community Office	512 kilobit / second / user	1	512 kilobit / second

2.5.1	Social Services	Mobilized access to case management databases for social workers	Office / individual	256 kilobit / second / user	4	1 megabit / second
2.5.2	Social Services	Web-based applications for employment insurance, social assistance, etc.	Office / individual	256 kilobit / second / user	4	1 megabit / second
2.5.3	Social Services	Web-based reporting of child abuse / neglect or domestic abuse	Office / Residence / individual	128 kilobit / second / user	4	512 kilobit / second
2.5.4	Social Services	Videoconferencing sign-language translation services for deaf individuals	Community Office	512 kilobit / second / user	1	512 kilobit / second
2.5.5	Social Services	Videoconferencing access to counselling services (mental health, addictions, etc)	Community Office	512 kilobit / second / user	1	512 kilobit / second
2.5.6	Social Services	Electronic banking / fund transfers for assistance recipients	Office	256 kilobit / second / user	1	256 kilobit / second
2.5.7	Social Services	Web-based information for clientele and the public	Office / Residence / individual	256 kilobit / second / user	4	1 megabit / second
2.5.8	Social Services	Web-based employment searching (saskjobs.ca, monster jobs, etc.)	Office / Residence / individual	256 kilobit / second / user	4	1 megabit / second

2.6.1	Public Works	GIS support for planning /documenting water, sewer, electrical, telecommunications, transportation, housing infrastructure	Office	1 megabit / second / user	1	1 megabit / second
2.6.2	Public Works	Remote monitoring for water / sewer treatment facilities	Treatment Facility / Office	128 kilobit / second / user	1	128 kilobit / second
2.6.3	Public Works	Professional development for water / sewer treatment operators by videoconferencing	Community Office	512 kilobit / second / user	1	512 kilobit / second
2.6.4	Public Works	Remote monitoring / control for building HVAC (heating, ventilation, air conditioning) systems -- also applies to health, education, etc	Facility / Office	128 kilobit / second / user	1	128 kilobit / second
2.6.5	Public Works	Delivery of information to residents (garbage pickup schedules, snow removal schedules, service disruption announcements, etc)	Office / Residence / individual	256 kilobit / second / user	4	1 megabit / second

2.7.1	Governance	Videoconferencing for government-to-government meetings (INAC, etc)	Community Office	512 kilobit / second / user	1	512 kilobit / second
2.7.2	Governance	Videoconferencing for community consultations (in multi-community First Nations)	Community Office / Public Halls	512 kilobit / second / user	1	512 kilobit / second
2.7.3	Governance	Electronic data reporting for funding agencies (INAC, etc)	Office	128 kilobit / second / user	4	512 kilobit / second
2.7.4	Governance	GIS for traditional land use / resource management	Office	1 megabit / second / user	1	1 megabit / second
2.7.5	Governance	Web presence for information to stakeholders and public	Office / Residence / individual	256 kilobit / second / user	4	1 megabit / second
2.8.1	Administration	Employment / Human Resources recruitment via internet	Office / Residence / individual	128 kilobit / second / user	4	512 kilobit / second
2.8.2	Administration	Human resource management	Office / Residence / individual	256 kilobit / second / user	4	1 megabit / second

2.9.1	Economic Development / Commercial	Promotion via web / internet (tourism, business advertising, etc)	Office / Businesses	256 kilobit / second / user	4	1 megabit / second
2.9.2	Economic Development / Commercial	Product sales via web / internet (Ebay, Craigslist, Kijiji, web stores, etc)	Office / Businesses	256 kilobit / second / user	4	1 megabit / second
2.9.3	Economic Development / Commercial	Services via web internet	Office / Businesses	1 megabit / second / user	1	1 megabit / second
2.9.4	Economic Development / Commercial	Purchasing via web / internet (web stores, Ebay, Craigslist, Kijiji, etc)	Office / Businesses	256 kilobit / second / user	1	256 kilobit / second
2.9.5	Economic Development / Commercial	Government to business services via web / internet (forms, communications, etc)	Office / Businesses	256 kilobit / second / user	4	1 megabit / second
2.9.6	Economic Development / Commercial	Videoconferencing for connections with funding agencies	Community Office	512 kilobit / second / user	1	512 kilobit / second

2.10.1	Recreational	Community recreational schedules and information	Residential	256 kilobit / second / user	4	1 megabit / second
2.10.2	Recreational	Community recreational fees payments	Residential	128 kilobit / second / user	4	512 kilobit / second
2.10.3	Recreational	Online streaming video	Residential	300 kilobit / second / user	10	3 megabit / second
2.10.4	Recreational	Online video download	Residential	5 megabit / second	1	5 megabit / second
2.10.5	Recreational	Online streaming audio	Residential	64 kilobit / second / user	4	256 kilobit / second
2.10.6	Recreational	Online audio download	Residential	1 megabit / second	1	1 megabit / second
2.10.7	Recreational	Online gaming	Residential	5 megabit / second	1	5 megabit / second
2.10.8	Recreational	Blogging	Residential	256 kilobit / second	2	512 kilobit / second
2.11.1	Social	Social web	Residential	256 kilobit / second / user	2	512 kilobit / second
2.11.2	Social	Online dating services	Residential	1 megabit / second / user	2	2 megabit / second
2.11.3	Social	Photo / video sharing	Residential	1 megabit / second / user	2	2 megabit / second