Communications Technologies for Co-operative Systems

1. Licence-free bands for short-range Communications

1.1 ZigBee

ZigBee is a low-cost, low-power, wireless mesh networking standard. The low cost allows the technology to be widely deployed in wireless control and monitoring applications, the low power-usage allows longer life with smaller batteries, and the mesh networking provides high reliability and larger range.

The ZigBee Alliance, the standards body which defines ZigBee, also publishes application profiles that allow multiple OEM vendors to create interoperable products. The current list of application profiles either published or in the works are:

- Home Automation
- ZigBee Smart Energy
- Telecommunication Applications
- Personal Home
- Hospital Care

The relationship between IEEE 802.15.4-2003 and ZigBee is similar to that between IEEE 802.11 and the Wi-Fi Alliance. The ZigBee 1.0 specification was ratified on December 14, 2004 and is available to members of the ZigBee Alliance. Most recently, the ZigBee 2007 specification was posted on October 30, 2007. The first ZigBee Application Profile, Home Automation, was announced November 2, 2007.

For non-commercial purposes, the ZigBee specification is available free to the general public.

ZigBee operates in the industrial, scientific and medical (ISM) radio bands; 868 MHz in Europe, 915 MHz in countries such as USA and Australia, and 2.4 GHz in most jurisdictions worldwide. The technology is intended to be simpler and cheaper than other WPANs such as Bluetooth. ZigBee chip vendors typically sell integrated radios and microcontrollers with between 60K and 128K flash memory, such as the Freescale MC13213, the Ember EM250 and the Texas Instruments CC2430. Radios are also available stand-alone to be used with any processor or microcontroller. Generally, the chip vendors also offer the ZigBee software stack, although independent ones are also available.

As of 2006, the retail price of a Zigbee-compliant transceiver is approaching $1, and the price for one radio, processor, and memory package is about $3. Comparatively, the price of consumer-grade Bluetooth chips is now under $3.

The first stack release is now called *Zigbee 2004*. The second stack release is called *Zigbee 2006*, and mainly replaces the MSG/KVP structure used in 2004 with a "cluster library". The 2004 stack is now more or less obsolete.

Zigbee 2007, now the current stack release, contains 2 stack profiles, stack profile 1 (simply called ZigBee), for home and light commercial use, and stack profile 2 (called ZigBee Pro). ZigBee Pro offers more features, such as multi-casting, many-to-one routing and high security with Symmetric-Key Key Exchange (SKKE), while ZigBee (stack profile 1) offers a

smaller footprint in RAM and flash. Both offer full mesh networking and work with all ZigBee application profiles.

ZigBee 2007 is fully backward compatible with ZigBee 2006 devices: a ZigBee 2007 device may join and operate on a ZigBee 2006 network and vice versa. Due to differences in routing options, ZigBee Pro devices must become non-routing ZigBee End-Devices (ZEDs) on a ZigBee 2006 or ZigBee 2007 network, the same as ZigBee 2006 or ZigBee 2007 devices must become ZEDs on a ZigBee Pro network. The applications running on those devices work the same regardless of the stack profile beneath them.

ZigBee protocols are intended for use in embedded applications requiring low data rates and low power consumption. ZigBee's current focus is to define a general-purpose, inexpensive, self-organizing mesh network that can be used for industrial control, embedded sensing, medical data collection, smoke and intruder warning, building automation, home automation, etc. The resulting network will use very small amounts of power so individual devices might run for a year or two using the originally installed battery.

Typical application areas include

- Home Entertainment and Control - Smart Lighting, Advanced Temperature Control, Safety & Security and Movies & Music
- Home Awareness - Water Sensors, Power Sensors, Smart Appliances and Access sensors
- Mobile Services – m-payment, m-monitoring and control, m-security and access control, m- healthcare and tele-assist
- Commercial Building– Energy Monitoring, HVAC, Lighting, Access Control
- Industrial Plant– Process Control, Asset Management, Environmental management, Energy Management,industrial device control

1.2 Bluetooth

Bluetooth is a wireless protocol utilizing short-range communications technology facilitating both voice and data transmissions over short distances from fixed and/or mobile devices, creating wireless personal area networks (PANs). The intent behind the development of Bluetooth was the creation of a single digital wireless protocol, capable of connecting multiple devices and overcoming issues arising from synchronization of these devices. Bluetooth provides a way to connect and exchange information between devices such as mobile phones, telephones, laptops, personal computers, printers, GPS receivers, digital cameras, and video game consoles over a secure, globally unlicensed Industrial, Scientific, and Medical (ISM) 2.4 GHz short-range radio frequency bandwidth. The Bluetooth specifications are developed and licensed by the Bluetooth Special Interest Group. The Bluetooth SIG consists of companies in the areas of telecommunication, computing, networking, and consumer electronics.

1.3 DSRC 5.8 GHz

Dedicated Short-Range Communications (DSRC) provide communications between a vehicle and the roadside in specific locations, for example toll plazas. They may then be

used to support specific Intelligent Transport System applications such as Electronic Fee Collection.

DSRC are for data-only systems and operate on radio frequencies in the 5,725 MHz to 5,875 MHz Industrial, Scientific and Medical (ISM) band. DSRC systems consist of Road Side Units (RSUs) and the On Board Units (OBUs) with transceivers and transponders. The DSRC standards specify the operational frequencies and system bandwidths, but also allow for optional frequencies which are covered (within Europe) by national regulations.

DSRC systems are used in the majority of European Union countries, but these systems are currently not totally compatible. Therefore, standardization is essential in order to ensure pan-European interoperability, particularly for applications such as electronic fee collection, for which the European imposes a need for interoperability of systems.

Standardization will also assist with the provision and promotion of additional services using DSRC, and help ensure compatibility and interoperability within a multi-vendor environment.

CEN TC 278 produced the following standards: EN 12253, EN 12795, EN 12834 [ISO 15628] and EN 13372 for DSRC.

The base standards for DSRC have been developed by CEN. ETSI's work on DSRC complements the CEN activity in response to a European Commission Mandate (M/338 - issued to ETSI, CEN and CENELEC) in support of Interoperability of electronic road toll systems.

With the assistance of a Special Task Force (STF 282) to produce interoperability test suites, ETSI is producing two multipart standards for DSRC:

- European Standard EN 300 674 - Road Transport and Traffic Telematics (RTTT); DSRC transmission equipment (500 kbit/s / 250 kbit/s) operating in the 5.8 GHz Industrial Scientific and Medical (ISM) band. Part 2 of this European Standard is the Harmonized Standard that may be used to demonstrate compliance of roadside equipment and on-board units to the European Commission's R&TTE Directive (1999/5/EC)
- ETSI Technical Specification TS 102 486 - Test specifications for DSRC transmission equipment.

Some parts of these standards have already been published.

External links

- CEN has developed the DSRC base standards, upon which the ETSI work is based
- Technical Committee TC 204 of the International Organization for Standardization (ISO) is working on Intelligent Transport Systems, and its TC22 is working on in-car equipment
- The ICT Standards Board has an Intelligent Transport Systems Steering Group.

Please use the ETSI Work Programme to find further related standards.

1.4 About interference issues in short-range communications

When communication interference appears, it is invariably caused by wireless transmitters in the immediate vicinity operating in the same frequency band. Given high radio density, this can result in substantial delays in time to transmit and even data losses.

A safeguard against other wireless transmitters combined with fast system response can be produced by making use of a frequency band that is less crowded. There is a very pronounced increase in the wireless networking of PCs, printers and other IT devices using the 2.4 GHz band, which is licence-free all over the world.

This makes the 868 MHz band, for example, much more suitable for reliable building automation and covering a large area. It is also licence-free in Europe, allowing no continuous transmissions but only very short transmitted pulses.

In addition, the laws of physics mean that 868 MHz radio waves have twice the range of 2.4 GHz signals and double the penetration through materials like walls and furniture – and all for the same transmitted power.

A 2.4 GHz system consequently requires about four times more receiving nodes over its area. That increases its cost compared to an 868 MHz solution. The need for security against collision of the wireless telegrams within your own system increases with the number of transmitters.

The radio data simultaneously sent by multiple transmitters can collide close to a receiver, and the latter will then be unable to decode them properly.

The problems are fewer in a small installation as long as a radio channel is not overloaded by the relatively small number of wireless sensors and switches. But in larger installations you find very many wireless components in what can be tight confines. So it is important to choose a wireless system that is suitably robust in its rejection of data collisions.

One effective method is to keep each of the transmissions very short. Extremely short wireless telegrams of only about a thousandth of a second and an intelligent strategy of multiply repeating each transmission create excellent collision safety in the EnOcean wireless standard, safeguarding against sporadic and periodic sources of interference.

As many as 500 closely located transmitters, all signalling once per minute, can be received with more than 99.9% certainty.

2. Other communications media

2.1 Digital Broadcast: DVB, DAB, DMB

Digital Video Broadcasting (DVB) is a family of standardized technologies designed to facilitate broadcasting of images, sound and multimedia, and to permit a large degree of user interaction. The standards provide for delivery of the programme content by terrestrial, cable, satellite and mobile communication systems.

The standards also include the Multimedia Home Platform (MHP), the DVB open middleware system that enables user interactivity, and other related applications such as Electronic Programme Guides.

Digital Audio Broadcasting (DAB) was conceived as a means of digitizing audio programmes in order to offer distortion-free reception and CD quality sound. However, the ability of this technology to carry any form of data has allowed it to evolve to convey text, pictures and even video.

Digital Mobile Broacasting (DMB) includes T-DMB Terrestrial Digital Mobile Broacasting and S-DMB Satellite Digital Mobile Broacasting

T-DMB is an advanced version of European Digital Audio Broadcasting that incorporates MPEG-4 Multimedia technology. T-DMB runs on networks of transmission towers and gap fillers, while S-DMB works on networks of a satellite and gap fillers.

2.2 Infrared Communications

IR data transmission is also employed in short-range communication among computer peripherals and personal digital assistants. These devices usually conform to standards published by IrDA, the Infrared Data Association. Remote controls and IrDA devices use infrared light-emitting diodes (LEDs) to emit infrared radiation which is focused by a plastic lens into a narrow beam. The beam is modulated, i.e. switched on and off, to encode the data. The receiver uses a silicon photodiode to convert the infrared radiation to an electric current. It responds only to the rapidly pulsing signal created by the transmitter, and filters out slowly changing infrared radiation from ambient light. Infrared communications are useful for indoor use in areas of high population density. IR does not penetrate walls and so does not interfere with other devices in adjoining rooms. Infrared is the most common way for remote controls to command appliances.

Free space optical communication using infrared lasers can be a relatively inexpensive way to install a communications link in an urban area operating at up to 4 gigabit/s, compared to the cost of burying fiber optic cable.

Infrared lasers are used to provide the light for optical fiber communications systems. Infrared light with a wavelength around 1,330 nm (least dispersion) or 1,550 nm (best transmission) are the best choices for standard silica fibers.

IR data transmission of encoded audio versions of printed signs is being researched as an aid for visually impaired people through the RIAS (Remote Infrared Audible Signage) project.

2.3 Wireless Access Systems (WAS) including Radio Local Area Networks (RLANs) at 5 GHz

Today, RLANs (also known as WiFi) can be used in so-called “hot spots” that can be found at airports, hotels, coffee shops, etc. They allow users to connect their laptop to the Internet and to make phone calls using “Voice over IP”. RLANs are part of a wider category called Wireless Access Systems (WAS) that give their users access to broadband communications in a nomadic environment, meaning the user can take his laptop to access these services at different locations, whenever in the range of a “hot spot”.

A Commission Decision in the framework of the Radio Spectrum Decision harmonising the 5 GHz frequency band for RLANs was adopted on 11 July 2005.

Commission recommendation 2003/203/EC of 20 March 2003 on the harmonisation of the provision of public R-LAN access to public electronic communications networks and services in the Community recommended Member States to allow the provision of public R-LAN access to public electronic communications networks and services in the available 5 GHz band.

It also considered that further harmonisation in particular of the 5 GHz band would be necessary in the framework of Decision No 676/2002/EC to ensure that the band be available for R-LAN in all Member States and to alleviate the growing overloading of the 2,4 GHz band designated for R-LAN by Decision (01)07 of the European Radiocommunications Committee.

The purpose of this Decision is to harmonise the conditions for the availability and efficient use of the frequency bands 5150-5350 MHz and 5470-5725 MHz for wireless access systems including radio local area networks (WAS/RLANs).

Member States shall designate by 31 October 2005 at the latest the frequency bands 5150-5350 MHz and 5470-5725 MHz and take all appropriate means relating thereto for the implementation of WAS/RLANs, subject to the specific conditions laid down in Article 4.

2.4 WiMAX

WIMAX Technology

WiMAX, the **W**orldwide **I**nteroperability for **M**icrowave **Ac**ce**s**s, is a telecommunications technology aimed at providing wireless data over long distances in a variety of ways, from point-to-point links to full mobile cellular type access. It is based on the IEEE 802.16 standard, which is also called WirelessMAN. The name "WiMAX" was created by the WiMAX Forum, which was formed in June 2001 to promote conformance and interoperability of the standard. The forum describes WiMAX as "a standards-based technology enabling the delivery of last mile wireless broadband access as an alternative to cable and DSL" (and also to HSPA).

The standard **IEEE 802.16-2004** is often called 802.16d, since that was the working party that developed the standard. It is also frequently referred to as "fixed WiMAX" since it has no support for mobility.

The standard **IEEE 802.16e-2005** is an amendment to 802.16-2004 and is often referred to in shortened form as 802.16e. It introduced support for mobility, amongst other things and is therefore also frequently called "mobile WiMAX".

WiMAX is a term coined to describe standard, interoperable implementations of IEEE 802.16 wireless networks, similar to the way the term Wi-Fi is used for interoperable implementations of the IEEE 802.11 Wireless LAN standard. However, WiMAX is very different from Wi-Fi in the way it works.

The bandwidth and reach of WiMAX make it suitable for the following potential applications:

- Connecting Wi-Fi hotspots with each other and to other parts of the Internet.
- Providing a wireless alternative to cable and DSL for last mile broadband access.
- Providing high-speed data and telecommunications services.
- Providing a diverse source of Internet connectivity as part of a business continuity plan. That is, if a business has a fixed and a wireless Internet connection, especially from unrelated providers, they are unlikely to be affected by the same service outage.
- Providing nomadic connectivity.

WiMAX is a possible replacement candidate for cellular phone technologies such as GSM and CDMA, or can be used as a layover to increase capacity. It has also been considered as a wireless backhaul technology for 2G, 3G, and 4G networks in both developed and developing nations.

Comparisons and confusion between WiMAX and Wi-Fi are frequent, possibly because both begin with the same two letters, are based upon IEEE standards beginning with "802.", and both have a connection to wireless connectivity and the Internet. Despite this, the two standards are aimed at different applications.

- WiMAX is a long-range system, covering many kilometers that typically uses licensed spectrum (although it is also possible to use unlicensed spectrum) to deliver a point-to-point connection to the Internet from an ISP to an end user. Different 802.16 standards provide different types of access, from mobile (similar to data access via a cellphone) to fixed (an alternative to wired access, where the end user's wireless termination point is fixed in location.)
- Wi-Fi is a shorter range system, typically hundreds of meters, that uses unlicensed spectrum to provide access to a network, typically covering only the network operator's own property. Typically Wi-Fi is used by an end user to access their own network, which may or may not be connected to the Internet. If WiMAX provides services analogous to a cellphone, Wi-Fi is more analogous to a cordless phone.
- WiMAX and Wi-Fi have quite different Quality of Service (QoS) mechanisms. WiMAX uses a mechanism based on setting up connections between the Base Station and the user device. Each connection is based on specific scheduling algorithms, which means that QoS parameters can be guaranteed for each flow. Wi-Fi has introduced a QoS mechanism similar to fixed Ethernet, where packets can receive different priorities based on their tags. This means that QoS is relative between packets/flows, as opposed to guaranteed.
- WiMAX is highly scalable from what are called "femto"-scale remote stations to multi-sector 'maxi' scale base that handle complex tasks of management and mobile handoff functions and include MIMO-AAS smart antenna subsystems.

<u>WIMAX Spectrum allocation issues</u>

The 802.16 specification applies across a wide swath of the RF spectrum, and WiMAX could function on any frequency below 66 GHz, (higher frequencies would decrease the range of a Base Station to a few hundred meters in an urban environment).

There is no uniform global licensed spectrum for WiMAX, although the WiMAX Forum has published three licensed spectrum profiles: 2.3 GHz, 2.5 GHz and 3.5 GHz, in an effort to decrease cost: economies of scale dictate that the more WiMAX embedded devices (such as mobile phones and WiMAX-embedded laptops) are produced, the lower the unit cost. (The two highest cost components of producing a mobile phone are the silicon and the extra radio needed for each band.) Similar economy of scale benefits apply to the production of Base Stations.

In the unlicensed band, 5.x GHz is the approved profile. Telecom companies are unlikely to use this spectrum widely other than for backhaul, as they do not own and control the spectrum.

Since October 2007, the Radiocommunication Sector of the International Telecommunication Union (ITU-R) has decided to include WiMAX technology in the IMT-2000 set of standards. This enables spectrum owners (specifically in the 2.5-2.69 GHz band at this stage) to use Mobile WiMAX equipment in any country that recognizes the IMT-2000.

A commonly-held misconception is that WiMAX will deliver 70 Mbit/s over 50 kilometers. In reality, WiMAX can do one or the other — operating over maximum range (50 km) increases bit error rate and thus must use a lower bitrate. Lowering the range allows a device to operate at higher bitrates.

Mobile WiMAX networks are usually made of indoor "*customer premises equipment*" (CPE) such as desktop modems, laptops with integrated Mobile WiMAX or other Mobile WiMAX devices. Mobile WiMAX devices typically have an omni-directional antenna which is of lower-gain compared to directional antennas but are more portable. In practice, this means that in a line-of-sight environment with a portable Mobile WiMAX CPE, speeds of 10 Mbit/s at 10 km could be delivered. However, in urban environments they may not have line-of-sight and therefore users may only receive 10 Mbit/s over 2 km. Higher-gain directional antennas can be used with a Mobile WiMAX network with range and throughput benefits but the obvious loss of practical mobility.

Like most wireless systems, available bandwidth is shared between users in a given radio sector, so performance could deteriorate in the case of many active users in a single sector. In practice, many users will have a range of 2-, 4-, 6-, 8-, 10- or 12 Mbit/s services and additional radio cards will be added to the base station to increase the capacity as required.

Because of this, various granular and distributed network architectures are being incorporated into WiMAX through independent development and within the 802.16j mobile multi-hop relay (MMR) task group. This includes wireless mesh, grids, network remote station repeaters which can extend networks and connect to backhaul.

The WiMAX Forum is the organization dedicated to certifying the interoperability of WiMAX products. Those that pass conformance and interoperability testing achieve the "WiMAX Forum Certified" designation and can display this mark on their products and marketing materials. Some vendors claim that their equipment is "WiMAX-ready", "WiMAX-compliant", or "pre-WiMAX", if they are not officially WiMAX Forum Certified.

WiMAX Spectrum Owners Alliance

WiSOA is the first global organization composed exclusively of owners of WiMAX spectrum with plans to deploy WiMAX technology in those bands. WiSOA is focused on the regulation, commercialization, and deployment of WiMAX spectrum in the 2.3–2.5 GHz and the 3.4–3.5 GHz ranges. WiSOA are dedicated to educating and informing its members, industry representatives and government regulators of the importance of WiMAX spectrum, its use, and the potential for WiMAX to revolutionize broadband.

WIMAX competing technologies

Speed vs. Mobility of wireless systems: Wi-Fi, HSPA, UMTS, GSM

Within the marketplace, WiMAX's main competition comes from existing widely deployed wireless systems such as UMTS and CDMA2000, as well as a number of Internet oriented systems such as HIPERMAN and WiBro.

3G cellular phone systems usually benefit from already having entrenched infrastructure, being upgraded from earlier systems. Users can usually fall back to older systems when they move out of range of upgraded equipment, often relatively seamlessly.

The major cellular standards are being evolved to so-called 4G, high bandwidth, low latency, all-IP networks with voice services built on top. With GSM/UMTS, the move to 4G is the 3GPP Long Term Evolution effort. For AMPS/TIA derived standards such as CDMA2000, a replacement called Ultra Mobile Broadband is under development. In both cases, existing air interfaces are being discarded, in favour of OFDMA for the downlink and a variety of OFDM based solutions for the uplink, much akin to WiMAX.

In some areas of the world the wide availability of UMTS and a general desire for standardization has meant spectrum has not been allocated for WiMAX: in July 2005, the EU-wide frequency allocation for WiMAX was blocked.

Mobile Broadband Wireless Access

Mobile Broadband Wireless Access (MBWA) is a technology being developed by IEEE 802.20 and is aimed at wireless mobile broadband for operations from 120 to 350 km/h. The 802.20 standard committee was first to define many of the methods which were later funneled into Mobile WiMAX, including high speed dynamic modulation and similar scalable OFDMA capabilities. It apparently retains fast hand-off, Forward Error Correction (FEC) and cell edge enhancements.

The Working Group was temporarily suspended in mid 2006 by the IEEE-SA Standards Board since it had been the subject of a number of appeals, and a preliminary investigation of one of these "revealed a lack of transparency, possible 'dominance,' and other irregularities in the Working Group".

In September 2006 the IEEE-SA Standards Board approved a plan to enable the working group to continue under new conditions, and the standard is now expected to be finalized by Q2 2008.

Internet-oriented systems

Early WirelessMAN standards, the European standard HIPERMAN and Korean standard WiBro have been harmonized as part of WiMAX and are no longer seen as competition but as complementary. All networks now being deployed in South Korea, the home of the Wibro standard, are now WiMAX.

As a short-range mobile Internet solution, such as in cafes and at transportation hubs like airports, the popular Wi-Fi 802.11b/g system is widely deployed, and provides enough coverage for some users to feel subscription to a WiMAX service is unnecessary.

HiperMAN stands for **High Performance Radio Metropolitan Area Network** and is a standard created by the European Telecommunications Standards Institute (ETSI) Broadband Radio Access Networks (BRAN) group to provide a wireless network communication in the 2 - 11 GHz bands across Europe and other countries which follow the ETSI standard.[1] HiperMAN is a European alternative to WiMAX (or the IEEE 802.16 standard) and the Korean technology WiBro.

HiperMAN is aiming principally for providing broadband Wireless DSL, while covering a large geographic area. The standardization focuses on broadband solutions optimized for access in frequency bands below 11 GHz (mainly in the 3.5 GHz band). HiperMAN is optimised for packet switched networks, and supports fixed and nomadic applications, primarily in the residential and small business user environments.

HiperMAN will be an interoperable broadband fixed wireless access system operating at radio frequencies between 2 GHz and 11 GHz.[2] The HiperMAN standard is designed for Fixed Wireless Access provisioning to SMEs and residences using the basic MAC (DLC and CLs) of the IEEE 802.16-2001 standard. It has been developed in very close cooperation with IEEE 802.16,[3] such that the HiperMAN standard and a subset of the IEEE 802.16a-2003 standard will interoperate seamlessly. HiperMAN is capable of supporting ATM, though the main focus is on IP traffic. It offers various service categories, full Quality of Service, fast connection control management, strong security, fast adaptation of coding, modulation and transmit power to propagation conditions and is capable of non-line-of-sight operation. HiperMAN enables both PTMP and Mesh network configurations. HiperMAN also supports both FDD and TDD frequency allocations and H-FDD terminals. All this is achieved with a minimum number of options to simplify implementation and interoperability.

WiBro (**Wi**reless **Bro**adband) is a wireless broadband Internet technology being developed by the South Korean telecoms industry. WiBro is the South Korean service name for IEEE 802.16e (mobile WiMAX) international standard.

WiBro adapts TDD for duplexing, OFDMA for multiple access and 8.75 MHz as a channel bandwidth. WiBro was devised to overcome the data rate limitation of mobile phones (for example CDMA 1x) and to add mobility to broadband Internet access (for example ADSL or Wireless LAN). In February 2002, the Korean government allocated 100 MHz of electromagnetic spectrum in the 2.3 - 2.4 GHz band, and in late 2004 WiBro Phase 1 was standardized by the TTA of Korea and in late 2005 ITU reflected WiBro as IEEE 802.16e (mobile WiMAX). Two South Korean Telco (KT, SKT) launched commercial service in June 2006, and the tariff is around 30 US$.

WiBro base stations will offer an aggregate data throughput of 30 to 50 Mbit/s and cover a radius of 1-5 km allowing for the use of portable internet usage. In detail, it will provide mobility for moving devices up to 120 km/h (74.5 miles/h) compared to Wireless LAN having mobility up to walking speed and Mobile Phone having mobility up to 250 km/h. From testing during the APEC Summit in Busan in late 2005, the actual range and bandwidth were quite a bit lower than these numbers. The technology will also offer Quality of Service. The inclusion of QoS allows for WiBro to stream video content and other loss-sensitive data in a reliable manner. These all appear to be (and may be) the stronger advantages over the fixed WiMAX standard (802.16a). Some Telcos in many countries are trying to commercialize this Mobile WiMAX (or WiBro). For example, TI (Italia), TVA (Brazil), Omnivision (Venezuela), PORTUS (Croatia), and Arialink (Michigan) will provide commercial service after test service around 2006-2007. While WiBro is quite exacting in its requirements from spectrum use to equipment design, WiMAX leaves much of this up to the equipment provider while providing enough detail to ensure interoperability between designs.

3. Cellular Communications GSM, GPRS, EDGE

3.1 GSM

Global System for Mobile communications (**GSM**: originally from *Groupe Spécial Mobile*) is the most popular standard for mobile phones in the world. Its promoter, the GSM Association, estimates that 82% of the global mobile market uses the standard. GSM is used by over 3 billion people across more than 212 countries and territories. Its ubiquity makes international roaming very common between mobile phone operators, enabling subscribers to use their phones in many parts of the world. GSM differs from its predecessors in that both signalling and speech channels are digital, and thus is considered a *second generation* (2G) mobile phone system. This has also meant that data communication was easy to build into the system.

The ubiquity of the GSM standard has been advantageous to both consumers (who benefit from the ability to roam and switch carriers without switching phones) and also to network operators (who can choose equipment from any of the many vendors implementing GSM). GSM also pioneered a low-cost alternative to voice calls, the Short message service (SMS, also called "text messaging"), which is now supported on other mobile standards as well. Another advantage is that the standard includes one worldwide Emergency telephone number, 112. This makes it easier for international travellers to connect to emergency services without knowing the local emergency number.

Newer versions of the standard were backward-compatible with the original GSM phones. For example, Release '97 of the standard added packet data capabilities, by means of General Packet Radio Service (GPRS). Release '99 introduced higher speed data transmission using Enhanced Data Rates for GSM Evolution (EDGE).

3.2 UMTS

Universal Mobile Telecommunications System (UMTS) is one of the **third-generation (3G)** cell phone technologies, which is also being developed into a 4G technology. Currently, the most common form of UMTS uses W-CDMA as the underlying air interface. It is standardized by the 3GPP, and is the European answer to the ITU IMT-2000 requirements for 3G cellular radio systems.

To differentiate UMTS from competing network technologies, UMTS is sometimes marketed as **3GSM**, emphasizing the combination of the 3G nature of the technology and the GSM standard which it was designed to succeed.

4G (also known as **Beyond 3G**), an abbreviation for **Fourth-Generation Communications System**, is a term used to describe the next complete evolution in *wireless communications*. A 4G system will be able to provide a comprehensive IP solution where voice, data and streamed multimedia can be given to users on an "Anytime, Anywhere" basis, and at higher data rates than previous generations.

As the second generation was a total replacement of the first generation networks and handsets; and the third generation was a total replacement of second generation networks and handsets; so too the fourth generation cannot be an incremental evolution of current 3G technologies, but rather the total replacement of the current 3G networks and handsets. The international telecommunications regulatory and standardization bodies are working for commercial deployment of 4G networks roughly in the 2012-2015 time scale. At that point it is predicted that even with current evolutions of third generation 3G networks, these will tend to be congested.

There is no formal definition for what 4G is; however, there are certain objectives that are projected for 4G. These objectives include: that 4G will be a fully IP-based integrated system. This will be achieved after wired and wireless technologies converge and will be capable of providing between 100 Mbit/s and 1 Gbit/s speeds both indoors and outdoors, with premium quality and high security. 4G will offer all types of services at an affordable cost.

Many companies have taken self-serving definitions and distortions about 4G to suggest they have 4G already in existence today, such as several early trials and launches of WiMax, which is part of the formal ITU standard for 3G. Other companies have made prototype systems calling those 4G. While it is possible that some currently demonstrated technologies may become part of 4G, until the 4G standard or standards have been defined, it is impossible for any company currently to provide with any certainty wireless solutions that could be called 4G cellular networks that would conform to the eventual international standards for 4G. These confusing statements around "existing" 4G have served to confuse investors and analysts about the wireless industry.