Key Wireless Technologies and Developing Trends

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Internationally, the wireless landscape is one that is characterised by continual evolution, rapid innovation and technological change. These innovations often act as a disruptive force to service providers, as market forces drive telecommunications companies to deploy ever more sophisticated networks in order to remain competitive. However, these same firms can also reap enormous benefits by implementing technologies that make more efficient use of available spectrum and offer consumers greater range, quality of service, and data transfer rates. Consequently, there is a strong incentive for equipment providers to develop new technologies, as scientific advances open up new possibilities.

What follows is a description of some important technologies and technological trends which are currently underway, and which will likely figure prominently in future. This list is not intended to be comprehensive, and while these seem to be the important developments of the moment, a technology considered promising or cutting edge today can quickly be made obsolete by unforeseen developments.

(Wi-Fi) Mesh Networking Trends

The Wi-Fi alliance was established in the late 90's as a consortium of industry leaders involved in the development of equipment meeting the IEEE's 802.11 standards for wireless internet equipment. Wi-Fi is actually a brand name registered to the Wi-Fi alliance, and Wi-Fi certification is bestowed upon products which conform to the standards of the Wi-Fi alliance, ensuring the interoperability of 802.11 networking equipment. While Wi-Fi is a brand name, in this paper, it refers to equipment based on the IEEE 802.11 family of standards.

The use of Wi-Fi in W-LANs (e.g., wireless routers, etc.) is relatively widespread and thus, in this application Wi-Fi can be considered a mature technology. However, using this technology in wireless mesh networks, which can increase the coverage area for a Wi-Fi 'hotspot', is a relatively new application.

Mesh networks are emerging as an effective means of enabling wireless networking over a given geographical area. These can be contrasted to other wireless network configurations, such as point-to-point networks, where each link requires a dedicated connection (such as conventional wired internet links, or wireless links where, for example, a wireless router could be used to bridge the connection) or point-to-multipoint links, where numerous devices connect to a single access point (such as conventional W-LANs or cellular networks). In a mesh network, coverage is provided by various 'nodes', which relay information packets to access points (in the case of a network which is connected to the internet or to a larger communications network). Access points can also act as nodes, as can individual clients within the network. This relaying of information between various clients, nodes and access points ('hopping') is the strength of mesh networks, as this can be used to circumvent bottlenecks (such as limited bandwidth availability at a given access point, or a node being 'down') and even to permit communication around physical obstacles (by using nodes to ring the obstacle and transmit the signal around it). Wireless mesh networks can be either fixed or mobile, and can incorporate some wired connections. Mesh networks have so far only enjoyed a

limited deployment, and are used in hospitals to provide easy mobile communications for doctors and nurses, in industrial settings for industrial control and monitoring, where they are used to connect various sensors and control systems, and in military applications to enable robust mobile communications for field units.

With the currently available technology, mesh networks are often prohibitively expensive to implement, which has limited their deployment. In the immediate future, mesh network sales will likely be confined to a few key vertical markets, such as healthcare, higher education and military.[1] Growth in wireless communications spending by these market segments is likely to be the main driver of growth in this field in the next few years. Recent progress towards a new standard (802.11s) for mesh networking should accelerate deployment of wireless mesh networks in the future.

Kazam Technologies forecasts that the market for Wi-Fi wireless mesh networks will increase to some CAD 976 million by 2009.[2] Canada is strong in this field, and the Canadian wireless industry stands to benefit from this growth in demand. Some Canadian firms developing Wi-Fi mesh networking equipment include Tranzeo Wireless Technologies, Nortel and BelAir Networks.

WiMAX Wireless Networking Trends

Like the Wi-Fi alliance, the WiMAX (Worldwide Interoperability for Microwave Access) forum is an industry trade organization formed by leading companies to promote and certify compatibility and interoperability of broadband wireless microwave access equipment that conforms to the IEEE 802.16 family of standards. WiMAX is not a technology, but rather a certification given to equipment that meets the standards of the WiMAX Forum. For brevity's sake, the terms 'WiMAX' and 'WiMAX technology' are used here to denote wireless microwave broadband access technology.

WiMAX is similar to Wi-Fi, but has much greater range and speed. While some consider WiMAX a competitor to Wi-Fi, the two technologies may ultimately complement each other, with WiMAX connectivity providing backhaul access to Wi-Fi hot-spots (i.e. connecting Wi-Fi LANs and mesh networks to the main communications network). In addition to its capacity to serve as a wireless backhaul for LANs, one of the greatest promises of WiMAX is that it will make mobile broadband access readily and cheaply available, and South Korea has already begun rollout of WiBro, a mobile broadband access technology similar to WiMAX. The long range, relative low cost and ease of installation of WiMAX equipment also means that the technology has the potential to enable broadband connectivity in remote or rural areas which are currently not serviced by land-line broadband internet access.

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[1] Faulkner Information Services, Mesh Networking Market Trends, 2005. Doc. ID #00018896

[2] Kazam Technologies, The Canadian Wireless Industry: Analysis, Positioning and Capabilities 2006-09. Industry Canada, 2007. p.213

WiMAX may also be used as a last mile wireless broadband connectivity solution as an alternative to cable and Digital Subscriber Loop (DSL). Metropolitan Area Networks, or MANs, cover a smaller geographical region than a wide area network, but have greater coverage than a local area network (LAN) by creating a network of linked LANs. While they can be useful for creating a high-speed network that covers, for example, several office buildings, MANs can be prohibitively expensive for many businesses. Wireless MANs based on WiMAX technology may increase the cost effectiveness of implementing this type of network, resulting in an increase in adoption. WiMAX is based on the IEEE standard designated 802.16-2004 (fixed wireless applications) and 802.16-2005 (mobile wireless applications). It has been developed specifically for MAN applications. There are two main applications of WiMAX today: fixed WiMAX applications enabling broadband access to homes and businesses, and applications that enable full mobility similar to that of cellular networks.

While the technology is to some extent still under development, the WiMAX Forum (a consortium of over 250 telecommunications services and equipment providers which is seeking to push forward WiMAX technology) is currently working with various governments to secure spectrum allocation for WiMAX applications. Allocation of the same spectrum bands internationally will help with deployment of WiMAX technology. WiMAX can enhance Wi-Fi technology, as mentioned above, and this characteristic should accelerate wider market deployment. Faulkner estimates that WiMAX is likely to follow a similar adoption pattern to Wi-Fi, and maturation of the technology should occur around 2008. [3]

Growth in the size of the WiMAX market will be affected by a number of factors, including regulatory issues, equipment interoperability issues, the cost of equipment and the level of cooperation between various players such as equipment providers, service providers and government regulatory bodies. Nonetheless, it is expected that the demand for the technology will be strong once products start being brought to market. Kazam Technologies estimates that the global WiMAX market will be worth over CAD 3 billion by 2009.[4]

Canada is well positioned for participation in the future WiMAX market. Several Canadian companies, including Redline Communications, Wavesat and Vecima Networks (formerly VCom) are currently conducting R&D and commercialization of WiMAX products. The MILTON broadband distribution system, developed by the Communications Research Centre of the Canadian Federal Government, is WiMAX compatible. Additionally, Wavesat recently announced that it obtained the first ever WiMAX Forum certification for WiMAX customer premise equipment when its fixed wireless broadband products were certified at the WCA symposium in San Jose, California in January of 2006.

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[3] Faulkner Information Services. WiMAX Technology, 2005. Doc. ID #00018874

[4] Kazam Technologies, The Canadian Wireless Industry: Analysis, Positioning and Capabilities 2006-09. Industry Canada, 2007. p.144

"Vienna, Austria – (May 22, 2006) – Redline Communications Inc., the leading provider of advanced broadband wireless access and backhaul solutions, and Wavesat, a developer of WiMAX chipsets, software and development tools, are delivering the world's first live demonstration of a portable WiMAX network using interoperable WiMAX products." [5]

In 2005, Nortel deployed Canada's first commercial WiMAX network in Alberta as part of a provincial government broadband initiative, called 'Alberta SuperNet', to get wireless broadband to south-eastern Alberta. Inukshuk, a joint venture between Bell Canada and Rogers, is also supplying wireless broadband to urban centers using pre-WiMAX certified equipment supplied by Nextnet Wireless (an American company, now a subsidiary of Motorola).

Intel, which has been a leading champion of WiMAX development and deployment, stands to gain considerably from widespread adoption of the technology (as it did through its earlier support for Wi-Fi and its leading role in the development of that technology), and is a leading WiMAX component supplier. Other firms involved in components or WiMAX equipment production include Fujitsu, Philips Semiconductor, Broadcom, Motorola, Aperto Networks, and Canadian firms Nortel, Wavesat, Wi-LAN, Vecima Networks, DragonWave, Redline Communications and SiGe Semiconductor.

Research by the consulting firm Kazam Technologies indicates that, with a significant number of companies conducting R&D into and commercializing WiMAX products, Canada is a leader in this field.[6]

Developing Cellular Technologies

Cellular telephony originally relied on the assignment of small pieces of frequency spectrum for each conversation. This method of accommodating cellular telephony, called Frequency Division Multiple Access (FDMA), is now known as 'analog' cellular telephony. In the 1990's, two new (digital) cellular technologies emerged which made more efficient use of the spectrum. The first technology (Time Division Multiple Access, or TDMA) allots a certain very small time-slot in a cycle for each conversation, enabling multiple users to time-share each channel of frequency. The second digitally combines all users on the same frequency and assigns the packets (small pieces of digitized voice data) of each conversation a specific code, so these can then be picked up and decoded by the receiving device (Code Division Multiple Access, CDMA). Several TDMA standards exist including IS-54 and IS-136 in North America and GSM (Global System for Mobile communications) which emerged in Europe. The difference in these standards is in the channel widths (bandwidths) (in kHz) and the number of time slots per channel. While

[5] Redline Communications website, "Redline and Wavesat Demonstrate World's First Portable and Interoperable WiMAX Network", http://www.redlinecommunications.com/news/pressreleases/2006/052206a.html, May 2006.
[6] Kazam Technologies, The Canadian Wireless Industry: Analysis, Positioning and Capabilities 2006-09. Industry Canada, 2007. p. 164

its origins were in Europe, GSM today is in use around the world and is the fastest growing standard of these second-generation (2G) cellular technologies.

Currently, third-generation (3G) cellular technologies are in various stages of development and deployment. CDMA technology has spawned cdma2000 1x-EV-DO and cdma2000 1x-EV-DV, while WCDMA has emerged as the evolution of the GSM standard. It should be noted that both of these third-generation standards are based on the CDMA air interface technology. 3G cellular communications systems offer much faster rates of data transfer between devices, enabling data services such as wireless television broadcasts and video streaming. Of the two technology streams, cdma2000 1x deployments are currently much more widespread than WCDMA deployments, with the ITU reporting 115 million cdma2000 1x subscribers in 2004, as opposed to 18.8 million WCDMA subscribers.[7]

However, there is the possibility that wireless broadband provided by the evolution of WCDMA technology, HSDPA (High Speed Download Packet Access) will lead to the market dominance of WCDMA. HSDPA is a modified WCDMA downlink technology which offers significantly faster rates of data transfer. Whether this will put 3G technology in competition with WiMAX broadband delivery, or complement WiMAX, is subject to some debate. Nortel is involved in HSDPA development, and recently (May of 2005) set up a trial HSDPA network in Israel as a joint venture with a local ICT firm. A further evolution to WCDMA networks which is currently in the works, HSUPA (High Speed Uplink Packet Access) has the potential to further increase the capabilities of WCDMA networks, especially for low-latency applications such as wireless VoIP.

In the meantime, commercial deployments of 3G in Canada (Bell and Telus) have been underway since 2005. Rogers, with Ericsson as its equipment supplier, has begun rolling out WCDMA-3G (strictly speaking it will be a 2.5G network, as the data transfer rates are below what is specified by the ITU as '3G'). Along with the upgrade to the Rogers network, Rogers will also be offering superior datacards and handsets which can take advantage of the improved network, including the new BlackBerry from RIM.

International leaders in the 3G equipment marketplace include Alcatel, Ericsson, Lucent Technologies, Motorola, NEC Corporation, Nokia, Samsung Electronics, and Siemens. Nortel is focusing its efforts on cdma2000 and other wireless technologies (such as WiMAX and WiFi mesh), and has sold its 3G/UMTS (WCDMA) access division to Alcatel. Some smaller Canadian firms, such as Til-Tek Antennae and SiGe Semiconductor, are also players in the 3G field.

[7] International Telecommunications Union website, "CDMA 2000 1X Vs. W-CDMA Subscribers Worldwide", http://www.itu.int/osg/spu/newslog/CDMA+2000+1x++Versus+WCDMA+Subscribers+Worldwide.aspx, October 2006.

Wireless Voice Over Internet Protocol (VoIP)

Legacy voice systems use dedicated equipment to digitize, transmit and enable calling features for voice communications. The limitation of this system is that the service (telephony, for example) is associated with a dedicated physical link. Voice over Internet Protocol (VoIP) differs from conventional telephony networks in terms of network design. IP networks switch messages or packets along paths within the network whereas legacy networks use dedicated circuits. Packet switching technology generally provides greater efficiency in terms of bandwidth when compared to dedicated circuits.

Different networks are required to move different payloads using a legacy framework. In a legacy framework, the telephone company moves voice over the public switched telephone network (PSTN), television services are provided over the air or over coaxial cable by the cable companies, and wireless capability is provided over a cellular network by a wireless company. Internet Protocol (IP) telephony changes all of this. IP is able to travel through dial-up, DSL internet connections, the coaxial cable through cable modems and third-generation cellular technologies. IP enables voice, data and video to travel across one network — an IP network.

In a very simple context, IP communication works by taking a payload (voice, data or video) and having it travel across a broadband backbone. In the case of IP telephony, voice is first digitized through a digital signal processor (DSP) contained in a gateway, IP phone or computer. The digital voice is then divided up into small portions (i.e., 20 ms) and coded with a unique sequence number. The portions are wrapped with an IP packet containing source and destination IP addresses, and sent across the network. Routers within the network determine the path the packets take to reach their intended destination. Once the packets arrive at their intended destination they are reassembled into their proper order and converted into sound by a DSP.

A common misconception is that IP-based communications implies that communications must operate over the public internet. While this can be the case, it certainly is not the normal case. At the enterprise level, there are many options regarding the deployment of an IP network: the enterprise can build its own dedicated network using leased or dedicated circuits, or it can choose to use a service provider solution; a managed IP service, perhaps over a multi-protocol label switching (MPLS) network. A combination of the above can be used to interconnect enterprise sites. Private VoIP traffic can be carried between IP endpoints using IP Private Branch Exchanges (IP-PBX, basically a private corporate switchboard) to provide the service. These private networks still require a way to access the public network to reach other 'off-net' destinations.

Wireless VoIP currently involves using Wi-Fi to connect the handset to the IP network, which transmits the signal through the network. This means that to take advantage of the cost savings of making an IP call, the consumer must be in a Wi-Fi hotspot when placing the call. Wi-Fi enabled mobile phones are generally able to switch between Wi-Fi and cellular transmission depending on location, which lets the user make VoIP calls when possible and cellular calls when necessary. Adoption of the IP Multimedia Subsystem

(IMS) for 3G cellular technology has the potential to improve the quality of service, feature set and coverage of wireless VoIP. Several firms including ZTE, Nortel and Sierra Wireless are in various stages of development and deployment of this technology.

VoIP can also be extended to mobile radio networks. Radio over Internet Protocol (RoIP) provides some cost savings over traditional radio networks. Also, packetized information lends itself well to hierarchical communication structures (where transmissions from some radios are to have priority over transmissions from others) and so RoIP can be useful to hierarchical networks such as emergency response teams.

High capacity mobile broadband networks based on 802.15-2005 (WiBro and mobile WiMAX) could be well-suited for mobile VoIP over wireless broadband.[8] Samsung has recently released a mobile phone for use on WiBro (WiMAX) networks, and other telecommunications companies are likely to follow suite. In addition, Sprint recently announced plans to deploy a mobile WiMAX network in the United States, which will allow both mobile internet connectivity and VoIP.

Handsets

As 3G and eventually 3.5G and 4G[9] networks are developed and deployed, and as there is ever increasing convergence of technology (broadband over cellular networks and voice over internet protocol, etc.). increasingly sophisticated content services will become available over these networks. This has obvious and direct implications for handset technology, as handsets will have to be available which are able to take advantage of these new services if telecommunications companies are to be able to offer them. Screen size and keyboard size are limiting factors for networking and viewing content over wireless devices, as it can be unpleasant or difficult to view data on a small screen and can be uncomfortable to type using a small keypad. Generally there is a trade-off between functionality and portability, though several firms are working on developing pliable screens that could be both large and portable. Overall, however, the physical 'package' design of mobile handsets (PDA's and hand-held mobile phones) has stabilized.

Hybrid phones, which are Wi-Fi enabled cellular phones that can make VoIP calls when in Wi-Fi hotspots and transfer over to cellular networks when out of these areas, are now being released. Such phones have the potential to reduce phone bills, as well as enable much cheaper web-browsing if used as nomadic devices (i.e., used to browse the web only when in a wireless access hotspot). Several challenges exist for Wi-Fi hybrid phones, including handover of the conversation between the Wi-Fi and cellular networks, security issues, interference from other devices operating on the unlicensed Wi-Fi band

[8] Silicon.com, VoIP Could Be The Key To Wimax, http://networks.silicon.com/mobile/0,39024665,39127948,00.htm, February 2005.

[9] It should be noted that, unlike 2G and 3G, 4G does not refer to any set standards but rather to technologies which will supplant or enhance existing cellular technologies. These could include, for example, mobile WiMAX VoIP.

and cost. Nonetheless, continued rollout of Wi-Fi across Asia, Europe and North America will likely spur greater demand for these hybrid telephones.

Convergence continues between smartphones, which are application-enabled, voice-centric cellular telephones, and voice-enabled, data-centric PDA's. As smartphones become more sophisticated, with more sophisticated applications and services available over them, they will likely start to encroach on the market for PDA's, such as RIM's BlackBerry. Some claim that the new generation of smartphones will render the PDA obsolete. The counter argument, however, is that voice-enabled PDA's offer similar telephony service to cellphones, and the larger PDA devices make data entry, writing emails, and viewing information on a screen much more pleasant than using the much smaller cellphones. In addition, the cost of smartphones is often higher than the cost of having both a PDA and a cellphone. In summary, both types of devices are likely to coexist for the medium term, but it is expected that they will converge into one device in the long term.

Future smartphones will be able to support more graphics-intensive applications. If issues such as the high cost of these devices can be addressed, then increased demand for such devices and services will be a positive development for graphics components manufacturers such as Canada's ATI Technologies (recently acquired by AMD). It is expected that in a few years up to 25% of phones sold will be considered "smart", as costs come down and the units continue to evolve (e.g., Bluetooth incorporation).[10]

Video phone technology has been available for some time. The first 'video phone' was actually invented by the Philippine inventor Gregorio Zara in 1955, though the technology was markedly different from what is in use today. The nascence of current video phone technology can be traced to AT&T demonstrations some 40 years ago. In recent years, the development of more sophisticated devices, as well as advances in network technology and capacity, has made video telephony feasible using mobile terminals. However, issues such as shakiness, small screen size and latency may hinder the long-term demand growth for such technology, at least as a video-conferencing tool.

Third-generation cellular networks have made streaming of video content to mobile units feasible, and the technology is now gaining much more widespread acceptance and use. Downloading internet content over Wi-Fi (or potentially WiMAX) is another possible medium for video transmission. A more efficient (in terms of use of scarce spectrum) alternative is to have a cellular phone which can support broadcast television reception, for example, using the DVB-H standard (Digital Video Broadcast – Handheld). DVB-H networks are currently being deployed in the U.S. and in many countries in Europe. Video streaming and video telephony are both positive developments for graphics card components manufacturers and developers, as well as for wireless infrastructure firms.

While handsets for developed markets are likely to continue increasing in their technological sophistication and capability, there will also be demand in developing markets for very cheap mobile devices. The GSM Association's Emerging Market

[10] Faulkner Information Services, Smartphones Market Trends, 2005. Doc. ID #00018004.

Handset program is dedicated to supplying such low-cost (less than USD 30) handsets to less developed economies.[11] Falling prices for basic handsets is likely to drive demand for network infrastructure in developing markets. Canada has some strength in wireless infrastructure development and deployment, and efforts to produce highly affordable wireless infrastructure technology could enable Canadian industry to enter highly under-developed economies which have generally received less attention.

In addition, there are some Canadian firms which develop and manufacture wireless handsets, including RIM (manufacturer of the BlackBerry) and Ascalade Communications, which is developing and selling PC-based cordless VoIP phones. Continuing growth in demand for wireless connectivity will provide future opportunities for these firms.

As handsets are expected to do more, the power requirements increase. Striking a balance between battery life and battery size is an important issue, and one that is likely to garner greater attention from designers and manufacturers in the future. Methanol fuel cells offer one possibility (Japanese firms Aquafairy and DoCoMo have brought such solutions to market). University of Toronto researchers have also recently developed a nanotechnology photovoltaic system which can be embedded in clothing fibres – which means that clothing could serve as a solar power source, including for handheld wireless devices.[12]

Satellite Communications

Canada was, and continues to be, a world leader in the field of satellite communications. Recently, satellites have started seeing use as a means of delivering internet access to remote areas lacking broadband connectivity. Telesat Canada's ANIK F2 satellite, developed in partnership with the Communications Research Centre, the Canada Space Agency, EMS Technologies and Com-Dev, is currently providing internet access to numerous remote communities in Canada and the United States, and the ANIK F3 is set to launch in the first half of 2007.

While satellites offer the opportunity to quickly connect huge geographical areas with almost no infrastructure (the only customer premise equipment required is a small satellite dish and a modem, and the infrastructure required is a single device which relays the satellite signals to and from the internet), there are some technical issues which are difficult to overcome. Repair or upgrade is not an option, this requires a space mission. With download speeds of up to 2MB/s and upload speeds of 0.5MB/s (for the ANIK F2),

[11] Emerging Market Handset Program website, GSM Association Forges Sub 30$ Mobile Phone Segment for Developing Countries, http://www.gsmworld.com/emh/news/emh2_press_gsma270905.html, September 2006.

[12] Canadian Broadcasting Corporation (CBC) website, Solar Revolution, http://www.cbc.ca/toronto/features/solar/sargent.html, December 2006.

satellite internet connectivity is slower than other types of internet access (for example, DSL).

An alternative to conventional satellites are high-altitude platforms (airships) with telecommunications equipment mounted on them. They are cheaper to launch than geostationary satellites, and can be brought back down to earth for periodic upgrades and maintenance. Their lower altitude (just below orbit) also results in lower latency than with orbiting satellites, since the transmitted data must travel a shorter distance, which significantly improves upload speed especially. This greatly facilitates two-way communications. However, the area that a single unit can cover is much less than the area covered by a single telecommunications satellite.

Some problems with current high altitude communications platforms include the cost of maintaining the airships themselves, which some see as a major impediment. In addition, for coverage of urban areas, there may be issues where tall buildings could block reception much like casting a shadow, in which case additional infrastructure would be needed to re-direct the signal from a receiver on top of the building to handsets and devices on the ground (perhaps using Wi-Fi networks).

Ultra Wideband (UWB) Technology

UWB can transmit data extremely rapidly, but only over a limited distance. This makes it an ideal technology for connecting various electronic devices (e.g., a television with a home stereo system) or for wirelessly enabling USB memory devices.

The technology employs multiple frequencies simultaneously. These frequencies are often in licensed spectrum bands. The short distances used by UWB mean that interference with other networks is generally not a major issue, but can become an issue when UWB emission limits are chosen improperly.

While UWB is useful for personal area network type applications, its limited range will likely restrict the use of this technology. Convergence with Bluetooth technology could accelerate adoption by forcing a standard and enabling backwards compatibility of UWB devices with Bluetooth.

There are two major groups in this industry, the WiMedia alliance (headed by Intel) and the UWB forum (headed by Motorola), and both have conflicting positions on the standard that should be adopted. Disagreement over adoption standards has somewhat limited the commercial deployment of the technology. However, if this and other regulatory issues can be overcome, there may be potential for the use of UWB technology in certain niche applications.

The consulting group Kazam Technologies indicates that Canada is lagging when it comes to UWB communications products.[13] Nonetheless, there are some Canadian

[13] Kazam Technologies, The Canadian Wireless Industry: Analysis, Positioning and Capabilities 2006-09. Industry Canada, 2007. p. 164

players in this technology, including Icron (developers of a wireless USB device) and Wireless 2000.

Radio Frequency Identification

Radio Frequency Identification, commonly known by its acronym 'RFID', is not really a new technology. What is new, however, is the advancement in its application, specifically to areas such as integrated supply chain management. RFID chips, which emit an identifying signal containing a varying amount of information, can easily be attached to goods or packaging, which enables tracking and identification. RFID could eventually replace the pervasive barcode, but the price of RFID units will have to come down before this development.

RFID chips, the core of RFID tags, can either be passive or active. Active chips require their own power source, and can generally emit a stronger signal with more information. Passive chips merely react to a signal emitted by a wireless reader, which then interprets the 'reflected' signal. There are two major trends in RFID at the moment: the trend towards smaller and smaller chips (enabled by developments in nanotechnology), and the trend towards increasingly sophisticated units which can transmit ever greater amounts of information.

Rewritable RFID chips are already in existence. These are chips that can be written with new information by the RFID readers as they are read. This enables more sophisticated uses for RFID technology. It makes it possible, for example, for an RFID-enabled package to be encoded with information about exactly where it had been, and at what times, along the course of its delivery.[14] Re-writable RFID tags are currently being used by the US Department of Defence for logistics, by Michelin Tires,[15] and a rewritable RFID system for use with laboratory test tubes has been devised by Maxell.[16]

Market research firm In-Stat predicts that the global RFID tag market will grow to 2.8 billion by 2009 (quoted from Kazam Technologies). Kazam Technologies reported that "With the exception of a few companies such as Psion Teklogix ... Canadian companies face challenges in RFID."[17] It seems unlikely that Canada will be able to assume a leadership position in this technology, though in terms of equipment design and manufacture, there may be more room for industrial development in the reader, rather than the chip, side of the equation.

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[14] RFID Talk website, "Impinj Introduces Zuma: Industry's Longest-Range Field Rewritable RFID Solution", http://www.rfidtalk.com/showthread.php?threadid=715, March, 2004.
[15] RFID Journal online, "Michelin Embeds RFID Tags in Tires", http://www.rfidjournal.com/article/articleview/269/1/1/, January, 2003.
[16] RFID Update online, "Maxell Introduces RFID Test Tube Tracking System", http://www.rfidupdate.com/articles/index.php?id=779, February, 2005.
[17] Kazam Technologies, The Canadian Wireless Industry: Analysis, Positioning and Capabilities 2006-09. Industry Canada, 2007. p. 98, p. 155

One factor which may limit or slow the wider diffusion of RFID technology could be public concern over privacy issues. To foster wider adoption of this technology, government policy and regulation to mitigate invasive aspects of RFID could be useful.

Software Defined Radio

Software defined radio (SDR) is a term applied to a radio in which the radio frequency operating parameters including, but not limited to, frequency range, modulation type, or output power can be set or altered by software. Cognitive radio (CR) has the capability to sense and be aware of its operational environment, to be trained to dynamically and autonomously adjust its radio operating parameters accordingly, and to learn from the results of its actions and environmental usage patterns.

Software defined radio and cognitive radio are both very promising developments for the world of wireless telecommunications and can be built to work together on a single device. If handsets could be enabled with SDR (which is still too expensive for mass commercial deployment) and cognitive radio, then these devices would be able to analyze their environment and adapt their operation based on the availability of wireless networks in their location. This would make it possible for a Canadian cell phone, for example, to work anywhere in the world, by downloading the new software when necessary. Another advantage of SDR is that it becomes possible to implement new technologies, which may not even have been invented at the time of the device's manufacture, with a simple software upgrade. Cognitive radio opens up new possibilities for efficient use of spectrum with its ability to sense and make use of unused frequency bands.

The key benefit of SDR to an end-user will be the increased availability of services, with a wide range of choices at lower costs and in much shorter time frames. A user could be provided with a number of choices of services for one single radio device, without the need to buy several different devices. A good example of this is in the vision of having a single SDR device that could function as a mobile phone (in either a GSM or CDMA environment), a garage-door opener, a TV receiver, and a GPS unit.

SDR also has the potential to improve interoperability between various radio services through its ability to handle different transmission standards. This could be very beneficial in areas such as public safety, where, for example, police or military devices could be reprogrammed quickly to operate with other services such as fire or ambulance radio systems.

Canada is a world leader in these fields. Canadian firms such as Spectrum Signal Processing, IP Unwired and others provide both the hardware and software components of SDR systems. In addition, the Communications Research Centre (CRC) is heavily involved in SDR/CR research, including development of interference-reducing cognitive radio systems and development of SDR enabled emergency services radio units that can operate on each others' networks as described above.

Convergence:

'Convergence' is a term which has gained prominence in the lexicon of wireless telecommunications, and which encompasses everything from the convergence of multiple applications and services onto a single handheld device to the engineering goal of seamless handoff between wired networks and wireless networks. This tendency has important implications for the wireless industry.

The movement towards networks which will be entirely based on internet protocol (IP) could essentially create a universal communications language. This would mean that any IP-based application or service could be brought onto a wireless network. The goal is transparency of service across networks – to give consumers a seamless experience where they can enjoy a wide range of entertainment and communications applications with full mobility.

Conclusions:

The technologies covered in this paper are relatively new and are in various stages of development and deployment in the market. At the time of writing, these technologies are evolving and they seem promising. However, there is the possibility that they may not live up to technical expectations, or that consumers and business adopters in the market will not see their value, or that they will be supplanted by new, superior technology more quickly than expected.

While this fast pace of innovation is important, it is not the only engine of dynamism in the wireless industry. The wireless business environment, both globally and in Canada, also changes very quickly. Businesses are continually expanding product lines, moving into new markets, selling off departments to concentrate on core competencies, outsourcing, merging, acquiring each other and spinning off to form new ventures.

In such a dynamic business environment, not only can the success or failure of a technology contribute to a firm's growth or demise, but developments not directly related to the technology underlying firms' products can impact on the ultimate success or failure of a technology. For Canada and Canadian firms, success in this environment will require strategies that not only recognize this dynamism, but are designed to take advantage of it.

Sources

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WiFi Mesh Networking

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