Communications Research Centre Canada
An Agency of Industry Canada

Centre de recherches sur les communications Canada
Un organisme d'Industrie Canada

New Video Distribution Technologies

A Canadian Overview

Communications Research Centre Canada
Report No. CRC-RP-2008-001

September 2008

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INTRODUCTION

Since its beginning in the forties, television has had a tremendous impact on the life of people. Television signals were first available only from over-the-air transmitters. With only a few channels in each region, the number of programs was limited. The picture was in black and white and the sound was monophonic. Today, programs are available in high definition with surround sound. Television channels are now available by the hundreds on cable and satellite, and thousands more programs and movies can be found on DVD and online. Thanks to personal video recorders, the public now has the choice of watching what they want when they want, and the evolution to more choice and more flexibility is continuing.

This document provides a description of various emerging video distribution technologies. It also briefly explains some of the issues surrounding the introduction of these technologies. Finally, it includes a list of Canadian enterprises involved in the development or implementation of these technologies.

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MOBILE TELEVISION

Due to recent advances in broadband wireless technologies and in digital video compression, mobile television is now being provided by cellular telephone (i.e. 3G) network operators. Specialized handheld devices can download pre-recorded or live audio-video services such as video-on-demand, live TV, music videos, etc. But digital video requires high data capacity and cellular networks have limited capacity which is shared among users. As a result, low resolution images, a limited number of available programs, and a restricted number of users have characterized mobile TV so far. The delivery of higher resolution images and more programming material to a larger number of users may required more efficient technologies and the allocation of new spectrum.

More efficient technologies are becoming available, such as DVB-H and Media FLO (and also DMB and DAB-IP described in the section on Digital Radio), which use the broadcasting bands to transmit mobile TV signals to portable devices or vehicles. The number of viewers in these cases is unlimited since the signal is broadcast (one-to-many) instead of unicast (one-to-one) – the links commonly used by the cellular networks.

The DVB-H and MediaFLO systems can typically use the same channel bandwidth as regular television transmission (e.g. 6 MHz in Canada). Their coverage can be improved using single frequency networks – a concept where a number of low power transmitters, instead of the now common single high-power one, are used to transmit the same signal from different locations, so that reception is improved everywhere and the signal is available over a larger area.

Depending on the bit rate allocated to each mobile TV program and the channel coding used, one DTV channel could support a large number of programs. For example, one channel could be used to distribute a low-resolution version of the TV programs available from all the conventional over-the-air TV stations in that region.

In addition, mobile TV transmission can also take place in parts of the spectrum other than the TV spectrum. For instance, Modeo in the United States was planning to use spectrum at 1.675 GHz, while Look Communications in Canada was to operate at 2.5 GHz.

The DVB-H system is being implemented in many other countries, while DMB is used in Korea, Integrated Services Digital Broadcasting-Terrestrial (ISDB-T) in Japan and Brazil, and China Mobile Multimedia Broadcasting (CMMB) is being planned for China.

Mobile TV receivers are expected to become integrated in existing portable devices such as personal players (e.g. iPods), cellular phones and portable computers.

Enhancements to the Advanced Television System Committee's (ATSC) digital television system used in Canada, such as the ATSC Handheld/Mobile (H-M) standard currently under development, are able to deliver mobile TV services using the existing DTV infrastructure, instead of new dedicated networks of mobile TV transmitters (see next section).

As mentioned, small-size portable devices generally characterize mobile TV, resulting in small size displays. Given the growth of mobile TV, it would appear that consumers are willing to trade-off picture quality (and money) for the benefit of having access to video services anytime, anywhere. Experiments have shown that simply down-sampling broadcast material to suit the resolution of mobile TV is not the best way to provide mobile TV. Mobile TV is more suited to news, short video clips, previews, news music video, etc., rather than full feature films, for example. Content must be properly re-packaged to suit this new delivery medium. From this point of view, mobile TV does not directly compete with regular television broadcasting, but may represent an opportunity for broadcasters and program producers to reposition their program material for another market.

In Canada today, mobile TV is available from cellular telephone networks including Telus, Bell Mobility and Rogers who charge a monthly fee between $10 and $15 for access to up to 30 TV channels such as Newsworld, RDI, BBC World, Treehouse, YTV, MuchMusic, the Shopping Channel and more. CBC/Radio-Canada is also offering video to mobile receivers using an experimental DMB transmission system operating in the L-Band (1.5 GHz).

IMPACT

Since many mobile TV programs can be transmitted over a single 6 MHz DTV or a 1.5 MHz DAB channel, several program providers could share a single TV channel, the same way a cable network is not dedicated to one TV station, but is used to distribute all the local stations of an area as well as distant signals, specialty and pay channels. For example, local TV stations could collaborate to set up one mobile TV transmitter. Each station could then transmit a lower resolution version of its regular programs to portable or mobile devices. Cellular telephone service providers could sell cellular telephones capable of receiving these programs.

Mobile television also constitutes an excellent communication link that could be used in case of emergencies. It could offer all the advantages of radio broadcasting with the added benefits of video and picture.

Other interesting questions surround the implementation of mobile television:

- Will broadcast mobile TV programs be paid by publicity or by subscription?
- Should mobile TV programs be identical to the regular broadcast programs or different?
- Could a digital TV or radio station be used to transmit only mobile TV and no regular TV? Could a broadcaster lease some data capacity to a content provider?
- Should the same regulations be applied to video regardless of which means is used for distribution: 3-4G cellular networks, Wi-Fi networks, TV or radio broadcast?
- What will be the impact of using many mobile video standards around the world? Could Canada's mobile video services use standard(s) different than the one(s) used in the U.S.?

There are many mobile TV trials now being conducted around the world; they should provide answers to these questions.

ENHANCEMENTS TO DIGITAL TELEVISION TRANSMISSION STANDARD

The ATSC's television digital TV broadcasting standard (ATSC-8 VSB) is used in Canada and the United States. Almost all the TV stations in the United States are now transmitting ATSC signals, while a few stations are on the air in Canada, mostly in Vancouver, Toronto, Montréal and Québec City. Analog TV transmission using the National Television System Committee (NTSC) standard will end in February 2009 in the U.S., and in August 2011 in Canada.

Improvements to the digital TV standard, such as the ATSC H/M now under consideration at the ATSC (http://www.atsc.org/communications/press/2007-06-22-mh-proposals.php), are designed to support enhanced, robust modes of transmission that make broadcasting to portable or mobile receivers possible. This should allow broadcasters to compete with audio/video services that are now offered by cellular telephone network operators.

Such enhancements bring new and previously developed improvements together, with a view to bringing extensibility and new functionalities to the standard 8-VSB technology. It is now demonstrated that they have the ability to:

- Support Single Frequency Network (SFN) operation, and provide transmitter synchronization schemes that are already endorsed by the ATSC A/110 synchronization standard;
- Insert more training sequences in the output data stream resulting in faster and better equalization in the receiver, which in turn results in more reliable reception in dynamic (i.e. portable/mobile) and high multipath environments such as the downtown core of a city;
- Incorporate a robust data stream (in the main data stream) to enable portable/mobile reception (TV to handheld sets) as well as security and safety services. Such a

robust data stream may be based on the recently developed advanced video codecs which are twice as efficient;

- Provide backward compatibility.

As mentioned, the ATSC H/M standard is currently under development. Results from the laboratory and field tests performed by the Open Mobile Video Coalition (OMVC) (http://www.openmobilevideo.com/) have already confirmed its potential. The new standard may be in place in time for the end of the analog-to-digital television transition in the United States in February 2009.

IMPACT

A backward-compatible system enables broadcasters to use their existing or soon-to-be-built, over-the-air DTV stations to transmit HDTV and/or standard definition programs to fixed locations, with the option of using part or all of their DTV channel data capacity to offer lower resolution TV programs to portable or mobile receivers.

This could be done without building new transmitters or allocating new spectrum, which would be required if incompatible standards such as DVB-H or MediaFLO were used instead of the backward-compatible enhanced ATSC H/M standard.

DIGITAL RADIO

The rapid evolution of other delivery media (wireless broadband Internet, 3G and 4G, satellite, wireless pit stops, cordless peer-to-peer data exchange, etc.) is having an impact on the radio broadcasting audience. Over-the-air broadcasting is evolving from the "only" source to "one of many" sources of content. The strength of radio broadcasting in the future wireless environment will be its ability to adapt to enhanced services and reach, very economically, a large number of mobile and portable receivers outside the service area of other delivery pipelines (WiMAX, 4G, etc.).

To remain competitive, digital broadcasting systems could evolve from the conventional radio services to a much wider variety of services with richer multimedia content such as video coupled with a degree of interactivity, and a broad spectrum of datacasting services, related or unrelated to the broadcast content.

In the early 1990s, DAB Eureka 147 seemed to be the only viable solution for the conversion of analog AM and FM stations to digital. This belief led to the current regulation on L-band (1.5 GHz) DAB broadcasting in Canada. Since then, remarkable progress has been made on other technologies such as In-Band On-Channel (IBOC), S-DARS, and other viable solutions which have emerged. Today and in the near future, Canadian broadcasters will offer a choice of options, which are described briefly in the following paragraphs. It is important to note that each of these digital technologies has the potential to evolve with time as technological breakthroughs emerge. It is also important to keep in mind the value of backward compatibility with consumer equipment already in the hands of the public.

An obvious example is research into audio coding that has produced several new techniques since the adoption of MPEG Layer 2 for the DAB Eureka 147 system. It is

expected that in due time, the existing standard will be modified to incorporate more advanced and efficient codecs to allow broadcasters to exploit the extra channel capacity within their existing spectrum allocation for more audio programs, or offer new multimedia and datacasting services.

DAB technology was adopted in Canada in 1995 and was initially intended as a replacement technology for conventional AM and FM radio. A new spectrum band was allocated to introduce the new service. The Canadian plan included a mix of terrestrial and satellite stations and this made the choice of L-band (1452 to 1492 MHz) the best compromise for such a system. Later, when the satellite component had to be abandoned due to various constraints, the terrestrial component alone, being at L-band, could not provide large area coverage similar to the full system with a satellite component. Most other countries that have successfully introduced DAB have opted for a different band: Band III, 174 to 240 MHz. By using several transmitters in a network arrangement called Single Frequency Network (SFN), a broadcaster can extend and tailor its coverage when and as needed.

DMB and DAB-IP – which are virtually identical other than the fact that DMB uses MPEG-4 video and audio codecs, whereas DAB-IP uses Windows Media codecs – are built on the DAB Eureka 147 broadcast standard. They can take advantage of the current DAB infrastructure (spectrum, transmitters, receivers, etc.) but in addition to conventional DAB services, they will allow the delivery of radio with pictures related to the audio content ("visual radio"), as well as mobile TV to cars and portable/handheld receivers. DMB is based on the MPEG coding and transport protocols while DAB-IP is based on the IP packet transport protocol.

In-Band On-Channel (IBOC) is promoted by iBiquity (U.S.) under the brand name HD Radio. IBOC is designed to allow a smooth transition from all analog to "all digital," with an initial transitory phase where some digital signals are added to the existing AM and FM analog signal. This is called Hybrid IBOC. In due time, the analog signal will be removed and replaced by more digital signals to reach the final goal of "all digital." The digital signals are positioned in the adjacent channels on both sides of the analog carrier. The low level of the digital signal is designed to avoid interference for adjacent analog stations. The main advantage of the IBOC technology is that no new spectrum is required by the radio broadcasters to make the transition to digital. The main shortcoming is that coverage is limited, given the lower power limit on the digital content, which cannot be improved by using SFN. The HD radio reverts to analog FM when the receiver is outside the reduced digital coverage.

The DRM (Digital Radio Mondiale) is an international consortium, which created a universal digital system for the AM broadcasting bands below 30 MHz. This open, non-proprietary worldwide standard for broadcasting in the LF/MF/HF bands was formally launched at the World Radio Conference in 2003, and several broadcasters began regular short-wave transmissions in the HF bands.

DRM+ is an extension of the original DRM standard, which would allow digital broadcasting operations up to 120 MHz, thereby encompassing the commercial FM band. While still in development, DRM+ will offer an attractive option for those FM broadcasters who wish to make a direct transition from an all-analog to an all-digital signal.

IMPACT

Several options are available to broadcasters to fully exploit the potential of new digital radio delivery networks in a complex and competitive environment.

Options for the AM broadcaster
In order to retain a large coverage area, the typical feature of an AM analog system, it is important to remain in the AM band for long signal propagation, unless the technology adopted is compatible with the SFN concept described earlier. Two options exist for operation in the AM band: AM-IBOC (HD Radio) and DRM (Digital Radio Mondiale). Both are not compatible with current AM receivers. These two technologies are being tested and deployed in other countries. In the case of a low power AM station satisfied with a relatively small coverage area, L-band DAB could be an interesting option.

Options for the FM broadcaster
Many options are offered to the FM broadcaster: FM-IBOC, L-band DAB, Band III DAB and DRM+ (DRM plus). The choice will be dictated by factors such as spectrum availability, the size of the coverage contour, receiver availability, requirement for SFN transmitter networks, backward compatibility with existing receivers, etc.

Broadcasters are currently evaluating the new technology options.

INTERNET TELEVISION

Internet TV is where the computer and the broadcast industries meet. To many people it represents the best example of convergence. With the increase in data rates available over broadband Internet connections, it has become increasingly common to find traditional television content accessible freely over the Internet at sites such as:

- Joost http://www.joost.com/
- YouTube http://www.youtube.com/
- Hulu: http://www.hulu.com/
- Divx: http://stage6.divx.com/

Virtually all the major broadcasters (see http://www.jumptv.com/), from the CBC (http://www.cbc.ca/video/features/) to China TV (http://www.cctv.com/english/vod/index.shtml) are "webcasting" some of their regular program material: previews, archived material and news clips. In addition, new Internet-only television content has appeared which is not distributed via cable, satellite or terrestrial systems. Movie and video "renting" downloaded over the Internet is another growing business.

Internet TV is convenient because it can be accessed from any web-enabled terminal, anywhere, anytime. Some drawbacks are:

- Lack of picture quality due to the low resolution and low bit rates used;
- Poor reliability of some Internet TV service providers and the annoyance of using a large number of different video players' software which needs to be downloaded for the service to be viewed;

- Limited access to some programs, determined by the location of viewers and geographical licence restrictions;
- Restricted bandwidth or capacity of the Internet, which will be a growing problem if more people decide to use Internet TV, as demand for limited bandwidth will rise;
- No quality of service, as video is currently delivered on the Internet network on a "best effort basis," that is, at the rate the network is capable of at the given time.

The lack of quality of service is perhaps the most serious limitation of present-day Internet services. This is why the Internet is mostly used for low quality video streaming applications, while high quality video from broadcasting networks is generally downloaded before viewing, but this is time consuming. This could change in the future with improvements in the Internet backbone capacity and the adoption of network protocols (e.g. IPv6) that support multicasting and quality of service.

In Canada, ZIM (http://www.zim.biz) provides publishing and licensing services for market-leading mobile content and peer-to-peer (P2P) Internet TV broadcasting. ZIM offers a wide portfolio of content services for mobile phones and Internet TV, ranging from popular sports, to cartoons and animations, to classic Hollywood movies.

IMPACT

Because of technical limitations, the present Internet network is not well suited for real-time television broadcasting. Internet TV is likely to remain a delivery method that complements, rather than replaces, regular broadcasting. For example, programs delivered in this format are mostly used for promotional clips or as a complement to regular TV viewing. This situation could change in the future as technological improvements are introduced that allow the Internet to adequately support real-time applications.

INTERNET PROTOCOL TELEVISION (IPTV)

IPTV is defined by the International Telecommunication Union as "multimedia services such as television/video/audio/text/graphics/data delivered over Internet Protocol-based networks managed to provide the required level of quality of service, security, interactivity and reliability." Although Internet TV and IPTV both use Internet Protocol (IP) to carry video as well as other services, their main difference is that IPTV guarantees a certain level of quality of service and includes security and copyright protection.

Many networks and distribution systems rely on IP for the transmission of voice, data and Internet services. With the appropriate network configuration needed to guarantee an end-to-end quality of service, these same networks can also carry streaming video and digital TV services.

IPTV is often associated with DSL-TV. New generation ADSL (Asymmetric Digital Subscriber Line) technologies (e.g. ADSL2 and ADSL 2+) support faster data transmission over traditional copper telephone twisted pair wires, which form the last link connecting telcos to homes. Whereas present-generation Asymmetric DSL (ADSL) has a limited capacity of up to 8 Mbps from the network to the subscriber (downstream), ADSL2 and ADSL 2+ technologies enables downstream data rates of up to 12 and 24

Mbps respectively, over short distances from the central office. In conjunction with advanced video compression technologies (e.g. H.264/AVC and VC-1), these new ADSL technologies now enable telecom operators to offer multiple SDTV and HDTV programs simultaneously over copper wire, thus competing with over-the -air (OTA), cable and satellite television broadcasting.

Television over IP is becoming more readily available and as the use of personal video recorders becomes more widespread, there may come a time when the viewer will not care to know where his television programs come from or when they were transmitted. This will not happen tomorrow, but with the younger generation more accustomed to portability and personal control, the traditional broadcast business model will need to evolve.

IMPACT

Improved ADSL and new video compression technologies enable telecom operators to offer multiple SDTV and HDTV programs simultaneously over copper wire, thus competing with OTA, cable and satellite television broadcasting.

The broadcast industry (over-the-air broadcasters, cable and satellite distributors) is now limited by regulation in the content it can offer. If some forms of IPTV are implemented without these restrictions, the consumer could then get unregulated access to new content. This raises questions about the impact of regulations on domestic broadcasters when consumers can freely access unregulated service providers located outside the country using the Internet. As well, new technologies may lead to new "grey markets," similar to those created when consumers bypass regulated Canadian suppliers, who hold Canadian distribution rights for programming, for American satellite television and radio services. They could access the same programs directly from foreign distributors who may offer a larger selection of material, better price or both.

DIGITAL BROADCASTING BY SATELLITE AND DIRECT-TO-HOME SERVICE

Satellite television broadcasting is offered in Canada via two services: Digital Broadcasting by Satellite (DBS) operated in the 12 GHz Broadcasting Satellite Service (BSS) band and Direct-to-Home (DTH) operated in the 12 GHz Fixed-Satellite Service (FSS) band.

In July 2006, Industry Canada issued a call for applications for 29 satellite licenses. Out of these 29 licenses, 10 were for new orbital positions for broadcasting satellite service in the 17 Hz BSS band, commonly referred to as the unplanned band, given that it is identified by international regulation for BSS but it has not been planned as in the case of the 12 GHz band. These new orbital positions, combined with the upcoming introduction of the new signal format (DVB-S2), will increase the capacity for DBS/DTH offerings by at least four times. For Canada, it means an impressive increase in capacity, which could address the need for more local programming television and HDTV.

Telesat and its partners introduced an Internet service to consumers via satellite in the 30/20 GHz FSS (Ka) band in spring 2005. The introduction of such a service required

the development of low cost ground terminal technologies. Although the ground terminals remain relatively expensive (i.e. a few hundreds dollars), in the years to come their cost is expected to become as low as that of current 12 GHz BSS receivers (e.g. free as part of a service contract of a few years) once a significant volume is reached. Other foreign satellite operators are also offering similar services.

This new Internet service, combined with the opening of new orbital positions in the 17 GHz BSS band, may potentially have a dramatic impact on the delivery of services by satellite. It is expected that the introduction of the 17 GHz BSS service will enable the use of a single outdoor terminal (antenna and microwave front end) to address both broadcasting and Internet access services. As such, Internet access will provide a return channel for video-on-demand services, enabling an increase in the use of personal video recorders, for instance. In addition, the Internet and broadcast traffic could be blended based on which channel (FSS or BSS) is less busy, escalating issues surrounding the convergence of services.

It is worth noting that in Europe, Internet service is blended to broadcast service, with a forward channel (to the users) in the 12 GHz BSS band, and a return channel (user to gateway) in the 30 GHz FSS band or via other terrestrial wired or wireless channels. Such systems have been in operation for many years.

Broadcasting to mobile users in the 12 GHz BSS band is currently commercially available. In the medium term, it is anticipated that broadcasting to mobile users in the 30/20 GHz FSS band will be developed. The technology does exist to do so, but it is not yet at a cost attractive to users.

Broadcasting of video content by satellite to personal devices in the Ka band FSS or the new 40 GHz BSS band is also being discussed at the present time, but significant technology developments are required to do so. It is not believed to be technically and/or commercially viable in the near future.

IMPACT

Current and forthcoming technology developments are likely to increase the availability of services to consumers via satellite, and to compete head-to-head with terrestrial digital service delivery technologies.

There is a trend that mobile, fixed and broadcast satellite services could be offered by satellite in various frequency bands as the technology evolves.

ADVANCED VIDEO CODECS

The MPEG-2 video compression standard, developed by ISO/IEC in the 1990s, is used almost universally as the bit rate reduction method for digital television broadcasting. Both the European DVB and North American ATSC standards utilize MPEG-2 video compression. MPEG-2 is capable of providing broadcast quality at bit rates in the range of 15-20 Mbps for High Definition TV (HDTV) and 3-5 Mbps for Standard Definition TV (SDTV). However, new and more sophisticated compression technologies that are now available are capable of providing video quality comparable to MPEG-2 at approximately half the bit rate. These include MPEG-4 AVC, part of the MPEG-4 standard also known

as H.264 (High Profile and Main Profile), and SMPTE VC-1, the standard based on Microsoft's Windows Media Video (WMV) technology. Yet even more powerful compression technologies are being investigated and will no doubt be developed in the future, but at this time, none are expected to provide significant benefits over H.264/AVC or VC-1.

Given that these advanced codecs provide video quality at low bit rates, it can be expected that they will be adopted by the broadcast industry in the near future. For example, these codecs are a logical choice for applications using advanced modulation techniques such as ATSC-H/M, where some of the channel capacity is traded for robustness. Most mobile TV and IPTV services already use H.264/AVC. The Blu-ray video disc format can support three video compression techniques: MPEG-2 enhanced for HD, MPEG-4 AVC and SMPTE VC-1.

ATSC is currently investigating the opportunity of supporting multiple video codecs (i.e. MPEG-2 plus one or more advanced codecs). The decision to go from one codec to multiple codecs is not expected to have significant implications on the broadcasting infrastructure, except for the important feature of compatibility of the broadcast signal with the DTV sets already on the market. As these codecs use a similar architecture, newer integrated circuits will be able to support all of them for future DTV receivers.

IMPACT

It is likely that several video compression technologies will co-exist in television broadcasting in the future. Future equipment will support multiple codecs and transport stream signalling, indicating which codec has been used to compress the video stream. Future equipment will make this issue transparent to users as long as their receivers contain the required decoders. The addition of these new system features to the ATSC standard could create compatibility issues with legacy equipment for the Canadian consumer in the short-term.

3D TELEVISION

Beyond HDTV, there is an emerging drive to develop 3D-TV and bring it to market. Whereas HDTV provides enhanced picture quality and larger image size, 3D-TV will impart increased realism by displaying objects with volume and at different depth positions in a "solid" world outside of the flat screen. 3D-TV will provide virtual presence by allowing viewers to immerse themselves with television characters in a three-dimensional world. This will reduce the gap between reality and fiction.

Stereoscopic 3D-TV using shutter glasses can be transmitted now within the existing DTV infrastructure with only minimal changes and impact on normal HDTV viewing. However, consumers are reluctant to adopt this technology because of the discomfort of wearing glasses. Experts agree that glasses-free multiview 3D systems will be needed for consumer acceptance of 3D-TV. Stereoscopic 3D-TV systems rely on two views (left and right) for depth portrayal, whereas multiview systems use multiple views representing different viewpoints. Multiview systems provide a better look around than stereoscopic systems.

Progress in computing and display technologies have reduced the development time towards the realization of practical 3D-TV systems. In addition, there are strong international efforts underway to standardize formats for transmission over various networks, including broadcasting, of multiple streams of images consisting of different viewpoints of a scene (i.e. multiview). Advances in video processing and compression technologies are such that the additional amount of information that needs to be transmitted for multiview 3D-TV is reduced to a minimum. Compatibility with regular monoscopic (2D) television can be assured by transmitting a 2D signal plus one or more depth map(s), and using one of the compression technologies used for regular 2D-TV.

This multiview format will add new functionalities that will allow for greater interactivity such as the choice to select a specific viewpoint of a scene. Critical to the successful deployment of 3D-TV broadcasting is the development of multiview autostereoscopic displays that can be mass-produced for consumers at a reasonable cost. Current multiview display devices lack resolution and size, but progress is rapid.

IMPACT

It is expected that 3D-TV can be supported within the existing DTV infrastructure and with minimum impact on data rate requirements. The expectation is that 3D-TV would have little impact on spectrum demand and regulation.

SUPER HDTV

Super HDTV, also known as Super Hi-Vision or Ultra High Definition Video (UHDV), is a digital video format currently being proposed by NHK of Japan. Its video format uses 7,680×4,320 pixels (16 times more pixels than HDTV), and a 60-Hz frame rate progressive scanning scheme, making it possible to present an unparalleled amount of information on a screen. NHK demonstrated the Super Hi-Vision at the 2005 World Exposition in Aichi, Japan, using a CCD camera that can take 4k x 8k images. The signal generates a raw data stream at a rate of 24 Gigabits per second.

IMPACT

Super HDTV represents an enormous technological challenge regarding camera and display technologies, storage, compression and transmission. Therefore it will not likely be considered for television broadcasting in the foreseeable future.

TV PLACESHIFTING TECHNOLOGIES

TV Placeshifting technologies such as Slingbox, Location Free TV and Orb can enable someone to watch TV programs which are normally available only on one's home TV set, anywhere in a home using a wireless local network such as Wi-Fi, or anywhere in the world on a PC, PDA or cellular phone through an Internet connection.

Sling Box

The Slingbox connects a TV source (via coaxial cable, composite cables, component cables, or S-video cable) to an existing Internet connection. Digital video recorders and

cable or satellite set top boxes can be controlled through a separate infrared (IR) cable that lets users change channels from the remote location. Software on a user's computer or mobile device connects to the Slingbox using the Internet, and provides the user interface for viewing the video stream and changing channels.

The basic process works like this:

1. You connect your TV's video output to the Slingbox tuner.
2. The Slingbox grabs the video signal from your TV.
3. The digital media processor, acting as a DSP, converts the signal into digital data that the Slingbox can manipulate.
4. The digital media processor, acting as a video encoder, compresses the data using a Windows or Mac-compatible codec.
5. The Slingbox broadcasts the compressed data stream in real time via the Ethernet port. It uses a proprietary streaming protocol called SlingStream, which adjusts the stream on the fly to adapt to varying network speeds.
6. You access the stream via your home network or a broadband connection using SlingPlayer software on your computer, PDA or cellular phone.

For more information see http://electronics.howstuffworks.com/slingbox.htm/printable and http://us.slingmedia.com/page/home. Three models are available for sale and are priced from US$100 to US$200. For more information see http://us.slingmedia.com/page/products.html.

SlingStream is the technology within the Slingbox that dynamically adjusts video quality by taking into account a variety of factors, including network bandwidth, SlingPlayer device characteristics, video content, and the type of video input. Using patent-pending algorithms, SlingStream automatically adjusts compression level, video bit rate, frame rate, and other settings to create a continuous quality video experience. SlingStream works with different connection types, whether it is LAN, Internet, or even wireless from one's mobile phone.

Sony LocationFree

The Sony LocationFree Player is another Internet-based multifunctional device used to stream live television broadcasts, including those from digital cable and satellite, DVDs and DVR content, over a home network or the Internet. It was introduced by Sony in 2004 alongside a co-branded wireless tablet TV. For more information see http://www.learningcenter.sony.us/assets/itpd/locationfreetv/index.html.

The LocationFree base station connects wirelessly to a home network and up to three devices, and can stream content through the network to local content provision devices, or across the Internet to remote devices. A remote user can connect to the Internet at a wireless hotspot or at any other Internet connection in the world, and the content can be streamed to the user.

In addition to live TV broadcasts, the player can stream content stored on:

- PlayStation Portable (PSP) - firmwares 2.50 and later
- PlayStation 3 (PS3)
- Personal computers - PC and Mac

- Digital video players/recorders, such as DVD, Blu-Ray, HD-DVD and hard-drive systems

... to the following:

- another PSP
- another PC or Mac
- Televisions, including wireless (below)
- Mobile/cellular phones
- Pocket PCs running Windows Mobile.

Up to three systems may be connected at any one time. A user can also access and control, from anywhere in the world, any device connected to the unit, and switch between multiple devices. The software does not allow TV content to be recorded to a hard drive, but by using the player with a PS3 supporting Linux, the user is able to record video direct to the PS3 hard drive.

Orb

While Sling Box and Sony LocationFree are hardware based, Orb is a software that uses a PC to perform the same operation. For more information see http://www.orb.com/.

Orb is a freeware streaming software that enables users to remotely access all their personal digital media files including pictures, music, videos, webcams and television. It can be used from any Internet-enabled device, including a laptop, pocket PC, smartphone, PS3, Xbox 360, or Wii video game console.

The Orb application is free to download and install, and there are no fees for MyCasting. Needing only a home computer to get setup, users can employ any web-enabled media player with streaming capabilities, portable or otherwise, to remotely play the desired media.

Once Orb software is installed on an "always-on" home PC, the computer acts like a personal broadcasting system, offering the ability to stream content through any Internet-connected device like a mobile phone, PDA, laptop or any other computer.

No additional hardware or software needs to be installed on any of the web-enabled devices used. With Orb, users can start MyCasting photos, music, videos, live[1] or recorded TV, documents and more.

IMPACT

The impact of this technology is well summarized by Julia Laighton who wrote on http://electronics.howstuffworks.com/slingbox3.htm that:

> The big issue right now surrounding "placeshifting" TV is about copyright and digital rights issues. Like the music and motion-picture industries, the TV industry is concerned that people are going to be able to access their product for free. In the case of Slingbox, it's not

[1] To access live TV, users need to purchase and install a TV tuner card on their home PC.

just a concern about one person subscribing to HBO and giving their friends their Slingbox access codes so they can watch "Rome" without paying for it. The spatial nature of TV licensing adds another dimension to the risk. TV stations typically purchase program rights for a specific region, so "placeshifting" the TV signal infringes on regional access rights for certain shows. Sling Media says it's observing copyright and digital media laws because the Slingbox is a one-to-one transmission device. Slingbox owners can't broadcast a show to everyone they know. Only one person can access a Slingbox at a time, and if the device is used properly, only the person who pays for the programming can watch it. Only time will tell whether the TV industry will accept placeshifting technology like it ultimately accepted the "timeshifting" capabilities of TiVo and other DVRs.

WIRELESS REGIONAL AREA NETWORKS

In an effort to maximize the use of the spectrum now allocated to broadcast television, especially where this spectrum is lightly used such as in rural areas, the Federal Communications Commission (FCC) proposed in its Notice of Proposed Rule Making (NPRM 04-186) to allow the use of licensed-exempt devices in the broadcast TV spectrum.

These devices could be deployed in vacant parts of the TV spectrum (white space) for the provision of Internet access services, similar to Wireless Local Area Networks (WLAN) services, provided there is no harmful interference caused to the TV broadcast operation. Fixed devices could be deployed anywhere in the network up to a limit of 4 watts Effective Radiated Power (ERP), whereas portable terminal devices would be allowed to roam within the network of access points with an ERP power limit of 400 milliwatts. Given the allowable power limits for both the fixed and portable license-exempt devices, some controls need to be implemented in order to mitigate the interfering effects on TV broadcast operation. The devices would need the ability to determine if a channel is used before they could transmit (control signal, sensing, geolocation, etc.) and they would need to be able to move off a previously vacant channel if the licensed user started to transmit.

This problem was studied by the IEEE Working Group 802.18 and comments were produced on behalf of the IEEE 802 Standards Committee on this issue. As a result of the positive findings for the use of fixed licensed-exempt devices in a point-to-multipoint system, based on a master-slave relationship between the wireless base station and the associated user terminals, the IEEE Working Group 802.22 was formed and is developing a standard for cognitive radio-based Wireless Regional Area Networks (WRANs), for use by license-exempt devices on a non-interfering basis in spectrum that is allocated to, but not locally used by, the TV broadcast service.

IMPACT

The operation of wireless regional area networks using vacant TV channels in rural areas has the potential of bringing Internet access in a cost-effective way in areas where

it is difficult to provide this service. However, the operation of an unrestricted number of license-exempt devices in the TV broadcast bands is likely to create scenarios where harmful interference to television services will result, especially in the more densely populated areas. Studies have shown that the ERP levels suggested by the FCC in its NPRM can create problems if there is no restriction on the deployment and operation of these license-exempt devices. In anticipation of the implementation of such license-exempt device networks, regulators and policy makers need to ensure that the incumbent TV broadcast operators are sufficiently protected. Features such as cognitive radio, dynamic frequency selection, transmit power control and geolocation could be requested from the technology standardization process, whereas centralized control of the operation at the base station, access to broadcast stations databases, professional installation and registration of base stations, and association of user terminals to the base station under specific non-interfering conditions, could all be requested at the time of the network deployment.

Ultimately, it is unsuspecting consumers who could be affected with random losses of service for which they will have no control.

MOBILE INTERNET AND BROADBAND WIRELESS NETWORKS

Internet gives Canadian consumers access to an unlimited number of radio and TV stations. Some offer a streaming service while others offer podcasting services (i.e. downloading of audio files). Consumer devices can access these "unregulated" sources to record and playback content. Internet will soon be even more easily accessible thanks to the emergence of wideband wireless networks such as WiMAX (WiBro in Korea), Broadband Wireless Access (BWA) technology and IEEE 802.16 equipment. The IEEE 802.16 working group on Broadband Wireless Access Standards, which was established by the IEEE Standards Board in 1999, aims to prepare formal specifications for the global deployment of Broadband Wireless Metropolitan Area Networks. The working group is a unit of the IEEE 802 LAN/MAN standards committee. A related future technology, Mobile Broadband Wireless Access (MBWA), is under development in IEEE 802.20.

Local radio markets risk audience erosion as these BWA networks are deployed. A similar effect will be felt on the mobile TV services currently offered by telecom providers (2.5 G, 3G) and soon to be offered by broadcasters (ATSC-H/M, DVB-H, DMB, DAB-IP, MediaFlo) since, again, an unlimited number of "unregulated" sources of video content can be found on the Internet. In those localities with available fixed BWA services, Canadian consumers owning portable PVRs equipped with an IEEE 802.16 transceiver will be able to select and download content from the Internet for subsequent viewing, for free or at low cost, thus completely bypassing broadcasting services.

A number of factors, such as spectrum availability, the number of simultaneous users and other technical constraints, will impose a ceiling in the number of streaming video and audio services that can be offered simultaneously in a given geographical area to mobile and handheld device users employing BWA. However, the podcasting approach overcomes this impediment since users can download the files from their Internet access at home and play them later when they are on the move.

The use of wireless means to provide broadband Internet is seen as a cost-effective way both in cities, where access to cabled facilities is difficult, and in rural locations, specifically for residential customers in areas where the cable facilities have insufficient capacity to deliver broadband Internet, or cable does not reach.

Since 2003, Canada's Wavesat has been solely focused, on the WiMAX market. Wavesat's unique EVOLUTIVE WiMAX Series, comprising a full-range of standards-based integrated circuits, software and reference system designs for OFDM BWA 802.16 compliant applications, will lead the company's growth with the transition from fixed to basic mobility. For more information on WiMAX activities in Canada, please see http://www.crc.ca/en/html/crc/home/info_crc/publications/wimax_2007/wimax_2007.

IMPACT

The regulation of broadcasting content as currently exercised may be rendered futile when content from anywhere can be easily accessible by Canadians living in urban centres, and by those in rural areas where BWA systems will be deployed.

MULTIMEDIA HOME NETWORKS

Home multimedia networks will be used to connect home entertainment systems, home appliances, home security systems, home computers and mass storage devices. There are two design approaches to this network: computer centric, where a home PC is expected to provide centralized control of the network; or entertainment system centric, because a digital video system demands most network bandwidth. The data rate required for the home multimedia network will be extremely high. For example, all HDTVs on the market now have an HDMI interface. The data rate for HDMI is about 2 GBps and there are increasing demands to make wireless HDMI connections. Wi-Fi and Wi-Max types of wireless cannot provide sufficient data throughput to distribute multiple HDTV programs. UWB or wireless USB will not meet the data rate and transmission distance requirement. Developments are underway to provide higher data throughput. The following table from *Wireless Telecom* (Issue One, 2007, p.29) lists various technologies:

Technology	Frequency	Data Rate	Range
Bluetooth	2.4 GHz	1-3 Mbps	1-100 m
Zigbee	2.4 GHz 868/915 MHz	20-250 Mbps	5-500 m
ANT	2.4 GHz	< 1 Mbps	<30 m
Wibree	2.4 GHz	1 Mbps	10 m
UWR	3.1-10.6 GHz	100-1000 Mbps	10-20 m
Wireless HD	60 GHz	2-5 Gbps	10 m

IMPACT

A few issues surround the introduction of multimedia home networks such as:

- Spectrum issues – licensed or unlicensed system, spectrum policies
- Interference issues – within a home and among adjacent homes
- Broadband propagation in a building
- Human interface, privacy, security, etc.
- Interfacing with other networks (telecom, Internet, broadcasting, home sensor networks, home appliances).

OPENING CELLULAR TELEPHONE NETWORKS TO NEW BROADCAST SERVICES

In North America most cellular telephones and devices such as a Blackberry are sold by operators (e.g. BellMobility, Telus, Rogers, Verizon, Sprint, etc.) as part of a service plan. For example, Rogers will offer a free Nokia phone as part of a three-year subscription to its mobile services.

Unlocked GSM phones which can be used on different networks are uncommon thus far in North America. But after getting telephone number portability between different networks, consumers may want to continue to use their old telephone when they move to a different network. This may be more difficult in North America than in Europe, where only the GSM cellular system is used.

Pressure for changes could also come from handset manufacturers (e.g. Nokia, Sony-Ericson, LG, etc.) who can now sell their devices only through an operator, or even from application providers such as Google, who has requested that the FCC consider its four "open" platform recommendations:

- open applications for users;
- open devices that will work with whichever network provider customers choose;
- open services that would allow third-party resellers to acquire wireless services on a wholesale basis; and
- open networks, which would allow third parties such as Internet service providers, to interconnect at any feasible point in the new 700MHz licensee's wireless network.

(See http://googleblog.blogspot.com/2007/07/our-commitment-to-open-broadband.html.)

Another player may be the broadcasters who would like to offer mobile television on handheld devices using their broadcasting transmitters, and the ATSC-Mobile/Handheld (ATSC-M/H) digital TV transmission standard now under development and being evaluated by CRC. Broadcasters have the video content and the wireless transmitter network to distribute it. The manufacturer could provide the necessary handsets.

IMPACT

Broadcasters and manufacturers are concerned that cellular network operators, who are selling handsets to consumers, may see them as competitors instead of partners, and will not include handsets with ATSC-M/H capabilities in their offering. Opening the market to "unlocked" phones would enable manufacturers to sell handhelds directly, with advanced features such as mobile TV receivers. Broadcasters could then provide users with TV programs.

Opening cellular networks to devices not sold directly by network operators could lead to an increase in the number of new applications and services. It could also have an impact on the cost of these devices and services.

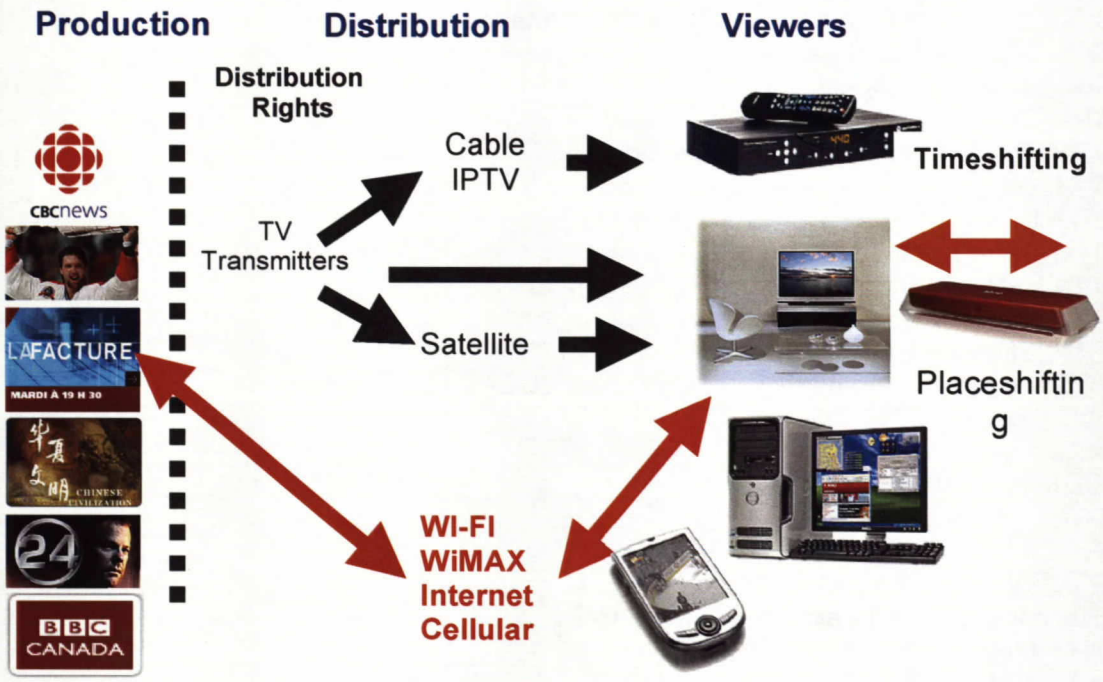
SUMMARY

Video will be available from many means in the future, as represented in the figure next page. It could be received on a cellular telephone through a cellular or mobile wireless broadcasting network. A portable computer could access the Internet through a wireless connection to watch TV programs from around the world. To enhance one's viewing experience, an HDTV set can even be connected to cable or satellite to receive picture in 3D. Over-the-air terrestrial broadcasting will likely remain a very economical and efficient way of distributing a huge quantity of information instantaneously to a very large audience, including mobile users, in a spectrum-congested environment.

It is difficult to predict which of these technologies will have more impact on viewers' habits, but it is certain that each one will influence the ways video will be received in the future.

For more information, please contact Bernard Caron (Bernard.Caron@crc.ca), Vice-President, Broadcast Technology Research Branch, Communications Research Centre Canada.

Video Delivery Technologies



LIST OF ABBREVIATIONS

3G: Third Generation
ADSL: Asymmetric Digital Subscriber Line
ATSC: Advanced Television System Committee
BCC: Binaural Cue Coding
BSS: Broadcasting Satellite Service
BTS: Broadcast Television System
BWA: Broadband Wireless Access
CDTV: Canadian Digital Television
CRC: Communications Research Centre Canada
DAB: Digital Audio Broadcasting
DBS: Digital Broadcasting by Satellite
DRB: Digital Radio Broadcasting
DMB: Digital Multimedia Broadcasting
DTH: Direct-to-Home
DTV: Digital Television
DTxN: Distributed Transmitters networks
DVB-H: Digital Video Broadcasting-Handheld
DVD: Digital Versatile Disc
ERP: Effective Radiated Power
FCC: Federal Communication Commission (USA)
FLO: Forward Link Only
FSS: Fixed-Satellite Service
ICI: Inter-Carrier Interference
IP: Internet protocol
IPv6: Internet Protocol version 6
IPTV: Internet Protocol Television
ITU: International Telecommunication Union
MHz: Megahertz
MPEG: Motion Pictures Experts Group
NPRM: Notice of Proposed Rule Making
NTSC: National Television System Committee
OTA: Over-the-Air
SBR: Spectral Band Replication
S-DARS: Satellite-Digital Audio Radio Services
SDR: Software Defined Radio
SDTV: Standard Definition Television
SFN: Single Frequency Networks
SSC: SinuSoidal Coding
T-DMB: Terrestrial-Digital Multimedia Broadcasting
TxID: Transmitter identification
UD: Unlicensed Devices
UHDV: Ultra High Definition Video
VSB: Vestigial Side Band
WLAN: Wireless Local Area Networks
WRAN: Wireless Regional Area Networks

ANNEX

SOME CANADIAN ENTERPRISES INVOLVED IN NEW VIDEO DISTRIBUTION TECHNOLOGIES

(With information from their respective websites.)

Algolith

Algolith Inc., based in Montréal, Québec is a privately held company founded in 2003 as a spin-off of Miranda Technologies. Algolith has developed the industry's most advanced set of video processing algorithms, leveraging more than a decade of R&D, and representing over 50 man-years of IP development. The company has built its reputation around its patented core Intellectual Property (IP), an unparalleled portfolio of technology which significantly improves image quality in all formats.

Algolith solutions include a series of FPGA-based image processing and enhancement cards designed to meet the exacting needs of broadcast, cable, satellite, and IPTV providers; as well as specialized IP solutions which can be used for FPGA or ASIC implementations by OEM and IP licensees.

With market-proven noise reduction and video format conversion solutions, Algolith's IP technology is behind some of the industry's leading video processing solutions and is recognized worldwide as "best-in-class." Since its inception, Algolith's mission has been firmly focused on empowering professionals with cutting-edge technology for delivering high-quality images.

http://www.algolith.com/

Communications Research Centre Canada
An Agency of Industry Canada

Centre de recherches sur les communications Canada
Un organisme d'Industrie Canada

The Communications Research Centre (CRC) is the only research laboratory in Canada that has a comprehensive broadcast research program with world-renowned experts and facilities.

The program directly supports both the Industry Canada's Spectrum Engineering Branch and the Canadian broadcasting industry. The research program provides significant technical input to the development of spectrum allocation plans for digital radio and television broadcasting, to planning of new broadcast services, and to spectrum coordination with other telecommunications services to avoid mutual interference. Hardware and software tools are developed to facilitate spectrum management in the digital world. Since some of the research and the technologies are also applicable to

non-broadcast areas, some of the research effort is devoted to selected areas as required.

The research program directly supports the broadcast industry in the implementation of advanced broadcast systems by participating in national and international standards organizations, by supporting field trials, and by providing facilities for testing and evaluating systems and equipment for proof of concept and design improvements. Technologies resulting from the research are transferred to industry for the development of new products and services.

http://www.crc.ca/en/html/crc/home/research/broadcast/broadcast

GENNUM

Gennum Corporation (TSX: GND) designs innovative semiconductor solutions and intellectual property (IP) cores for the world's most advanced consumer connectivity, video broadcast and data communications products. Leveraging the company's proven optical, analog and mixed-signal products and IP, Gennum enables multimedia and data communications products to send and receive information without compromising the signal integrity.

A winner of a Technical Emmy award for advances in high definition (HD) broadcasting, Gennum is headquartered in Burlington, Ontario and has global design, research and development and sales offices in Canada, Mexico, the United States, Japan, Korea, Germany, Taiwan and the United Kingdom. It employs approximately 370 people worldwide.

http://www.gennum.com/

www.norpak.ca

norpak corporation

With over 28 years of experience, Norpak Corporation is a leading supplier of TV data solutions to the professional content delivery market. Norpak's products and technology have been adopted worldwide for use by major TV broadcasters, cable TV system operators, satellite operators, content creators, systems integrators, value-added service providers and OEM equipment suppliers.

Norpak products address metadata, closed-caption, interactive TV, monitoring and filtering applications and include analog, serial digital, HD and MPEG-TS encoders, bridges and receivers.

http://www.norpak.ca

Nortel makes telecommunications network equipment including optical transmission equipment, wireless, voice, multimedia, and packet networking and associated services. Its service-provider customers include large public network carriers (i.e. telecom providers) including telephone, cellular and cable operators. Nortel also sells phone systems and related equipment to small, medium and large businesses. Nortel does business in more than 150 countries around the world.

http://www.nortel.com/

LARCAN innovates, designs and manufactures digital and analog TV transmitters for wireless and broadcast markets worldwide. Larcan specializes in Custom Network Planning and RF Synergies for Broadcast and Mobile Video / DVB-H technologies.

LARCAN offers "end-to-end" engineering solutions in solid state VHF, UHF, high power IOT transmitters, as well as low power transmitters / translators.

LARCAN's digital UHF and VHF product lines include a full range of innovative television broadcast transmitters, using LARCAN's own proven solid state technology. LARCAN brings the best in digital TV and digital transmitter technology from start to service – its products are customer driven, and purpose designed for optimum performance. Each of its digital products – from solid state to IOT-based high power transmitters – incorporate LARCAN's leading-edge technology and reputable experience to ensure the highest quality broadcast signal. Built for broadcast standards worldwide, LARCAN's digital products deliver the clear and consistent results broadcasters are looking for.

http://www.larcan.com/

Look Communications Inc. delivers a full range of communications services, including digital television distribution, high-speed and dial-up Internet access. Look provides its digital television and wireless Internet services using a Multipoint Distribution System (MDS) technology, operating with 90 MHz of capacity in the 2.5 GHz band. Look has exclusive use of these frequencies since it received licenses from the Canadian Radio-television and Telecommunications Commission (CRTC) as a "broadcast distribution undertaking" in August 1997 for Southern Ontario and in 1998 for Quebec and Eastern Ontario.

With this MDS technology, television, audio and data signals are received at Look's headend and digitally transmitted via fibre optics links to broadcast sites. The signals are then broadcast over the air from one of several transmission towers or base stations to a receiving antenna at subscribers' homes or businesses.

Look has offices in Montreal, Quebec and Milton, Ontario, and Look's shares are listed on the TSX Venture Exchange under the symbol LOK.

http://new.www.look.ca/

matrox
Digital Video Solutions

Matrox Video Products Group is a technology and market leader in the field of HD and SD digital video hardware and software for realtime editing, DVD authoring, capture/playout servers, clip/still stores, and CGs. Matrox's Emmy award-winning technology powers a full range of content creation and delivery platforms used by broadcasters, post-production facilities, project studios, corporate communicators, and videographers worldwide. Founded in 1976, Matrox is a privately held company headquartered in Montreal, Quebec.

http://www.matrox.com/

Miranda

Miranda must constantly reinvent its line to keep abreast of change. That is why it makes substantial investments in research and development year after year. Miranda takes pride in putting new ideas to work.

Miranda's solutions are developed with the knowledge attained through the attentiveness paid to customers' evolving needs and, armed with this knowledge, the company is determined to provide them with innovative and cost effective solutions. Whilst venturing into uncharted territories, Miranda can also rework existing technologies to move products ahead of the market.

More than one third of Miranda's employees are engineers equipped with many years of experience; the people who are now shaping the future of television. Miranda is making strides in the fields of monitoring, audio production, HD conversion and real-time graphics, amongst others.

http://www.miranda.com/

ROSS

Ross Video designs, markets, manufactures, and supports a wide range of innovative products for use in broadcast, distribution, live event and production applications. Ross

products are found in over 100 countries and are used 24 hours a day, 365 days a year to produce and distribute video and audio signals. Its reach is worldwide with Ross sales office locations throughout Canada, the United States, the United Kingdom, Germany and China, with more office openings planned in the future.

http://www.rossvideo.com/

Spectrocan

Headquartered in Ottawa, Ontario SPECTROCAN is a global systems integrator focused on delivering comprehensive spectrum management and network planning solutions to regulators and operators around the world. In 2005 SPECTROCAN combined its operations with LS telcom AG, a leader in engineering tools for radio communication.

SPECTROCAN is a developer of state-of-the-art fully integrated software tools that cover all radio services and frequency ranges. Its systems are compliant with ITU recommendations and incorporate the Canadian model for spectrum management.

The company is a strong proponent of long-term human resource development programs. Its commitment to this knowledge transfer is reflected in its active contributions to telecommunications institutions such as TEMIC and the ITU Centres of Excellence, as well as in its extensive training program.

With a wealth of knowledge in radio spectrum management and telecommunication, its strategic consultants advise clients all over the world on matters of radio regulations development, communication policies, spectrum planning, and computer-based frequency management and radio station licensing.

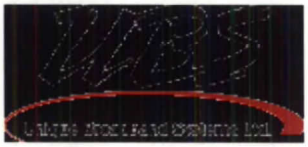
http://www.spectrocan.com/

Tin Lee Electronics (TLE) Ltd. specializes in the production of precision filters for cable TV, VHF/UHF and FM reception and RF communications, as well as products for TV/FM headend and signal distribution systems. TLE offers:

- High-quality products
- Custom-made products designed to best suit customer needs
- Competitive prices on all of its products
- Experienced technical assistance
- A broad spectrum of products designed for the TV/FM/RF industry
- In-house production for quick delivery and reduced lead time
- Strict quality control to ensure reliability.

Most of its products are made in Canada.

http://www.tinlee.com/



UBS has deployed systems and solutions spanning the globe on five continents. Unique Broadband Systems' staff is a power house of qualified electronic and software engineers, master engineers and Ph.D. level engineers. With such a wealth of technical resources UBS is capable of handling all the technical and service requirements for any scope of project. The company continues to invest heavily in this area in the future to ensure that new products are developed, along with ongoing improvements to existing products. UBS expertise includes:

- Digital waveform analysis and synthesis
- Solutions for all key international standards:
  DVB-T/H, DVB-SH, DAB/DAB+, T-DMB, DTMB, T-MMB, CMMB
- High power LDMOS technology
- Embedded technology: COFDM
- Network and RF coverage analysis and design
- Satellite/Terrestrial SFN and MFN solutions.

http://www.uniquesys.com/

ZIMTV is the first P2P Internet TV platform to offer content owners the option to provide free online streaming programs as well as pay per view content. Unlike other Internet streaming platforms which charge large set up fees, monthly hosting fees and additional fees per gigabyte of bandwidth, ZIMTV offers unlimited bandwidth for a flat rate.

It is based on integrated P2P technology which provides users with a smooth TV viewing experience with no interruptions. With P2P technology, excellent video quality is achieved without the high costs of traditional streaming. The more users are online, the faster the programs can be loaded.

http://www.zim.biz/index.html

Wavesat is a global leader in mobile broadband, providing advanced semiconductor solutions to the world's leading carrier and mobile device manufacturers to deploy future-proof broadband services and products. With award winning technology and the industry's first WiMAX Forum Certified CPE design, Wavesat delivers silicon that enables customers to deploy multiple broadband wireless technologies such as WiMAX Wave2, WiFi and XG-PHS today, and to migrate seamlessly to future 4G technologies such as LTE.

Wavesat's technology leadership resides in an intelligent, multimode 4G architecture and cost effective platforms that combine software and reference designs with superior technical support to provide highly integrated, power efficient broadband solutions. Mobile device manufacturers can maximize investment, reduce development time and risk and accelerate time-to-market with Wavesat's industry-leading performance, integration, size and power management.

As a key player in the broadband ecosystem, Wavesat partners with technology industry leaders to offer complete and interoperable solutions that accelerate broad market adoption. Wavesat is a principal member of the WiMAX Forum.

http://www.wavesat.com/