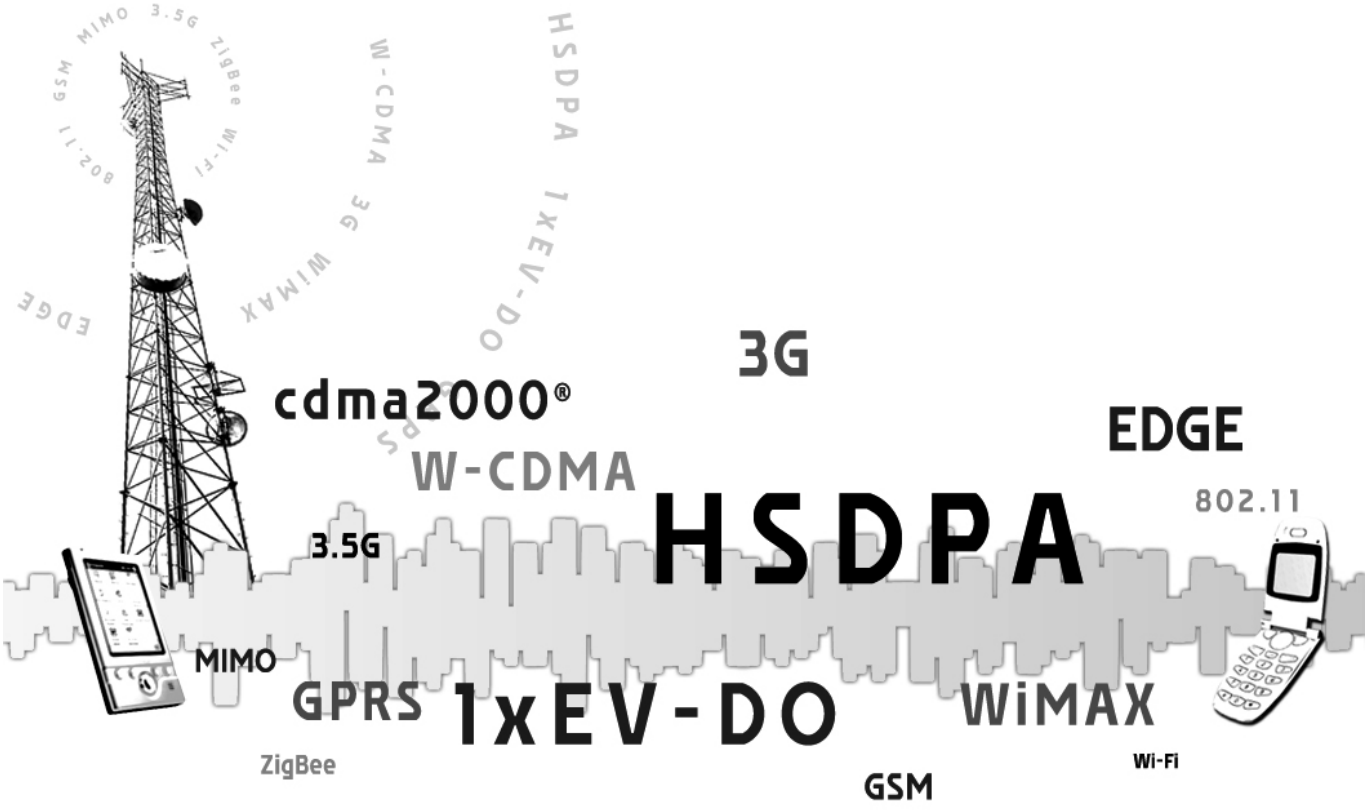
Anritsu

Must-Have Reference

For Wireless Communication



Understanding Wireless Telecom and Data Communications Terminology

The Must-Have Reference for Wireless Communication

This reference will help you understand the terminology associated with wireless telecom and data communications to let you make more informed decisions about new technology, products, and services. In addition, it shows which Anritsu products provide test and measurement solutions in each area. Some of the terms referenced here go beyond wireless applications and are explained in Anritsu Company's *Must-Have Reference For IP and Next Generation Networking*. Furthermore, the online version of this document is updated frequently and may contain new terminology or more recent information. Both reference documents plus an overview of Anritsu wireless test and measurement products are available at www.us.anritsu.com/wireless.

Wireless Telecom Technology (Part 1)

Wireless Technology	**CDMA IS-95**	**cdma2000® 1xRTT**	**cdma2000 1xEV-DO**	**cdma2000 1xEV-DV**	**TDMA**
Wireless Standard	TIA/EIA/IS-95A, TIA/EIS IS-95B	TIA/EIA/IS-2000 www.3gpp2.org	TIA/EIA/IS-856 www.3gpp2.org	TIA/EIA/IS-2000 Releases C & D www.3gpp2.org	TIA/EIA-136 www.tiaonline.org
US Operators	Verizon Wireless Sprint PCS	Verizon ("National Access") Sprint PCS Leap Wireless	Verizon ("Broadband Access")	Sprint (planned)	Cingular (AT&T)
Upgrade Path	cdma2000 1xRTT	cdma2000 1xEV-DO			GSM GPRS EDGE
Frequency Range (MHz)	824-894 1850-1990	495 824-894 1850-1990	(same as 1xRTT)	(same as 1xRTT)	824-894 1850-1990
Channel Bandwidth	1.25 MHz (1.23 MHz carrier)	1.25 MHz (1.23 MHz carrier)	1.25 MHz (1.23 MHz carrier)	1.25 MHz (1.23 MHz carrier)	30 kHz
Data Rate	14.4 kbps	144-307 kbps	Rev.0: 2.4 Mbps (down) 153.6 kbps (up)	3.09 Mbps (down) 153.6 kbps (up)	9.6-19.2 kbps
Generation	2G (IS-95A) 2.5G (IS-95B)	2.5G	3G	3G	2G
Relevant Anritsu Test and Measurement Products					
Mobile Unit or Base Station	MS8608A MS8609A MS2681A/83A/87B MS2721A MS2711D MT8212B S332D MG3700A	MS8608A MS8609A MS2681A/83A/87B MS2721A MS2711D MT8212B S332D MG3700A	MS8608A MS8609A MG3681A ML2480A MS2681A/83A/87B MS2721A MS2711D MT8212B S332D MG3700A	MS2721A MS2711D MT8212B S332D MG3700A	MS8608A MS8609A MS2681A/83A/87B MS2721A MS2711D MT8212B S332D MG3700A
Mobile Unit Only	MT8820A MT8815A CRCA Software MA8120C	MT8820A MT8815A MA8120C	MT8820A MT8815A MA8120C	MA8120C	MT8815A CRCA Software MA8120C

cdma2000® is a registered trademark of the Telecommunications Industry Association (TIU-USA). When applied to goods and services, the cdma2000® mark certifies their compliance with cdma2000® standards.

Wireless Telecom Technology (Part 2)

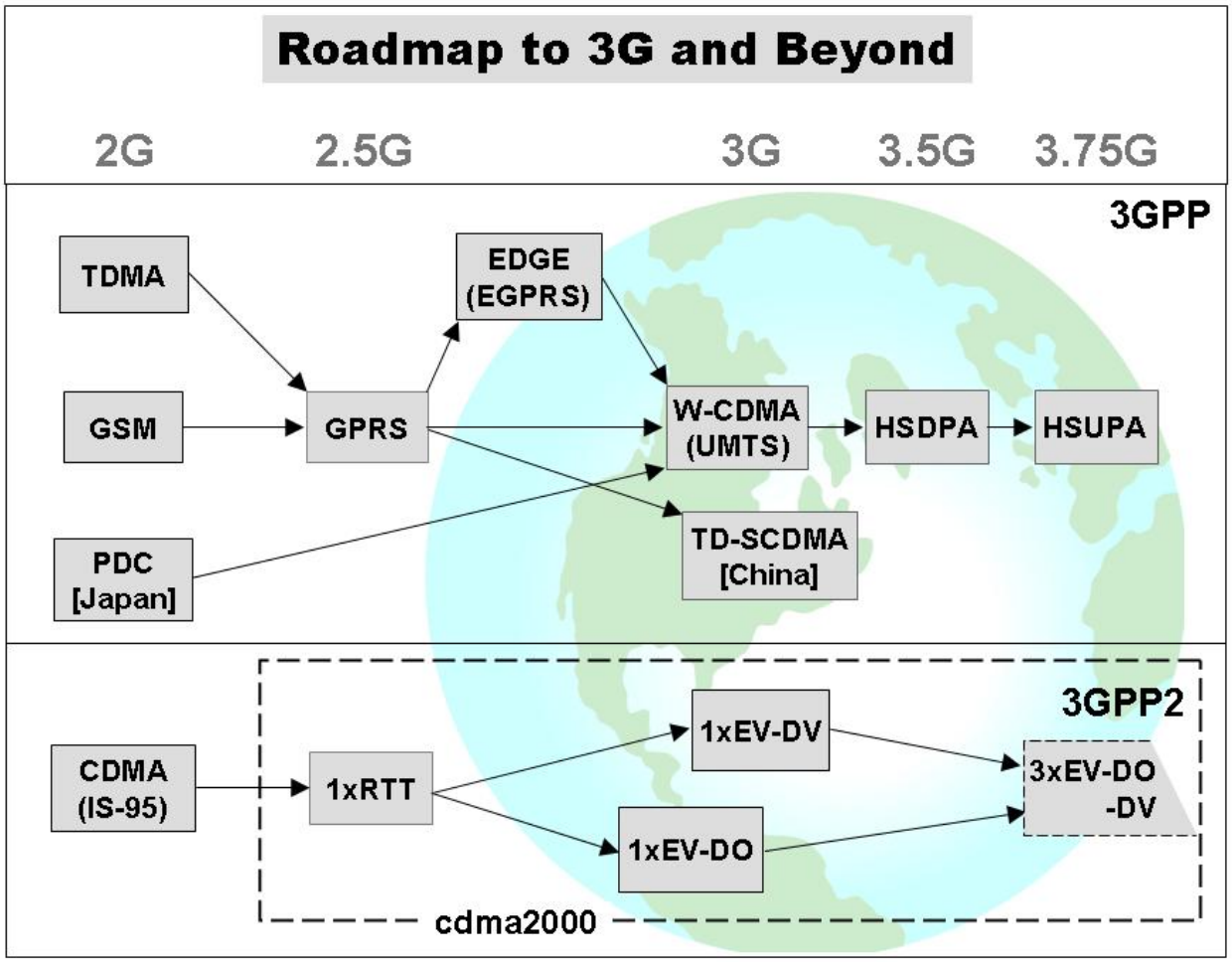
Wireless Technology	GSM	GPRS	EDGE (EGPRS)	W-CDMA (UMTS)	HSDPA	HSUPA
Wireless Standard	GSM 01.01 version 8.0.0 Release 1999 www.3gpp.org	GSM 01.60 version 6.0.0 www.3gpp.org	3GPP TS 43.051 version 5.9.0 Release 5 www.3gpp.org	3GPP Release 99 www.3gpp.org	3GPP Release 5 www.3gpp.org	3GPP Release 6 www.3gpp.org
US Operators	Cingular (AT&T) T-Mobile	Cingular (AT&T) T-Mobile	Cingular (AT&T) T-Mobile		Cingular (planned for late 2005)	Cingular (future)
Upgrade Path	GPRS EDGE W-CDMA	EDGE W-CDMA	W-CDMA	HSDPA	HSUPA	
Frequency Range (MHz)	450-486 824-894 876-960 1710-1880 1850-1990	450-486 824-894 876-960 1710-1880 1850-1990	450-486 824-894 876-960 1710-1880 1850-1990	824-894 830-885 1710-1880 1710-2155 1850-1990 1920-2170	824-894 830-885 1710-1880 1710-2155 1850-1990 1920-2170	824-894 830-885 1710-1880 1710-2155 1850-1990 1920-2170
Channel Bandwidth	200 kHz	200 kHz	200 kHz	5 MHz (3.84 MHz carrier)	5 MHz (3.84 MHz carrier)	5 MHz (3.84 MHz carrier)
Data Rate	9.6-19.2 kbps	44-171.2 kbps	384 kbps max; 120 kbps typ eff throughput	144 kbps-2 Mbps max; 384 kbps typ	14 Mbps max; 10.8 Mbps max eff throughput	5.76 Mbps max
Generation	2G	2.5G	2.5G+	3G	3.5G	3.75G
Relevant Anritsu Test and Measurement Products						
Mobile Unit or Base Station	MS8608A MS8609A MS2681A/83A/87B MS2721A MS2711D MT8212B S251C S332D MG3700A MT8220A	MS8608A MS8609A MS2681A/83A/87B MS2721A MS2711D MT8212B S251C S332D MG3700A MT8220A	MS8608A MS8609A MS2681A/83A/87B MS2721A MG3681A ML2480A MS2711D MT8212B S251C S332D MG3700A MT8220A	MS8608A MS8609A MS2681A/83A/87B MS2721A MG3681A ML2480A ML8721B (BS only) MS2711D MT8212B S332D MG3700A MS2781A MT8220A	MS8608A MS8609A MG3681A MG3700A MT8220A	
Mobile Unit Only	CRCA Software MT8820A MT8815A MT8510B MA8120C	MT8820A MT8815A MA8120C	MT8820A MT8815A MA8120C	ME7873A MT8820A MT8815A MT8510B PTS Software RTD Software MD8480B MA8120C	MD8480C MT8820A MT8815A MA8120C	MA8120C

Wireless Datacom Technology

Wireless Technology	IEEE 802.15.1 *Bluetooth*®	IEEE 802.11a Wi-Fi	IEEE 802.11b Wi-Fi	IEEE 802.11g Wi-Fi	IEEE 802.16d WiMAX
Wireless Standard	www.bluetooth.org	www.Ieee.org/11	www.Ieee.org/11	www.Ieee.org/11	www.ieee802.org/16
Frequency Range	2.402-2.480 GHz	5.150-5.825 GHz	2.4 GHz	2.4 GHz	2-11 GHz
Channel Bandwidth	1 MHz	20 MHz	10-30 MHz	25 MHz	1.25-20 MHz
Max Link Length	10 m	60-100 ft	150-300 ft		31 mi
Data Rate	v1: 1 Mbps v2: 3 Mbps	Up to 54 Mbps; 1-2 Mbps throughput common	Up to 11 Mbps; 8-10 Mbps throughput common	Up to 54 Mbps	Up to 75 Mbps
Relevant Anritsu Test and Measurement Products					
Mobile Unit or Base Station	MS2681A/83A/87B ML2480A MT8850A MT8852A ME7865A MA8120C	MT8860A MS8608A MS8609A MS2681A/83A/87B MS2721A ML2480A S332D+FCN4760 MS2711D+FCN4760 MG3700A	MT8860A MS8608A MS8609A MS2681A/83A/87B MS2721A ML2480A MS2711D MT8212B S332D MG3700A	MT8860A MS8608A MS8609A MS2681A/83A/87B MS2721A ML2480A MS2711D MT8212B S332D MG3700A	MS2721A MG3700A
Mobile Unit Only	[Not applicable]		MA8120C	MA8120C	MA8120C

The *Bluetooth* word mark and logos are owned by the Bluetooth SIG, Inc. and any use of such marks by Anritsu is under license. Other trademarks and trade names are those of their respective owners

The Must-Have Reference for Wireless Communication



Terms and Mnemonics

1G First Generation Cellular Wireless

The first generation of cellular wireless (1G) was based on analog technology. The systems were designed only to carry voice technology.

1xEV-DO 1x Evolution Data Only

1xEV-DO (cdma2000) is a 3G mobile standard that is the next EVolution of cdma2000 (1xRTT), intended to provide powerful data transmission capabilities for mobile phones using a second 1.25 MHz channel exclusively for non-real time data applications. 1xEV-DO is a TDMA technology. Multiple users are supported by giving all available radio link power to users one at a time. It is not backward compatible to 1xRTT and does not support voice.

Most cdma2000 network operators are expected to combine 1x and 1xEV-DO channels in their systems to provide varying voice and data capacities as required by customer demand. Qualcomm was originally driving this standard. Verizon began deploying 1xEV-DO service trials in 2003, and 1xEV-DO had 4.2 million subscribers at the end of 2003. Verizon expects to offer a version of 1XEV-DO service to in-flight airline passengers in 2007, based on trials begun in 2004 with peak speeds of 2.4 Mbps.

Rev. 0 provides a peak data rate of 2.4 Mbps downstream and 153.6 kbps upstream, although actual downstream rates are often 300-600 kbps. It uses adaptive coding and modulation based on radio conditions: QPSK, 8-PSK, or 16QAM.

Rev. A (or 1xEV-DOrA) increases peak data rates to 3.1 Mbps downstream and 1.8 Mbps upstream, enabling more applications and improving capabilities for services such as VoIP and video calling. It also adds QoS, important for VoIP,

and multicast capabilities, important for live video streaming. Rev. A has 1.2 times the Rev. 0 sector capacity on the forward link and 2.0 times the sector capacity on the reverse link within the same 1.25 MHz, supporting more users. It is fully backward compatible and interoperable with Rev. 0 systems. First Rev. A chipset samples were available in April 2005, with likely availability for carrier services to be launched in 2006.

Rev. B, whose definition will not likely be completed until late 2006, proposes multiple carriers to improve bandwidth, somewhat like HSDPA.

1xEV-DV 1X Evolution Data and Voice

1xEV-DV (cdma2000) is a 3G mobile standard that promises to provide data-rate speeds of 1.2 Mbps for mobile users, with peak data speeds up to 5.2 Mbps for stationary users. It is a true CDMA technology that integrates voice and simultaneous high-speed packet data multimedia services on the same frequency channel, based on a combination of 1xRTT and 1xEV-DO technologies. It uses adaptive coding and modulation based on radio conditions: QPSK, 8-PSK, or 16QAM.

Nokia and Motorola were key backers of this standard. Sprint originally proposed this service for 2005-2006. There is some recent lack of interest in pursuing 1xEV-DV quickly, however, due to the improved performance of 1xEV-DO Rev. A. Also, both base and mobile stations need significant enhancements to support dynamic decisions and higher speeds, requiring the BTS to dynamically allocate the radio link power.

1xRTT 1X Radio Transmission Technology

1xRTT indicates cdma2000, the next generation of standard CDMA that offers between 1.5 and 2 times the number of voice channels as a standard CDMA system – see cdma2000. It has peak data rates of 153 kbps and backwards compatibility with cdmaOne networks. 1x stands for one times 1.25 MHz carrier, as used in 2G CDMA. RTT stands for Radio Transmission Technology. cdma2000 1x is 21 times more efficient than analog cellular and 4 times more efficient than TDMA networks. 1xRTT provides for a 307.2 kbps peak data rate in both the downstream and upstream directions. Multiple users are supported by distributing the available radio link power among them all.

2G Second Generation Cellular Wireless

2G cellular wireless technology converts voice to digital data for transmission over the air and then back to voice. Most 2G systems provide 9.6-14.4 Kbps circuit-switched data service.

2.5G Enhanced Second Generation Cellular Wireless

2.5G refers to technology that is added to a 2G network to provide packet-data service. In practice, 2.5G is synonymous with the GPRS technology that has been added to GSM networks, defined by 3GPP Release 97 (see 3GPP).

3G Third Generation Cellular Wireless

3G systems have been designed for both voice and data. By International Telecommunications Union (ITU) definition, 3G systems must provide a minimum of 144 kbps packet-data service. Regarding 3G Release specifications, see 3GPP.

3.5G Enhanced Third Generation Cellular Wireless

3.5G refers to evolutionary upgrades to 3G services starting in 2005-2006 that provide significantly enhanced performance. High Speed Downlink Packet Access is expected to become the most popular 3.5G technology (see HSDPA).

3.99G

See Super 3G.

3GPP Third Generation Partnership Project

3GPP is a global body dedicated to developing 3G specifications. In 1997-98, Nokia was active in establishing 3GPP as the organization for developing global 3G standards based on W-CDMA technology. Specifications for W-CDMA radio access networks were rapidly established and in 2000, Nokia promoted the transfer of GSM/EDGE standardization to 3GPP. The first commercial W-CDMA products were released based on the 3GPP Release 99. Standardization continues with Releases 4, 5, 6, and 7.

3GPP standard releases, also referred to as UMTS or GSM/EDGE releases, are described on the 3GPP Specifications Web page. These include:

Release 97 or R97 (1997)	Introduced GPRS for delivering data over GSM.
Release 99 or R99 (1999)	First release of the 3G UMTS standard, including W-CDMA.
Release 4 or Rel-4 (2001)	Introduced separate circuit switched and packet switched domains. Introduced EDGE.
Release 5 or Rel-5 (Mar'03)	Introduced IMS as the packet domain control structure. Updated GSM

	specifications. Introduced HSDPA. (See IMS, HSDPA.)
Release 6 or Rel-6 (Dec'04-Mar'05)	Enhances IMS specifications, including QoS improvements.
Release 7	Definition started in mid-2005. Will add to IMS specifications.

3GPP2 Third Generation Partnership Project 2

3GPP2 is a collaborative Third Generation (3G) telecommunications specification-setting project comprising North American and Asian interests on the development of the next generation cdma2000 wireless communications. 3GPP2 is largely based on Qualcomm cdma2000 product standards.

3GSM

3GSM is another name for the W-CDMA 3G standard. (See 3G.)

3GSP 3G Service Provider

A mobile operator that has a 3G license to provide 3G services to customers.

3xEV-DO/DV 3X Evolution Data Only/Data and Voice

Enhanced versions of 1XEV-DO or 1xEV-DV with three channels of data/voice. The details of 3xEV are unclear.

4G Fourth Generation Cellular Wireless

4G technologies are still in the early research stage and no consistent industry definition exists yet. NTT DoCoMo has described technology for a possible future 4G standard based on a 101.5 MHz bandwidth downlink and 40 MHz bandwidth uplink. The downlink scheme uses VSF (Variable Spreading Factor) OFCDM (Orthogonal Frequency and Code Division Multiplexing) with a target data rate over 100 Mbps, and the uplink uses VSF CDMA with a target data rate over 20 Mbps. 4G is likely to include MIMO technologies (see MIMO). NTT does not expect 4G utilization until 2010.

802.11 Wireless LANs (Wi-Fi)

802.11, known as Wi-Fi, defines standards for wireless LANs (WLANs) and was approved in Jul'97. WLANs provide half-duplex (not simultaneous bidirectional) connections that are shared, not switched. IEEE 802.11a and 802.11b (standardized in Sept'99) and 802.11g (standardized in mid-2003) define different physical layer standards for WLANs, and the 802.11 standard offers no provisions for interoperability between these physical layers. Microsoft certification applies to both 802.11a and 802.11b. The IEEE 802.11 Working Group page has helpful information. Toshiba said it shipped the industry's first laptop PC with built-in dual 802.11a/b connectivity in Dec'02. The Wi-Fi Alliance (www.wi-fi.org), previously known as WECA, promotes the standard, tests products for interoperability, and awards the "Wi-Fi" mark to those that past. Wi-Fi Alliance certified over 500 products by November '02. Security is one of the biggest issues with wireless LANs – see WPA and WEP, as well as 802.11i (below).

By the end of 2003, unit shipments of 802.11g interfaces surpassed shipments of 802.11b and continued to grow while 802.11b shipments decline. By the end of 2004, nearly all chip sets being supplied by manufacturers support either 802.11b or a combination of 802.11b/802.11g. An 802.11g device typically uses four times the power of an 802.11b device, so 802.11b is often preferred for mobile units and handheld data terminals. 802.11b implementations are also less expensive, so 802.11b is often used in wireless gaming products and toys.

802.11a

802.11a operates at 5 GHz and provides data rates up to 54 Mbps using OFDM (Orthogonal Frequency Division Multiplexing) modulation, like European digital TV. 802.11a supports a maximum of 24 unique connections per access point, far more than the three connections supported by 802.11b and 802.11g. Compared to 802.11b, 802.11a offers higher (2X-5X) theoretical throughput, more available frequencies, avoiding multipath echoes, but shorter range (60-100 feet). Actual throughput at typical operating distances is often only 1-2 Mbps. 802.11a products did not become available from most U.S. vendors until early 2002.

802.11b

802.11b operates at 2.4 GHz (along with cordless phones and microwave ovens) and provides theoretical data rates up to 11 Mbps over links of 150-300 feet using Direct Sequence Spread Spectrum (DSMM) modulation. Actual throughput is typically never more than 5 Mbps. 802.11b supports a maximum of three unique connections per access point, and 802.11b-compatible products were the first ones to become available in the U.S. Regarding 802.11a vs. 802.11b, Wi-Fi Planet has a helpful paper on making choices and Linksys has helpful information on the technical differences.

802.11d

Similar to 802.11b with options to adjust frequency, power level, and signal bandwidth for use in countries where the other 802.11 standards are not allowed.

802.11e

Provides QoS (Quality of Service) that will be important for voice and multimedia transmission by describing error correction and bandwidth management to be used in 802.11a and 802.11b. There are two versions. EDCA (Enhanced Digital Control Access) mode, called WME (Wireless Multimedia Extensions), will become available first with certification testing planned starting Sept'04. WME defines eight levels of access priority and provides more access to higher-priority packets than to lower-priority packets but provides no bandwidth guarantees, and is probably best suited for one-way audio. HCCA (HCF Coordinated Channel Access), also known as WSM (Wireless Scheduled Multimedia), is a polled access method that includes WME and provides guaranteed bandwidth scheduling reservations. WSM, with certification testing planned starting Dec'04, is probably best suited for two-way streaming voice and video. The IEEE approved 802.11e in September 2005. Regarding QoS for Voice Over WLAN (VoWLAN), see SpectraLink Voice Priority (SVP). Also see Wi-Fi Multimedia (WMM).

802.11g
802.11g is an extension to 802.11b to provide data rates up to 54 Mbps while operating at 2.4 GHz like 802.11b but using OFDM modulation like 802.11a. Products are expected to have RF interference problems similar to 802.11b. Like 802.11b, 802.11g supports a maximum of three unique connections per access point. The IEEE approved the specification in June '03, and the first products claiming compatibility with the draft standard shipped in Jan'03. In July '03 the Wi-Fi Alliance completed successful interoperability testing of the first products. 802.11 Planet has a helpful tutorial comparing 802.11a with 802.11g.

802.11h
Defines processes that 802.11a systems can use to comply with ITU recommendations for avoiding conflict with other users of the 5 GHz spectrum such as military radar systems. These processes include DFS (Dynamic Frequency Selection), for using channels uniformly and avoiding channel conflict; and TPC (Transmit Power Control), for reducing the radio transmit power of Wi-Fi devices. See TPC.

802.11i
A standard approved in June'04 that provides security enhancements based on WPA, TKIP, and AES. AES is the new U.S. Government data encryption standard and is far more secure than WPA, the previous 802.11 security mechanism. 802.11i incorporates key management and authentication, and may eventually replace WEP and WPA for WLAN security. The Wi-Fi Alliance planned to start certifying 802.11i products in September'04 under the name "WPA2", indicating that the security is enhanced relative to WPA. 802.11i includes provisions for fast authentication needed to enable practical Voice Over Wireless LAN (VoWLAN) operation.

802.11j
A standard approved in Nov'04 that adds the 4.9 GHz band to the 5 GHz frequency band available for 802.11a networks. 4.9 GHz is not available in the U.S. but is important for Japan, although the IEEE insists that the "j" in 802.11j does not stand for "Japan". In the U.S. the FCC has allocated this same band for use related to public safety and homeland security.

802.11k
A proposed standard to improve WLAN traffic distribution by optimizing channel selection, roaming decisions, and transmit power so that a wireless device does not necessarily connect to the access point having the strongest signal. It defines Layer 1 and Layer 2 statistics that wireless clients report to WLAN switches and access points. Software implementation should allow upgrading existing equipment to support 802.11k. An 802.11k first draft was published in March'04, but progress has slowed and various proprietary solutions, including Cisco CCX, are available (see CCX).

802.11n
A standard in development to provide WLANs with at least 100 Mbps throughput, measured at the interface between the 802.11 media-access control (MAC) and higher layers. Speeds up to 300-600 Mbps are theoretically possible. 802.11n is founded on Multiple-Input Multiple-Output technology (see MIMO) and OFDM modulation. The IEEE began debating various proposals in Sept'04. TGn Sync and WWiSE were alliances of major companies with different proposals; see WWiSE and TGn Sync. A different group of at least 26 vendors called Enhanced Wireless Consortium (EWC) – including Atheros, Broadcom, Intel, and Marvell – converged late in the process and proposed a PHY layer with actual throughput up to 100 Mbps and interoperability with 802.11a/b/g that was accepted in Jan'06 as the basis for 802.11n. Some pre-standard products are shipping now, but ratification of the standard and standards-based products are unlikely before 2007.

802.11p
A working group that is developing extensions applicable to automobiles in the 5.9 GHz spectrum allocated to vehicles. Considerations include better security, mobile operation, identification, and a more sophisticated handoff system. 802.11p will be the basis of DSRC (Dedicated Short Range Communications), a system intended for communications from one vehicle to another or to a roadside network. See DSRC.

802.11r

A “fast roaming” initiative started in 2004 to avoid re-authentication when transitioning to a new access point so that roaming applications such as VoIP calls made over wireless LANs (VoWLAN) work without interruption. 802.11r ratification is not expected before late 2006. Meanwhile, vendors including 3Com and Cisco have developed and shipped products with proprietary fast roaming mechanisms.

802.11s
An initiative started in 2004 to allow access points to route data to other access points, somewhat like the way that IP routers operate in wired networks. Objectives include the use of routing to avoid failed access points and to balance traffic loading.

802.11v
An initiative for wireless LAN management that began in early 2005, with a 2008 completion target. 802.11v is expected to address identifying networks that a client can connect to, load balancing and other network optimizations, minimizing management traffic and reducing power consumption on portable devices, and statistics handling. Also see CAPWAP.

802.15 Wireless Personal Area Networking (WPAN)

The IEEE Wireless Overview Web site is helpful to explain what is happening in this area.

802.15.1 – *Bluetooth*®
Bluetooth wireless technology enabled devices are intended for short-range links between computers, personal digital assistants, mobile phones, printers, digital cameras, keyboards, and other PC peripherals. Version 2.0, which is backward compatible with earlier versions, was standardized in June 2004 and provides a maximum data rate of 2.1 Mbps operating in a total bandwidth of 3 Mbps (see EDR). Apple was the first to incorporate v2.0 in a computer (PowerBook, early 2005). The original standard allowed a maximum data rate of 721 kbps in a 1 Mbps bandwidth, operating at 2.4 GHz over a range of up to 10 meters. The 1 Mbps data rate was a serious limitation preventing this technology from acting as a USB replacement except for very low-speed peripherals and limiting multimedia applications. The Bluetooth.com and Bluetooth.org sites have helpful information.

802.15.3
IEEE task group planning a standard for high rate WPANs with 11-55 Mbps data rates. In addition to high speed, the new standard will provide for low power, low cost solutions addressing the needs of portable consumer digital imaging and multimedia applications.

802.15.3a
An IEEE task group begun in January 2003 to develop high data rate UWB standards, but terminated in January 2006. One result was the consolidation of 23 UWB PHY specifications into two proposals: Multiband Orthogonal Frequency Division Multiplexing (MB-OFDM) UWB, supported by the WiMedia Alliance, and direct sequence-UWB (DS-UWB), supported by the UWB Forum. See UWB and WiMedia.

802.15.4 – ZigBee
This addresses the low cost and low power needs that remote monitoring and control and sensory network applications have, including the ability to run for years on standard batteries. Applications include industrial control, home automation, and commercial building control. 802.15.4 products, first expected in early 2005, operate with rates up to 250 Kbps in the unlicensed bands that include 2.4 GHz globally, 915 MHz in the Americas, and 868 Mhz in Europe. The ZigBee Alliance is promoting this technology, and completed the ZigBee 1.0 specification in Dec’04. In mid-2005 In-Stat forecasted growth to over 150 million units by 2009.

802.16 WiMAX (Worldwide Interoperability for Microwave Access)

This IEEE standard defines broadband wireless for the metropolitan area. Intel predicts WiMAX will be applied to “last mile” wireless alternatives to wired broadband services such as DSL and cable (2005-2006), mobile connections in large WiMAX hot zones (2006-2007), and full roaming not limited to hot zones (2007-2008). Another application is backhaul connections for Wi-Fi, delivering additional bandwidth to WLAN hotspots. Currently WiMAX, which is based on 802.16, supports data rates up to 75 Mbps over the 2-11 GHz frequency range using a channel bandwidth up to 20 MHz using QAM (16QAM or 64QAM) or QPSK (OFDM) modulation. WiMAX was planned from the beginning to be compatible with European standards. Besides wired alternative such as cable and fiber, market competition includes the newer high-performance 3G/3.5G wireless protocols such as 1xEV-DO and HSDPA. Also see MIMO and HIPERMAN.

The WiMAX Forum of over 100 companies was established in 2001 by Nokia, Ensemble Communications, and the Orthogonal Frequency Division Multiplexing Forum. The WiMAX Forum now works to promote deployment of broadband wireless access networks based on 802.16 and to certify product interoperability, planning to begin certifying 3.5 GHz radios in Q3’2005. The WiMAX Trends website shows WiMAX business and technology news and events. By April 2005, Intel, Fujitsu, and Texas Instruments had announced chip sets supporting WiMAX. At least 13 carriers around the world are currently deploying fixed WiMAX networks.

802.16 This initial version, approved in Dec'01, operates in the 10-66 GHz frequency band with line-of-sight towers to fixed locations.

802.16a Ratified in Jan'03, 802.16a does not require line-of-sight transmission and allows use of lower 2-11 GHz frequencies for both fixed and portable applications. It claims up to a 30-mile range and up to 75 Mbps data transfer (at 20 MHz channelization) that can support thousands of users, plus improved latency and per-connection QoS features. A typical cell radius is probably 3-5 miles. 802.16a provides selectable channel bandwidths from 1.25 to 20 MHz with up to 16 logical sub-channels. Interoperability forums have been held, and the first commercial products were expected to ship in 2H'04.

802.16c Approved in Dec'02, this adds 10-66 GHz operation.

802.16d Correctly named 802.16 REVd, this draft updates and replaces 802.16, 802.16a, and 802.16c to incorporate the many amendments associated with them. The official released version of the WiMAX standard for transmission between fixed locations is named **802.16-2004** (June'04). The WiMAX Forum is testing products for compliance, but none was certified by 2005.

802.16e Ratified by the IEEE in December 2005, 802.16e adds regional roaming ("Mobile WiMAX") for broadband wireless applications up to 15 Mbps (at 5 MHz channelization) with a typical cell radius of 1-3 miles. Chips for portable applications should become available in 2006, with first products certified by the WiMAX Forum by late 2006. True mobility (moving between cells at high speed) may be delayed until later. Widespread availability and use of 802.16e technology may be as late as 2009. Also see WiBro.

A key feature distinguishing WiMAX from other wireless technologies is per-flow Quality of Service (QoS), the ability for a client to have several connections that each has its own QoS characteristics. 802.16 defines four kinds of QoS:

- **UGS**: Unsolicited Grant Service, supporting constant bit-rate services such as T1 emulation and VoIP without silence suppression.
- **rtPS**: Real-Time Polling Service, providing irregularly-timed variable-sized packets for MPEG and VoIP with silence suppression.
- **nrtPS**: Non Real-Time Polling Service, supporting consistent variable-sized packets for services such as FTP.
- **BE**: Best Effort Service, for low-priority applications.

802.21

The IEEE 802.21 working group, which began in early 2004, is developing standards and protocols that support mobile communication handover (passing control from one base station to another) and interoperability between similar and dissimilar networks. This work includes 802-type networks such as Wi-Fi (802.11), *Bluetooth* (802.15.1), and WiMAX (802.16) as well as non-802 networks such as those for 2.5G/3G mobile cellular communications. The standard is expected to enable mobile devices to determine when to switch from 802.11 to cdma2000, for example, based on their current radio environment. One goal is to allow VoIP and other office applications to move seamlessly to the field and operate there equally well. No timeframe is established yet for completing this standard.

ACLR Adjacent Channel Leakage Ratio

The ratio of the power leaking to the communication channels adjacent to the carrier wave. This value is used to measure the degree of interference to adjacent communication channels.

AFH Adaptive Frequency Hopping

Adaptive Frequency Hopping improves resistance to radio interference from other unrelated communication devices or from microwave ovens or cordless phones. For example, when two *Bluetooth* wireless technology enabled devices connect under normal circumstances, they establish a frequency hopping scheme across 79 frequency channels in the 2.4 GHz ISM band. AFH aims to improve the performance of a *Bluetooth* connection by identifying channels with high error rates and excluding the use of these channels.

AMPS Advanced Mobile Phone System

The original standard for analog mobile telephony systems widely used in North America, Latin America, Eastern Europe, Australia, and parts of Russia and Asia. AMPS uses narrowband FM modulation with 30 KHz channels, dividing geographic areas into cells where each connection uses a dedicated frequency (around 1000 per cell). Two cells that are not adjacent can use the same frequency for different connections. The digital IS-136 TDMA standard (D-AMPS) provided an evolutionary path from analog AMPS – see D-AMPS. cdma2000 is a dual-mode standard combining analog AMPS and digital CDMA – see cdma2000.

AMR Adaptive Multi Rate

A system used in W-CDMA and GSM to adapt the data rate based on demand.

AN **Access Node**

A point on a network that allows subscribers to access the network.

AP **Access Point**

A station with a radio receiver and transmitter that terminates the radio link to a wireless local area network device. APs can connect wireless LAN users to each other directly, or can connect them indirectly via wired connections to other APs. APs may also provides connections to wired networks.

ARB **Arbitrary Waveform Generator**

Arbitrary waveform generators use digital sampling technology to create complex real-word test signals based on customized waveforms designed in software that are far more complex than simple sine waves or frequency sweeps. The capability of a generator is determined in part by the capability of the ARB memory, which is specified by its storage capacity (in Gigabytes) and speed (in Msamples/second).

AT **Access Terminal**

A cdma2000 1xEV-DO handset used in data-only mode.

AWG **Arbitrary Waveform Generator**

See ARB.

AWGN **Additive White Gaussian Noise**

Noise signal typically used in addition to the desired signal for receiver frame error rate testing. AWGN models the distortion incurred by transmission over a lossy medium by adding a zero-mean Gaussian random value to each bit.

BLER **Block Error Rate**

Bluetooth®

See 802.15.1.

BS **Base Station**

The location of the radio equipment for one or more cells. In 3GPP2, a Base Station comprises a Base Station Controller and one or more Base Transceiver Stations (see BTS).

BTS **Base Transceiver Station**

The termination of a radio interface in a cellular system.

CAPWAP **Control and Provisioning of Wireless Access Points**

An IETF initiative to define standard ways for Wi-Fi APs to exchange information about control, management, and provisioning that will be based on Cisco's LWAPP (Lightweight Access Point Protocol) protocol. Nokia and Airespace (now Cisco) were major proponents. Cisco's CCX is a proprietary protocol with some similar objectives (see CCX). The IEEE 802.11v project is very similar to CAPWAP (see 802.11v).

CCDF **Complementary Cumulative Distribution Function**

CCDF of envelope power is used in digital communications test equipment and shows the cumulative probability of a particular peak-to-average power occurring.

CCX **Cisco-Compatible Extensions**

A proprietary program intended for manufacturers of WLAN devices that allows the devices to take advantage of various Cisco Aironet network features. CCX allows WLAN access points to optimize radio transmissions to each wireless device (client) based on status information sent from the device.

CDMA **Code Division Multiple Access**

CDMA is a spread-spectrum technology that spreads multiple conversations across a wide segment of the spectrum as opposed to splitting a channel into time slots. With CDMA, unique digital spreading codes are used to differentiate subscribers that are simultaneously using the same spectrum – see Orthogonal Variable Spreading Factor (OVSF). The CDMA Development Group Web site has helpful information about CDMA generally. See IS-95.

CDMA 1X WIN

The brand name for a 3G service based on cdma2000 1xEV-DO announced by the Japanese KDDI and Okinawa Cellular Telephone in October 2003.

cdma2000

cdma2000 represents a family of technologies that includes cdma2000 1x and cdma2000 1xEV. cdma2000 1xEV includes 1xEV-DO and 1xEV-DV. cdma2000 services are being implemented in North America and Asia, but not in Europe. cdma2000 was first commercialized in October 2000 in South Korea. cdma2000 is a registered trademark of the Telecommunications Industry Association (TIU-USA). When applied to goods and services, the cdma2000® mark certifies their compliance with cdma2000 standards.

cdma2000 1x or cdma2000 1xMC

cdma2000 1x is the basic cdma2000 technology, and is also known as cdma2000 1xMC (Multi-Carrier). It can use one of up to three separate 1.25 MHz carriers for transmission.

cdma2000 1xEV-DO/1xEV-DV

See 1xEV-DO or 1xEV-DV.

cdmaOne IS-95

cdmaOne is the brand name for IS-95 CDMA technology and was introduced by Qualcomm. cdmaOne provides a family of related services including cellular, PCS and fixed wireless (wireless local loop). See IS-95.

CDP Code Domain Power

Measuring Code Domain Power means measuring the power of each information code in the code channels. This verifies that the various channels are at expected power levels and determines when one code channel is leaking energy into the other channels. The correctness of the transmitted code channel numbers, their powers, and their code lengths should be verified.

DCCH Digital Control Channel

A channel for communications between a mobile phone and the network.

DECT Digital Enhanced Cordless Telecommunications

DECT is a digital wireless technology that originated in Europe for cordless telephones when ETSI defined the DECT standard in January 1988. It is suitable for voice, multimedia, and data networking traffic, including Internet access, and integrates well with other fixed and wireless services such as the PSTN, ISDN, and GSM. DECT is seeing increasing adoption worldwide, including use in wireless offices and wireless telephone lines to homes. In the U.S., DECT gained FCC approval in April 2005, with permission to operate in the 1920-1930 MHz band, as part of a "general reorganization of frequency bands in the U.S." The biggest advantage for DECT cordless phones is operation in a frequency band dedicated to DECT products, avoiding interference with Wi-Fi devices and other phones. It is a radio access technology, not a complete system architecture. The DECTWeb and DECT Forum Web sites have helpful information.

D-AMPS Digital Advanced Mobile Phone System

Original designation of the American standard for digital mobile telephony, used primarily in North America, Latin America, Australia and parts of Russia and Asia. D-AMPS was originally defined by IS-54, using an analog control channel, and is now usually considered to be defined by IS-136, using a digital control channel (see IS-136). D-AMPS was the digital evolution of the AMPS analog mobile telephony system (see AMPS). D-AMPS adds time division multiple access (see TDMA) to AMPS to get three channels for each AMPS channel, tripling the number of calls that can be handled on a channel. Like AMPS, D-AMPS uses frequency ranges within 800 and 900 MHz spectrum. Each provider can use half the 824-849 MHz range for receiving signals from cellular phones and half the 869-894 MHz range for transmitting. The bands are divided into 30 kHz sub-bands that are called channels.

DL Downlink

DMB Digital Multimedia Broadcasting

A system for sending multimedia information such as radio, TV, and data to mobile devices that can operate via satellite (S-DMB) or terrestrial (T-DMB) transmission. T-DMB is an ETSI standard (TS 102 427 and TS 102 428) and uses MPEG-4 coding for video and audio data. It has a practical data rate of 1.06 Mbps in a 1.712 MHz channel and can operate in the VHF-III (for terrestrial) or UHF-L (for satellite) bands using differential QPSK modulation. The U.S. has not allocated these bands so DMB is not available there – Qualcomm's MediaFLO is a proprietary system used instead. The 1seg standard based on ISDB is used in Japan. South Korea started both S-DMB and T-DMB services in 2005; by June 2006 South Korea had 7 TV channels, 13 radio channels, and 8 data channels with approximately one million receivers sold.

The major competitor of this technology is DVB-H (Digital Video Broadcasting – Handheld) – see DVB-H. The Nokia mobiletv website has helpful information comparing DMB and DVB-H.

DMR Digital Mobile Radio

DRM Digital Rights Management

Provisions for managing intellectual property rights (such as copyrights) of material within a digital environment. DRM processes could include protecting material from unauthorized use and managing financial transactions associated with using the material. It could include some form of encryption or digital watermarking for protection. The Open Mobile Alliance is actively involved in DRM standards development (see OMA).

DSRC Dedicated Short Range Communications

A system intended for communications between two vehicles, or from one vehicle to a roadside network. The IEEE and the Armstrong Consulting Web sites have helpful information. See 802.11p.

DVB-H Digital Video Broadcasting – Handheld

DVB-H is one of several alternatives for mobile TV. It adapts the DVB-T (Digital Video Broadcasting – Terrestrial) standard that is widely used for digital video broadcasting to the unique needs of handheld, battery-powered receivers. DVB-H became ETSI standard EN 302304 in November 2004; specifications and other technical data are available on the www.dvb-h.org website. It has a practical data rate of 3.32-13.8 Mbps in an 8 MHz channel, and can operate in 174-230 MHz (VHF-III), 470-830 MHz (UHF-IV/V), or 1.452-1.492 GHz (L) using QPSK, 16QAM, or 64QAM modulation. There is helpful DVB-H information on the Nokia mobiletv website.

The major competitor of this technology is DMB (Digital Multimedia Broadcasting) – see DMB.

EDGE Enhanced Data Rates for Global Evolution

EDGE is a 2.5G technology being promoted by the TDMA and GSM communities that is capable of both voice and 3G data rates. It extends the GPRS 10-50 Kbps service to 100 Kbps or more. Cingular promised a full deployment by around mid-2004, and AT&T is expected to install EDGE technology in 6500 U.S. cities in 2004. Regarding EDGE Release specifications, see 3GPP.

EDR (*Bluetooth*) Enhanced Data Rate

Enhanced Data Rate is a feature of *Bluetooth* v2.0 which was standardized in June 2004. EDR provides a maximum data rate of 2.1 Mbps operating in a total bandwidth of 3 Mbps, reduces power consumption because the transmitter is not active as long, and extends the operating range. The previous maximum data rate was 721 kbps. New devices equipped with EDR retain full backward compatibility with previous *Bluetooth* versions since EDR is an addendum to the existing *Bluetooth* v1.2 specification. See 802.15.1.

EGPRS Enhanced General Packet Radio Service

See EDGE.

EV-DO or EV-DV

See 1xEV-DO, 1xEV-DV, and 3xEV-DO/DV.

EVM Error Vector Magnitude

Used to determine errors and their causes. Error Vector = Measured Vector (actual signal magnitude and phase) – Reference Vector (the ideal signal).

FDD Frequency Division Duplex

See UTRA (Universal Terrestrial Radio Access).

FOMA Freedom of Mobile Multimedia Access

The Japan NTT DoCoMo brand name for 3G services based on W-CDMA.

GCF Global Certification Forum

GCF (gcf.gsm.org) is a partnership between network operators and terminal manufacturers that provides an independent process to ensure global interoperability and other functionality of 2G and 3G mobile wireless terminals. A GCF-certified terminal has been tested to a suite of test cases based on criteria developed by the global standards-making community and validated through the GCF Agreement Group.

GGSN Gateway GPRS Support Node

The interface between a GPRS wireless data network and the Internet or other networks. See SGSN.

GMR GEO (Geostationary Earth Orbit) Mobile Radio

Used for mobile satellite services based on geostationary satellites. GMR is derived from the terrestrial digital cellular standard GSM and supports access to GSM core networks (see GSM).

GPRS GSM Packet Radio Service or General Packet Radio Service

GPRS is an upgrade to a GSM network that adds packet data to the voice network. GPRS uses the same time slots as voice calls and each time slot is capable of approximately 9.6 Kbps of data throughput. A GPRS network that offers 28.8 Kbps down to the phone and 9.6 Kbps from the phone back to the network is using three time slots down and one up. See 3GPP.

GSM Global System for Mobile Communications

GSM is a TDMA digital technology deployed first in Europe. Today 65-70% of all wireless voice networks use GSM technology. GSM uses a combination of Frequency Division Multiple Access (FDMA) and Time Division Multiple Access (TDMA). In FDMA, the 25 MHz band is divided into 125 frequencies of 200 kHz each. One or more of those frequencies are assigned to each base station. In TDMA, each of those frequencies uses 8 time slots. GSM uses GMSK (Gaussian Minimum Shift Keying) modulation. A list of GSM US operators can be found at www.gsmworld.com/roaming/gsminfo/cou_us.shtml. The GSM World Web site has helpful information about GSM generally. Regarding GSM Release specifications, see 3GPP.

H.223 Multiplexing Protocol for Low Bit Rate Multimedia Communication

An ITU standard multiplexing protocol for low bit rate multimedia mobile communication over highly error-prone channels.

H.245 Control Protocol for Multimedia Communication

The ITU standard control protocol used for H.323 (Real Time Multimedia Communications) and H.324 (Low Bit Rate Multimedia Communication) for negotiating the capabilities of the communication channel, and for flow control.

H.263 Video Coding for Low Bit Rate Communication

An ITU standard for compressing video communications such as video conferencing.

H.324 Terminal for Low Bit Rate Multimedia Communication

A suite of ITU standards defining videoconferencing over telephone lines.

HiperLAN2 High Performance Radio LAN

A 3GPP standard specifying a broadband wireless LAN that supports data rates of 25 to 54 Mbps on a carrier frequency of 5 GHz.

HIPERMAN Broadband Wireless Metropolitan Area Network

The European Telecommunication Standards Institute (ETSI) standard for broadband wireless MANs. It operates only in 2-11 GHz, but shares PHY and MAC specifications with WiMAX – see 802.16. The WiMAX Forum is working with IEEE and ETSI to ensure that the products interoperate worldwide.

HiSWANa High Speed Wireless Access Network Type a

An ARIB standard “ARIB STD-T70" that uses the 5.15 to 5.25GHz band with a variable transmission rate from 6 to 36 Mbps. This system guarantees bandwidth usage and can manage bandwidth for each user.

HSDPA High Speed Downlink Packet Access

HSDPA, part of the 3GPP Release 5 W-CDMA specification, is a packet-based data service in a W-CDMA downlink with a peak data rate of 14 Mbps (and 20 Mbps for MIMO systems) and a maximum effective data rate of 10.8 Mbps over a 5 MHz bandwidth in a W-CDMA downlink. An adaptive modulation feature adjusts the modulation scheme automatically to compensate for varying link quality. For users who are close to the base station with good connections, HSDPA creates an improvement for W-CDMA similar to that which EDGE does for GSM, providing a 2X increase in air interface capacity and a 5X increase in downlink data speeds. Such a fast service could ultimately reduce the appeal of 802.11 Wi-Fi by providing equivalent speed with much more widespread deployment.

Siemens planned to conduct the first live demonstrations of an HSDPA network in January ’05, and field tests with mobile operators in Japan and Europe in 2Q’05. Cingular launched the first widely available public service in Dec’05. Many service providers are planning 2006 roll outs -- NTT DoCoMo, for example, plans a 2H’06 launch. ARCchart and UMTS World have helpful HSDPA overviews. Also see HSUPA.

HSUPA High Speed Uplink Packet Access

HSUPA is a companion protocol to HSDPA introduced in Release 6 (2006) of the 3GPP specifications that will enable mobile device uplinks to the Node B (base station) to operate at much higher data rates, up to 5.76 Mbps, and with lower latency. Video conferencing and interactive multimedia, which need high data rates that are similar in both the uplink and downlink directions, are expected to be key applications. These functions will be impaired with HSDPA by itself, which is an unbalanced system emphasizing downlink speed only. T-Mobile announced plans to introduce HSUPA service in Europe as soon as it is proven stable and commercially viable – perhaps by 2007.

Compared to HSDPA, HSUPA increases the demands on the Node B because it must handle a more complex decode environment and take over some control functions that were handled by the RNC (Radio Network Controller) in HSDPA. The six categories of HSUPA UE operation are summarized below:

HSUPA UE Categories				
Category	**Inter-TTI (Transmit Time Interval)**	**Modulation**	**Data Rate**	**Spreading Factor**
1	2 ms	QPSK	700 kbps	4
2	10 ms	QPSK	1.5 Mbps	4
2	2 ms	QPSK	1.5 Mbps	4
3	10 ms	QPSK	1.5 Mbps	4
4	10 ms	QPSK	2.0 Mbps	2
4	2 ms	QPSK	3.0 Mbps	2
5	10 ms	QPSK	2.0 Mbps	2
6	10 ms	QPSK	2.0 Mbps	2
6	2 ms	QPSK	5.8 Mbps	2

iDEN

iDEN is a Motorola proprietary version of TDMA with a unique “push-to-talk” (PTT) two-way radio capability originally developed for Nextel. Sprint Nextel Corporation is the largest iDEN operator in the U.S. Anritsu products currently do not support iDEN. Also see PTT.

IMS IP Multimedia Subsystem

An undertaking by 3GPP and 3GPP2 to create standards for all-IP mobile networks with end-to-end QoS (Quality of Service), addressing the situation that today’s mobile phones do not generally use IP for voice transport. At the same time, IMS is expected to allow broadband vendors to preserve traditional telephony carrier controls over user signaling and usage-based billing while creating new revenue sources based on Internet usage. IMS theoretically allows a mobile operator to extend its services over any IP wired or wireless network. It has extensive support from major vendors such as Nortel, Ericsson, Siemens, and Lucent, plus endorsement from ETSI, ATIS, and the ITU. IMS is the basis of the ITU Next Generation Network project (see NGN).

IMS is based on a SIP control plane, but uses Diameter instead of RADIUS for authentication, and has other enhancements for session policies and registration. IMS was initially defined in the 3GPP UMTS Release 5 standards (March’03), with enhancements defined in Release 6 (March’05). Some IMS-based products are hoped for during 2005.

Issues include the fact that IMS is complex and expensive to implement but provides few benefits or new applications that end users can recognize.

IMT-2000 Third Generation Mobile Systems

A global standard for third generation (3G) wireless communications linking terrestrial and satellite networks, and defined by a set of interdependent ITU recommendations. IMT-2000 is the result of collaboration between groups inside the ITU (ITU-R and ITU-T) and outside the ITU (such as 3GPP, 3GPP2, TIA). The IMT-2000 Web site has more information.

I/Q or IQ In-Phase and Quadrature

I/Q is a method of representing digital modulation. All baseband signals can be represented by an I (In-Phase) portion and a Q (Quadrature-Phase) portion. IQ vectors describe the I&Q states (or equivalently the amplitude and phase) of a signal, so all possible information about that signal can be derived from them. IQ text files contain pairs of I/Q values for signals they represent. I/Q modulators are 90 degrees out of phase with each other. I/Q modulation combines two channels of information into one signal and then separates them later.

IS-136 Interim Standard 136

IS-136, sometimes referred to as D-AMPS, is an evolved version of IS-54 and the U.S. standard for TDMA for both the cellular (850 MHz) and PCS (1.9 GHz) spectrums. Unlike IS-54, which uses an analog control channel, IS-136 utilizes time division multiplexing for transmitting both voice and the control channel. The Digital Control Channel (DCCH) is a key element of IS-136. privateline.com has a helpful reference explaining IS-136. See TDMA and D-AMPS.

IS-95

A TIA/EIA standard that was the first widely used CDMA system, and is heavily installed in North America (see CDMA). The initial specification, known as IS-95A, was later upgraded to IS-95B. IS-95B combines cellular and PCS systems. In addition to voice, IS-95A is able to carry data at rates up to 14.4 kbps, and IS-95B supports data rates up to 115 kbps. Radio-Electronics.com has a helpful explanation of IS-95.

ISDB-T Integrated Services Digital Broadcasting-Terrestrial

ISDB-T is the Japan system for terrestrial broadcasting of high definition digital television started in Dec'03. The world's two other digital TV terrestrial broadcasting systems are ASTC (or DTV), adopted as a standard in the U.S. and Canada, and DVB-T, used in Europe and most of the rest of the world. ISDB-T is closely related to DVB-T but claims advantages in mobile reception plus compatibility with the digital terrestrial sound broadcasting system. ISDB-T is applicable to all 6, 7, and 8 MHz bandwidth systems. The Digital Broadcasting Experts Groups Web site has helpful ISDB-T information.

Iu UMTS interface between the CN and the UTRAN

See UMTS.

Iub UMTS interface between the RNC and the Node B

See UMTS.

Iur UMTS interface between two RNSs (RNCs)

See UMTS.

LWAPP Lightweight Access Point Protocol

See CAPWAP (Control and Provisioning of Wireless Access Points).

MBMS Multimedia Broadcast/Multicast Service

A point-to-multipoint broadcasting service that can be offered via existing GSM and W-CDMA/UMTS networks for transmitting data (typically streaming video and audio) from a single source to multiple recipients. It includes an option to use an uplink channel for interaction between a recipient and the service. The first phase 3GPP standards are for UMTS Release 6, and the first mobile terminals supporting MBMS may be available by 2008.

Mcps Million Chips Per Second

The number of million bits (chips) per second in the spreading sequence of a direct sequence spreading code. Each user's voice or data information is separated by multiplying the information by pseudo-random bits called chips. Also see OSVF.

MIMO Multiple-Input Multiple-Output

A process in which information is transmitted over two or more antennas and received over two or more antennas. The signals reflect off objects and create multiple paths that cause interference and fading in conventional radios. MIMO uses these paths to carry more information, which is recombined on the receiving side based on MIMO algorithms. MIMO is expected to greatly increase performance and range but handle existing 802.11a/b/g radios with only a slight cost increase. Some form of MIMO may be used by the IEEE 802.11n Task Group, which is creating a specification for WLANs having at least 100 Mbps throughput (see 802.11), and for WiMAX/802.16 wireless "last mile" access. Airgo Networks was the first company to produce chipsets supporting MIMO (see 802.11n and 802.16). Also see Tx Diversity.

MMS Multimedia Messaging Service

A technology developed by 3GPP that extends the SMS (Short Message Service) text messaging protocol to provide a means for sending graphics, photos, audio clips, and/or video clips to other MMS phones or to e-mail accounts. MMS is becoming increasingly popular where GSM/GPRS or W-CDMA services are deployed. A Multimedia Messaging Service Center (MMSC) provides the required storage and network switching.

MPEG-4 Motion Picture Experts Group v4

A compression/decompression technology that defines how video, audio, text, and data are transmitted over the Internet. Standardized in October'98 in the ISO/IEC document 14496, MPEG-4 is based on MPEG-1, MPEG-2, and Apple QuickTime technology. It includes provisions for digital multimedia representation and digital rights management.

MS Mobile Station

The term used in GSM to describe a mobile phone.

Multicall

A supplementary service developed in 3GPP to dynamically control parallel network connections. The specification is available on the 3GPP Web site.

NFC **Near Field Communication**

Defined by ECMA-340 and ISO/IEC 18092, NFC is a short-range connection standard developed by Philips and Sony that uses magnetic induction to let devices establish a peer-to-peer network when they are touching or very close together. This communication uses a center frequency of 13.56 MHz.

NGN **Next Generation Network**

A huge and far-reaching undertaking by the ITU to further the integration and interoperability of IP networks with the PSTN and mobile networks. It includes the ability to support instant messaging, push-to-talk, voice mail, video, and other multimedia applications in both real-time and streaming modes. NGN is packet-based with capability for multiple broadband QoS links where services are independent from the underlying transport technology. NGN is based on the IMS framework – see IMS. NGN Release 1 with limited roaming originally had a mid-2005 target, with Release 2 by end-2007 and Release 3 by end-2009.

NLOS **Near (or Non-) Line of Sight**

Refers to an RF signal path between a transmitter and receiver that is partially obstructed by natural or manmade objects such as trees, hills, or buildings.

Node B **Base Station**

A 3G term for the base station transceiver system (see UMTS).

OBW **Occupied Bandwidth**

Occupied Bandwidth is a measure of the bandwidth containing 99% of the total integrated power of the transmitted spectrum, centered on the assigned channel frequency. Interference to other channels or to other systems can occur if OWB is too large.

OCNS **Orthogonal Channel Noise Simulation**

OMA **Open Mobile Alliance**

An organization of more than 300 mobile operators, device and network suppliers, information technology companies, and content providers formed in June'02. OMA promotes global user adoption of mobile data services by developing open technical specifications that help create useful mobile services with proven interoperability to fulfill market needs.

OVSF **Orthogonal Variable Spreading Factor**

CDMA uses a unique spreading code for each recipient to encode the baseband data before transmission and ensure that only the intended recipient recognizes the received data. W-CDMA spreading codes are called OVSF codes because they must be orthogonal to enable multiple users and channels to operate without interference. OVSF codes are also called Walsh Codes. Code sequences are produced at a much higher rate than that of the baseband data. This spreading code rate is called "chip rate" rather than bit rate (see Mcps).

OTA **Over The Air**

Refers generally to any transfer of information or signal that takes place in a wireless environment, rather than using a wired connection. OTA is usually used in connection with a standard defining the provisioning of mobile devices and applications, such as downloading or uploading content or software, and commonly used in conjunction with the Short Messaging Service. SMS OTA Messages contain information used to configure the settings of a WAP browser in a mobile phone (see SMS, WAP).

PCS **Personal Communications Services**

Second generation (2G) digital cellular technologies operating over frequencies near 1900 MHz that provide two-way mobile communications in the U.S. and that can be used internationally. These services can operate over IS-95 (CDMA), GSM, and IS-136 (TDMA). PCS, a term used by the U.S. FCC, thus excludes other cellular services that operate near 800 MHz.

PDC **Personal Digital Cellular**

PDC is a version of TDMA technology used exclusively in Japan.

PHS **Personal HandyFone System**

PHS is a Japan-only TDMA technology. Originally, the difference between PDC and PHS systems was that PDC was true cellular while PHS provided voice and data access but did not support moving from one cell to another.

PoC **Push-To-Talk Over Cellular**

The Push-To-Talk Over Cellular (PoC) working group of the Open Mobile Alliance is developing protocols and interfaces to support PTT services over 1xEV-DO Rev. A as well as 3G UMTS services with high data rates and QoS capability. See PTT (Push-To-Talk).

PSTN Public Switched Telephone Network

The original international public telephone system based on switched connections of copper wiring carrying analog voice data.

PTT Push-To-Talk

A mobile communication voice service much like the old walkie-talkie system used by groups such as law enforcement and taxi drivers, enabling quick contact to a person or a group by pushing a button on a mobile phone. Through 2005, the only successful PTT service was based on Sprint Nextel iDEN technology (see iDEN). Kodiak Networks and Cingular have new PTT services. See PoC.

RC Radio Configuration

Radio Configuration (RC) in cdma2000 systems indicates the channel data rate. RC1 (9600 bps) and RC2 (14440 bps) are backward compatible with IS-95B. RC3 and above use cdma2000 coding for higher capacity. The Spreading Rate (SR) indicates the multiples of 1.2288 Mcps (see Mcps), where SR1 is 1.2288 Mcps and SR3 is 3.6864 Mcps:

RC	Forward Channel	Reverse Channel
1	1200-9600 bps (SR1)	1200-9600 bps (SR1)
2	1800-14,400 bps (SR1)	1800-14400 bps (SR1)
3	1500-153,600 bps (SR1)	1500-153,600 bps (SR1)
4	1500-307,200 bps (SR1)	1800-230,400 bps (SR1)
5		1500-614,400 bps (SR3)
6		1800-1,036,800bps (SR3)

RFID Radio Frequency Identification

An RFID system uses radio frequencies to retrieve stored identification information from a tiny object called an RFID Tag that is typically attached unobtrusively to a pallet, a product, an animal, or some other item. Unlike Universal Product Code (UPC) labels, RFID Tags do not have to be visible, can have alterable memory to maintain state information, and thus can be modified by the RFID reader. The huge retailer Wal-Mart has required its top suppliers to provide RFID tagging for pallets or cases by January'05, and the U.S. Dept. of Defense is beginning to make similar requirements for its suppliers, so 2005 will likely be the first year for significant RFID use.

A Passive RFID Tag, the most common kind, derives all its operation and response power from the signal it receives on its antenna, typically operates over ranges of 10mm to 5m, and responds with just an ID number. An Active RFID Tag has its own power source such as a small battery, a greater range, and the ability to respond with much more information. RFID systems typically operate at 902-928 MHz but can use a wide variety of frequencies, including 125-135 kHz, 6.7 MHz, 13.5 MHz, and 2.4 GHz. Maximum data rate is 26 Kbps. The AIM Web site has a helpful summary of information about RFID.

ROF Radio On Fiber

A system where an optical signal modulated with a radio signal is transmitted via optical fiber to roadside receiver stations, where it is then converted back to a radio signal for broadcasting from antennas. This technique can be used to transmit wideband wireless signals with relatively low noise.

RNC Radio Network Controller

See UMTS.

RNS Radio Network Subsystem

See UMTS.

RRM Radio Resource Management

The methods used in a digital cellular network to manage the allocation of radio channels, frequencies, and characteristics to match the requirements of the users on the network.

RBW Resolution Bandwidth

For spectrum analyzers, a narrow band filter is swept across a frequency span to create the spectrum display. The filter bandwidth (RBW) determines the frequency resolution across the frequency axis.

SDR Software-Defined Radio

A wireless communication device using computer-based software control for transmitter modulation, receive demodulation, and possibly security functions. SDRs provide versatility for handling different and changing communication protocols and

applications, as well as reducing time to market. Ongoing improvements in digital signal processing (DSP) technology make SDR more feasible.

SGSN Serving GPRS Support Node

The interface in a GPRS/UMTS network between the Radio Network Controller (RNC) and the core network. The SGSN maintains information about the locations of the mobile stations (MS) and handles the data communication between each mobile station and the GGSN, which in turn provides access to the Internet or other networks. See UMTS and GGSN.

SHO Soft Handoff

A process in which a mobile phone communicates simultaneously with base stations in two or more overlapping cell sites while the call is being passed from one cell site to another.

SMS Short Messaging Service

A protocol for sending short text messages up to 160 characters to and from a mobile phone, fax machine, and/or IP address. SMS cannot handle images or graphics. Unlike paging, the SMS recipient phone does not have to be active or within range when the message is sent; a Short Message Service Center (SMSC) stores the message and forwards it when the recipient is available.

SMSCB Short Messaging Service Cell Broadcast

A method for broadcasting text or binary messages to an unspecified number of subscribers within a region of a mobile network. Sending traffic or weather information could be typical uses.

SR Spreading Rate

See RC (Radio Configuration).

SPA Spectrum Analyzer

Super 3G

A 3GPP initiative also known as “3.99G” led by NTT DoCoMo and Vodafone begun in Dec’04 to achieve an upgraded version of 3G W-CDMA services having up to 100 Mbps downlink speeds and 50 Mbps uplink speeds. Contributors include other large vendors such as Cingular, Siemens, and Alcatel. The target for completing the first stage of the development was 2007, with service offerings perhaps by 2009. Some providers, however, have equated “Super 3G” with simply offering HSDPA service (see HSDPA).

SVP SpectraLink Voice Priority

An open defacto standard for handling voice priority issues on wireless LANs developed by SpectraLink Corporation that was widely adopted before efforts began to define QoS performance for wireless LANs in the 802.11e standard.

TD-CDMA Time Division CDMA

A time division duplex technology developed by Siemens that is part of the 3GPP UMTS standard, though not mentioned often. It the TDD portion of the UTRA radio interface – see UTRA. Since it uses time division rather than frequency division, TD-CDMA can use unpaired spectrum. Also see TD-SCDMA. The 3G Phones Web site has a helpful overview.

TDD Time Division Duplex

See UTRA (Universal Terrestrial Radio Access).

TDMA Time Division Multiple Access

TDMA is an air interface that allows mobile stations to use the same frequency separated by time slots. TDMA uses its spectrum by assigning each user on a channel a different "slot" in time. D-AMPS is one of several digital wireless technologies that use TDMA (see D-AMPS). Others are GSM, PDC, and iDEN. iDEN is Motorola’s wireless communications technology that supports voice, data, short messages (SMS), and dispatch radio (two-way radio) in one phone. IS-136 and iDEN have 3 slots per channel, while GSM has 8 slots per channel. . Each of these technologies interprets TDMA differently so they are not compatible.

T-DMB Terrestrial Digital Multimedia Broadcasting

See DMB.

TD-SCDMA Time Division Synchronous CDMA

A 3G technology developed by Siemens in conjunction with the China Academy of Telecommunications Technology, adapted from TD-CDMA and part of 3GPP UMTS Release Phase 4 in March 2001. Using the Time Division Duplex (TDD) UMTS transmission mode, traffic is sent and received in different time slots over the same frequency band; see UTRA. The

synchronous aspect of TD-SCDMA means that it can handle synchronous circuit-switched services such as speech and video as well as asynchronous packet-switched services such as Internet access. It will be deployed initially in China. The China TD-SCDMA Web site provides more information and the 3G Phones Web site has a helpful overview.

TGn Sync

A consortium of companies (TGnSync.org) including Agere Systems, Atheros, Cisco, Infineon, Intel, Mitsubishi, Nokia, Nortel, Panasonic, Philips, Qualcomm, Samsung, Sony, and Toshiba developing a proposal for high-performance wifeless networks in conjunction with IEEE 802.11n. Some key technical features include use of MIMO technology to support 315 Mbps with two antennas and seamless Interoperability with 802.11a/b/g products. See 802.11n; MIMO; WWiSE.

TPC Transmit Power Control

WLAN radio management functions defined by 802.11h that include the ability for a WLAN client to adjust its own transmit levels and prolong battery life (see 802.11h). Cisco's CCX provides some similar proprietary features (see CCX).

TRX Tx/Rx or Transceiver

TTCN Tree and Tabular Combined Notation

Tree and tabular combined notation is an ISO/IEC standard (9646-3) for specifying communication systems conformance tests. Anritsu's MX785201A W-CDMA (UMTS) Protocol Test System (PTS) provides an environment that supports TTCN.

Tx Diversity

A process in which information from a wireless base station is transmitted over two or more antennas to reduce interference and fading. The mobile terminal (UE) uses a single antenna. Also see MIMO.

UE User Equipment

Refers to a mobile phone, PDA, or other user device. "UE" is a 3G term normally used only in connection with W-CDMA, and typically only in Europe. (See MS.)

UL Uplink

UMA Unlicensed Mobile Access

An initiative backed by several companies and led by Nokia whose objective is making GSM and GPRS services available over 802.11 Wi-Fi and 802.15.1 *Bluetooth* wireless technology enabled networks. UMA transmits cellular information packets through the Internet when Wi-Fi is available, but uses the cellular network when Wi-Fi is not available. Call forwarding is a key capability: routing calls over a Wi-Fi network to and from the cellular network. In early 2006 trade shows, Samsung, Nokia, and Motorola showed phones capable of seamlessly switching between Wi-Fi and cellular network access.

UMTS Universal Mobile Telecommunications System

UMTS is a part of the International Telecommunications Union's IMT-2000 vision of a global family of third-generation (3G) mobile communications systems. This version of 3G is a W-CDMA technology being developed primarily by Europe's GSM community; UMTS is synonymous with W-CDMA in Europe. UMTS is the planned 3G technology for GSM networks worldwide. Regarding UMTS Release specifications, see 3GPP.

The UMTS architecture is based on the combination of a Core Network (CN), a UMTS Terrestrial Radio Access Network (UTRAN – See UTRA), and mobile terminals known as User Equipment (UE). The Core Network provides switching and routing for user traffic, and is based on a GSM network with GPRS (see GSM, GPRS). The UTRAN is composed of radio network subsystems (RNS). The UTRAN provides the radio interface to the UE in which each base station is referred as Node B, and the control equipment for one or more Node B stations is called the Radio Network Controller (RNC).

The interfaces in UMTS are:

- Iu – an external interface between the CN and the UTRAN
- Uu – an external interface between the UTRAN and the UE
- Iur – an internal (or sometimes external) interface between two RNSs (RNCs)
- Iub – an internal interface between the RNC and the Node B

UTRA Universal Terrestrial Radio Access

UTRA is the UMTS radio interface defined by 3GPP for 3G W-CDMA communication between user equipment (UE) and a base station. A UTRAN (UTRA Network) is composed of a Node B (base station), the Node B control equipment (RNC – Radio Network Controller), and the air interface.

UTRA has two operation modes: Frequency Division Duplex (FDD) and Time Division Duplex (TDD). TDD handles asymmetric traffic well and can be implemented in an unpaired frequency spectrum – see TD-CDMA and TD-SCDMA. FDD requires paired frequency bands, making its implementation more difficult when there is limited frequency availability. The world's first commercial FDD networks were launched in Japan and Europe in late 2001. See UMTS.

UTRA/FDD operates in the following frequency bands:

Band	Upstream (UE Transmit)	Downstream (UE Receive)
I (Europe)	1920-1980 MHz	2110-2170 MHz
II (US-PCS)	1850-1910 MHz	1930-1990 MHz
III (Europe)	1710-1785 MHz	1805-1880 MHz
IV	1710-1755 MHz	2110-2155 MHz
V (US-Cellular)	824-849 MHz	869-894 MHz
VI (Japan)	830-840 MHz	875-885 MHz

UTRAN UMTS Terrestrial Radio Access Network

See UMTS, UTRA.

Uu UMTS interface between the UTRAN and the UE

See UMTS.

UWB Ultra-Wideband

As applied to local area networking, UWB is a wireless technology that uses narrow (picosecond or nanosecond) pulses at very low power to transmit high data rates over distances up to approximately 10-100 m across all frequencies at once. UWB uses spread-spectrum technology spread over about 7.5 GHz with such low power that it does not interfere with other wireless transmission. Current product data rates are around 50 to 500 Mbps. This communications technology, also called digital pulse wireless or carrierless, can carry data through doors and other obstacles that obstruct other signals. UWB could be an alternative to *Bluetooth* (see 802.15). UWB solutions demonstrated at the January 2006 Consumer Electronics Show included wireless USB 2.0 over UWB, Bluetooth Wireless Technology over UWB, wireless DVI component video, 1394-over coax via UWB, and UWB HDTV over electrical wire.

The IEEE 802.15.3a task force (see 802.15.3a) worked for several years to develop high data rate UWB standards, but terminated in January 2006 without proposing an IEEE standard. It did consolidate many UWB PHY specifications into two proposals that are now being pursued by the UWB Forum (see below) and the WiMedia Alliance (see WiMedia).

The UWB Forum, founded in late 2004, is a group of over 100 companies focused on ensuring that UWB products from multiple vendors are truly interoperable. The UWB Forum is promoting direct sequence-UWB (DS-UWB) technology. Also see WiMedia.

VoWLAN Voice Over Wireless LAN

Refers generally to transporting voice over wireless LAN IP networks, somewhat like VoIP transports voice over wired IP networks, but is not associated with a specific standard. Key issues for VoWLAN include ensuring low end-to-end latency for voice quality (see 802.11e), roaming between access points without dropping voice packets (see 802.11i and 802.11r), and providing adequate security from eavesdropping (see 802.11i). Many major vendors support using UMA technology for VoWLAN, but UMA does not fully support SIP (Session Initiation Protocol, needed for key functions such as push-to-talk) and IMS -- see UMA, IMS.

Walsh Codes

See OVSF.

WAP Wireless Application Protocol

The WAP protocol provides for optimized Internet-type information services on wireless terminals such as digital mobile phones and pagers. All major operating systems support WAP, and WAP supports most wireless networks. WAP supports HTML and XML, but WML (Wireless Markup Language, an XML application) is designed to create pages to be displayed in a WAP browser on a small screen. The Open Mobile Alliance, which combined the WAP Forum and the Open Mobile Architecture Initiative, is working to grow the mobile industry market and ensure application interoperability. The IEC provides a useful WAP Tutorial.

W-CDMA Wideband CDMA

W-CDMA is a version of CDMA that uses 10 MHz of wireless spectrum: a 5-MHz uplink from the mobile terminal and a 5-MHz downlink to the mobile terminal. NTT DoCoMo (Japan) introduced the world's first W-CDMA service in 2001. The version of W-CDMA used by NTT DoCoMo is called FOMA or J-W-CDMA; the European version is referred to as UMTS or

E-W-CDMA. AT&T and Cingular are planning W-CDMA service in the U.S. W-CDMA provides a maximum data rate of 2 Mbps.

WEP Wired Equivalent Privacy

A security protocol for wireless LANs that is part of the 802.11 Wireless LAN standard – see 802.11. It uses 40 or 104-bit encryption. WEP has been criticized for its relatively weak RC4-type encryption and lack of user authentication. The "Security of the WEP algorithm" paper by UC Berkeley addresses some of the security concerns with WEP. A near-term improvement to WEP is Wi-Fi Protected Access (see WPA); other current alternatives include 802.1x, TKIP, and VPN technology (see 802.1x, TKIP, and VPN). The 802.11i standard is expected to provide a long-term solution (see 802.11i).

WiBro Wireless Broadband

A broadband wireless internet technology being developed in Korea based on 100 MHz of spectrum in the 2.3 GHz band allocated by the Korean Government in Feb'02 for what it called the "portable Internet". WiBro provides 30-50 Mbps data throughput with Quality of Service (QoS) capability. Base stations covering 1-5 km are expected to be widespread, rather than in localized hotspots like Wi-Fi networks. The Technology Association of Korea standardized WiBro Phase 1 in late 2004. WiBro has strong backing from some Korean companies; POS Data and LG Electronics expect to roll out WiBro networks in mid-2006. WiBro is very similar to, and will supposedly interoperate with, 802.16e Mobile WiMAX – see 802.16.

Wi-Fi Wireless Fidelity

Originally referred to the 802.11b standard, but now usually refers to the 802.11 wireless LAN standards generally – see 802.11.

Wi-Fi5 Wi-Fi In 5 GHz Band

Originally signified the 5 GHz band used by 802.11a, as opposed to the 2.4 GHz band of 802.11b. Official use of Wi-Fi5 has been discontinued to avoid confusion and maintain the integrity of the "Wi-Fi" name.

WiMAX Worldwide Interoperability for Microwave Access

See 802.16.

WiMedia

The WiMedia Alliance is an open industry association promoting the rapid adoption, regulation, standardization, and multi-vendor interoperability of UWB (Ultra-Wideband) worldwide. Based on Multiband Orthogonal Frequency Division Multiplexing (MB-OFDM) technology, WiMedia UWB is optimized for wireless personal area network (WPAN) technologies such as Bluetooth, Certified Wireless USB, Wireless 1394, and Wireless IP. The solution enables short-range multimedia file transfers at data rates of 480 Mbps or higher with low power consumption, and operates in the 3.1 to 10.6 GHz UWB spectrum. In December 2005 Ecma International released UWB standards based on the WiMedia UWB Common Radio Platform. The ECMA-368 standard covers the physical (PHY) layer and MAC layer specifications, and ECMA-369 specifies the MAC-PHY interface. Also see UWB.

WISP Wireless Internet Service Provider

An Internet service provider that provides public Internet connectivity through services such as 802.11 Wi-Fi.

WLL Wireless Local Loop

Any of several kinds of systems using radio signals instead of copper wiring to connect telephone subscribers to the public switched telephone network (PSTN).

WME Wireless Multimedia Extensions

See 802.11e.

WMM Wi-Fi Multimedia

A subset of the 802.11e EDCA Wireless LAN QoS standards (see 802.11e EDCA) adopted by the Wi-Fi Alliance to support voice and video transport over Wireless LANs. The Wi-Fi Alliance began certifying products for WMM compliance in September 2004., and chip sets supporting WMM are available. Major communication product vendors including Proxim, 3Com, and Cisco began shipping WMM products near the end of 2004.

WPA Wi-Fi Protected Access

The WPA specification was developed by the Wi-Fi Alliance and some members of the 802.11i task group to significantly enhance Wi-Fi security. WPA was designed to be a software upgrade forward compatible with the 802.11i standard – see 802.11. WPA is standard in 802.11i. WPA includes data encryption via TKIP using RC4 WEP, a 128-bit encryption key, and 802.1x authentication. Products supporting WPA began shipping in 2H'03 and by mid-2004 over 400 products using

WPA were certified by the Wi-Fi Alliance. The Wi-Fi Alliance site has helpful information about WPA. WPA is an upgrade to the original Wired Equivalent Privacy protocol – see WEP.

WPA2 The Wi-Fi Alliance certified the first 802.11i products in September'04 under the name "WPA2", indicating that the security is enhanced relative to the original WPA. WPA2 uses AES encryption.

WPAN Wireless Personal Area Network

See the *Must-Have Reference for IP and Next Generation Networking*.

WSM Wireless Scheduled Multimedia

See 802.11e.

WWiSE Worldwide Spectrum Efficiency

A consortium of semiconductor and consumer electronics companies (WWiSE.org) including Airgo Networks, Bermai, Broadcom, Conexant Systems, Motorola, Nokia, STMicroelectronics, and Texas Instruments developing a proposal for IEEE 802.11n high-speed WLANs. The proposal is based on a combination of OFDM and MIMO (Multiple-Input, Multiple-Output) technologies and achieves up to 540 Mbps data rate. See 802.11n; MIMO; TGn Sync.

ZigBee Wireless Personal Area Networking

See 802.15.4.

ANRITSU COMPANY SALES & SUPPORT

- **UNITED STATES and LATIN AMERICA**
  1155 East Collins Boulevard, Richardson, TX 75081, USA
  Tel +1-800-ANRITSU (+1-972-644-1777)
  www.us.anritsu.com
  E-mail: us-sales@anritsu.com
- **CANADA**
  700 Silver Seven Road Suite #120, Kanata, Ontario K2V 1C3, Canada
  Tel +1-800-ANRITSU (+1-613-591-2003)
- **EUROPE – U.K.**
  200 Capability Green, Luton, Bedfordshire LU1 3LU, U.K.
  Tel +44-1582-433433
  www.eu.anritsu.com
  E-mail: info@eu.anritsu.com
- **SOUTH AMERICA – Rio de Janeiro, Brazil**: Tel +55-21-2527-6922
- **JAPAN – Atusgi, Kanagawa**: Tel +81-46-223-1111
- **ASIA-PACIFIC – Hong Kong**: Tel +852-2301-4980

31 July 2006