Technical Reference

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*. The online version of this document is updated frequently and may contain new terminology or more recent information than a printed version. Both reference documents plus an overview of Anritsu wireless test and measurement products are available at www.eu.anritsu.com/musthaveguides.

Wireless Telecom Technology (Part 1)

Wireless Technology	CDMA IS-95	cdma2000® 1xRTT	cdma2000 1xEV-DO (0,A,B)	cdma2000 1xEV-DO (C)	TDMA	TD-SCDMA
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	www.3gpp.org
Operators	Verizon Wireless Sprint PCS	Verizon Sprint PCS Leap Wireless	Verizon Telus Mobility Bell Mobility	Sprint (planned)	Cingular (AT&T)	China Mobile
Upgrade Path	cdma2000 1xRTT	cdma2000 1xEV-DO			GSM, GPRS W-CDMA (UMTS)	HSPA
Frequency Range (MHz)	824-894 1850-1990	495 824-894 1850-1990	(same as 1xRTT)	(same as 1xRTT)	824-894 1850-1990	1900-2025
Channel Bandwidth	1.25 MHz (1.23 MHz carrier)	1.25 MHz (1.23 MHz carrier)	1.25 MHz (1.23 MHz carrier)	Scalable up to 20 MHz	30 kHz	1.6 MHz
Data Rate	14.4 kbps	144-307 kbps	Rev. 0: 2.4 /0.1536 Mbps Rev. A: 3.1/1.8 Mbps	280 Mbps (down) 68 Mbps (up)	9.6-19.2 kbps	384 kbps
Generation	2G (IS-95A) 2.5G (IS-95B)	2.5G	3G	3.75G	2G	3G
Relevant Anritsu Test and Measurement Products						
Mobile Unit or Base Station	MS8608A MS8609A MS268x MS2721B MS2711D MT8212B S332D MG3700A	MS8608A MS8609A MS268x MS2721B MS2711D MT8212B S332D MG3700A	MS8609A/09A MG3681A ML2480A/90A MS268x MS2721B MS2711D MT8212B S332D MG3700A (0)	MS2721B MS2711D MT8212B S332D	MS8608A MS8609A MS268x MS2721B MS2711D MT8212B S332D MG3700A	MG3700A MS8608A MS8609A MS2721B MT8222A
Mobile Unit Only	MT8815B/20B CRCA Software MA8120E	MT8815B/20B MA8120E	MT8815B/20B MA8120E	MA8120E	MT8815B CRCA Software MA8120E	MD8470A MT8815B/20B MA8120E

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.

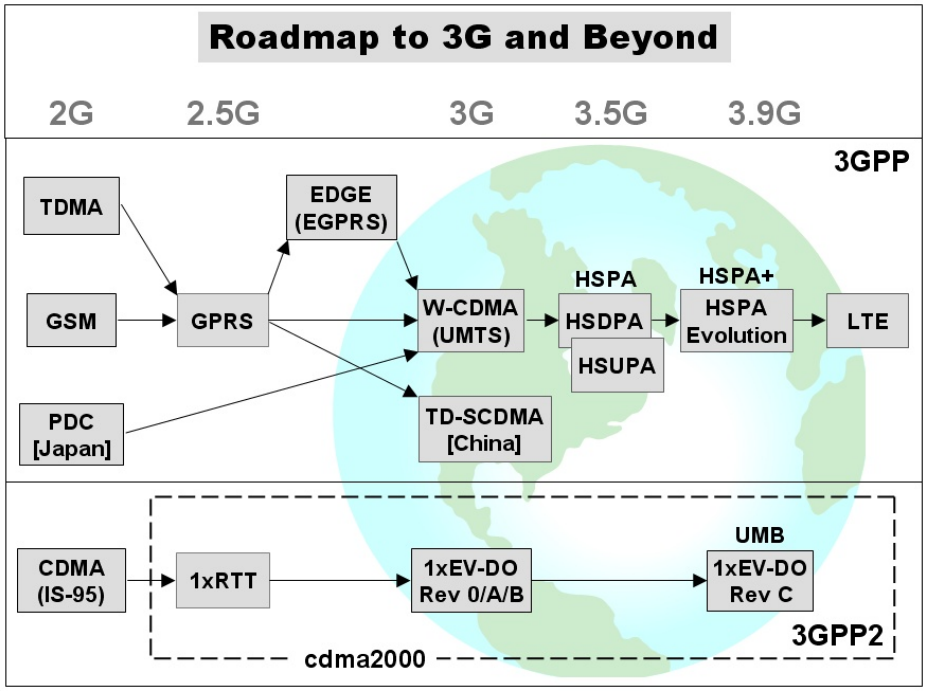
Wireless Telecom Technology (Part 2)

Wireless Technology	GSM	GPRS	EDGE (EGPRS)	W-CDMA (UMTS)	HSPA	
					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
Operators	Cingular (AT&T) T-Mobile Vodafone T-Mobile France Telecom Telefónica	Cingular (AT&T) T-Mobile Vodafone T-Mobile France Telecom Telefónica	Cingular (AT&T) T-Mobile Telefónica Rogers Wireless	Vodafone T-Mobile France Telecom Telefónica 3	Cingular Vodafone T-Mobile France Telecom Telefónica 3	Cingular Vodafone T-Mobile France Telecom Telefónica 3
Upgrade Path	GPRS, EDGE W-CDMA	EDGE W-CDMA	W-CDMA	HSDPA	LTE	LTE
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 MS268x MS2721B MS2711D MT8212B S251C S332D MG3700A MT8222A	MS8608A MS8609A MS268x MS2721B MS2711D MT8212B S251C S332D MG3700A MT8222A	MS8608A/09A MS268x MS2721B MG3681A ML2480A/90A MS2711D MT8212B S251C S332D MG3700A MT8222A	MS8608A/09A MS268x MS2721B MG3681A ML2480A/90A MS2711D MT8212B S332D MG3700A MS2781B MT8222A	MS2781B MS8608A MS8609A MG3681A MG3700A MT8222A	MG3700A
Mobile Unit Only	CRCA Software MT8815B/20B MT8510B MA8120E	MT8815B/20B MA8120E	MT8815B/20B MA8120E	ME7873F/74F MT8815B/20B MT8510B PTS Software RTD Software MD8480B MA8120E	MD8480C MT8815B/20B MA8120E	MA8120E

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/e WiMAX
Wireless Standard	www.bluetooth.org	www.ieee.org/11	www.ieee.org/11	www.ieee.org/11	www.ieee802.org/16
Operators					Sprint
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/90A MT8852B MA8120E MG3700A	MT8860B MS8608A MS8609A MS2681A/83A/87B MS2721B ML2480A/90A S332D+FCN4760 MS2711D+FCN4760 MG3700A	MT8860B MS8608A MS8609A MS2681A/83A/87B MS2721B ML2480A/90A MS2711D MT8212B S332D MG3700A	MT8860B MS8608A MS8609A MS2681A/83A/87B MS2721B ML2480A/90A MS2711D MT8212B S332D MG3700A	MS2717B MS2721B MS2781B MG3700A (e only) MS269xA MT8222A
Mobile Unit Only	[Not applicable]		MA8120E	MA8120E	MA8120E

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 Rev. 0/A/B 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.

The CDMA Development Group website has helpful summary information about the various 1xEV-DO revisions:

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 theoretical 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. Actual downstream throughputs may be only around 1 Mbps. It is fully backward compatible and interoperable with Rev. 0 systems. First Rev. A chipset samples were available in April 2005.

Rev. B introduces dynamically scalable bandwidth by aggregating multiple EV-DO Rev. A channels to provide higher performance for multimedia delivery, bi-directional data transmissions, and VoIP-based concurrent services. When 15 channels are combined in a 20 MHz channel, Rev. B provides a peak rate of 46.5 Mbps in the forward link and 27 Mbps in the reverse link. Rev B was approved in March 2006 and is expected to be commercially available in 2008.

1XEV-DO Rev. C 1X Evolution Data and Voice

An evolutionary upgrade within the family of cdma2000 standards for deployment in existing or new spectrum allocations using scalable bandwidths up to 20 MHz. It is an IP-based technology that combines the best aspects of CDMA, TDM, and

OFDM with MIMO and SDMA antenna techniques. Rev. C provides peak data rates up to 280 Mbps (forward link) and 68 Mbps (reverse link), an extremely low average end-to-end network latency of 16.8 msec (32-byte, RTT), and capacity for up to 500 simultaneous VoIP users (10 MHz FDD allocations). The Rev. C standard is being developed by 3GPP2, with publication scheduled for April 2007 and commercial availability expected in early 2009. See UMB, the brand name associated with 1XEV-DO Rev. C. Also see MIMO, SDMA.

1xEV-DV 1X Evolution Data and Voice

1xEV-DV (cdma2000) was a 3G mobile standard proposal backed by Nokia and Motorola to provide data-rate speeds of 1.2 Mbps for mobile users, with peak data speeds up to 5.2 Mbps for stationary users. Sprint originally proposed this service for 2005-2006. Instead, see 1xEV-DO Rev. C.

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).

3.9G Enhanced Third Generation Cellular Wireless

The wireless industry does not agree on the meaning of "3.9G." This term often refers to HSPA Evolution and UMB technologies, although it sometimes includes LTE technology.

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. For W-CDMA frequency bands, see W-CDMA.

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 (Sep'07)	Definition started in mid-2005. Includes HSPA Evolution.
Release 8 (Dec'07)	Includes LTE.

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 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. For example, the ITU definition requires data transfers at 1 Gbps for stationary users and 100 Mbps for moving users. An October 2007 global conference will allocate 4G service spectrum, but commercial services are not expected before 2010. Likely contenders for "4G" technologies include WiMAX, LTE, and UMB.

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.

Overview of 802.11 Amendments

Interference – 802.11h/y	Radios – 802.11a/b/d/g/j/n/p/y
Interoperability – 802.11u	Roaming – 802.11r
Management – 802.11k/v	Security – 802.11i/w
Mesh – 802.11s	Test – 802.11T
QoS – 802.11e	Voice/Video – 802.11e/r/u

802.11-2007

An edition of the 802.11 standard approved in Mar'07 that incorporates 802.11a, b, c, d, e, g, h, I, and j.

802.11a

802.11a operates at 5.180 to 5.825 GHz and provides data rates of 6 to 54 Mbps using the same OFDM (Orthogonal Frequency Division Multiplexing) modulation as 802.11g, 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). It has 4 channels with 20 MHz spacing, and provides data rates of 1 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 the Linksys Network Basics webpage 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 of 6 to 54 Mbps while operating at 2.4 GHz like 802.11b but using OFDM modulation like 802.11a. It uses 13 channels with 20 MHz spacing. 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.

802.11i (WPA2)
A standard approved in June'04 that provides security enhancements based on WPA, TKIP, and AES. AES is the new Rinjdael-based 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 will likely 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, and the protocol is now widely supported in WLAN switches. 802.11i/WPA2 includes provisions for fast authentication needed to enable practical Voice Over Wireless LAN (VoWLAN) operation. Also see 802.11w.

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 (Radio Resource Management)
A standard approved in Mar'08 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 Mar'04. Various proprietary solutions, including Cisco CCX, are available (see CCX).

802.11n (High Throughput)
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. 802.11n is founded on Multiple-Input Multiple-Output technology (see MIMO) and OFDM modulation. Speeds up to 600 Mbps are theoretically possible, but throughput around 100 Mbps is probably more realistic. Consumer tests of "Draft N compliant" products vs. 802.11b/g products under real conditions in early 2007 showed only 2-3X speed improvements and only very slight range improvements.

The IEEE began debating various proposals in September 2004. 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 January 2006 as a first-draft basis for 802.11n. A second draft was approved in February 2007. Many pre-standard products began shipping, and Intel said it planed to put pre-standard support in its Centrino chips in 2007. In September 2006 the Wi-Fi Alliance announced an unusual plan to begin certifying pre-standard (Draft 2.0) 802.11n products starting in June 2007 to try to avoid interoperability issues. By mid-2008, one third of U.S. enterprises planned to adopt the pre-standard technology during the coming 12 months. IEEE publication of the 802.11n standard is planned for November 2009.

802.11p (Wireless Access Vehicular Environment – WAVE)
A working group that is developing extensions in the 5.9 GHz spectrum that would provide connectivity to automobiles and other vehicles traveling up to 200 km/hour. 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. Expected completion is Mar'09.

802.11r (Fast Roaming)
An initiative started in 2004 and approved in May'08 to avoid re-authentication when transitioning to a new access point. This will enable connectivity aboard vehicles in motion, with seamless fast handoffs from one base station to another. A key objective is enabling roaming applications such as VoIP calls made over wireless LANs (VoWLAN) to work without interruption. 802.11r enables authentication and QoS to be established at a new access point before handover with a loss of connectivity less than 50 ms, the interval detectable by the human ear. Prior to 802.11r ratification, vendors including 3Com and Cisco developed and shipped products with proprietary fast roaming mechanisms.

802.11s (ESS Mesh Networking)
An initiative started in 2004 to allow access points to route data to other access points in a mesh network, somewhat like the way IP routers operate in wired networks. Objectives include extending network range where wired access-point connectivity is impractical; using routing to avoid failed access points; enabling new applications based on high-bandwidth peer-to-peer networks; and balancing traffic loading. 15 proposals for a standard submitted in 2005 were resolved to a single joint protocol (the "SEE-Mesh" and "Wi-Mesh" proposals) in January 2006, which was still being debated in mid-2007. Expected completion is in May'09.

802.11T (Wireless Performance Prediction)
A task group formed in July 2004 to develop recommended test methods and metrics. Its objective is to give guidelines to manufacturers, independent test labs, service providers, and end users for measuring the performance of 802.11 equipment and networks: measurement methods, performance metrics, and test recommendations. The capital "T" in "802.11T" designates a recommended practice rather than a standard. The target for completion is Jun'09.

802.11u – (Wireless Internetworking with External Networks – WIEN)
An amendment addressing internetworking issues between an 802.11 network and external networks such as 3G cellular networks or the Internet. It considers situations where the user is not pre-authorized. An 802.11 network will, for example, be able to allow access based on the user's relationship with the external network, based on online enrollment, or based on limited services such as emergency calls. Its goals are to provide better and more useful experiences for 802.11 users who are traveling, and to assist manufacturers and operators in providing common components and services for 802.11 users. Final approval is expected in Sep'09.

802.11v (Wireless Network Management)
An initiative for wireless LAN management that began in 2004, with an early 2010 completion target. It will define how an 802.11 network can control various parameters on wireless client devices. 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 monitoring and retrieval. Features include a Wireless Network Management Sleep Mode, improvement on base 802.11 power savings and longer power-off times for 802.11 radios. Location features will offer more accuracy for RFID and emergency services. Support for 802.11v might be implemented by software. Also see CAPWAP.

802.11w
An initiative started in early 2005 with a late-2008 approval target to extend 802.11i with protection for sensitive network information currently being exchanged in unprotected 802.11 management frames. A key objective is preventing network disruption caused by malicious systems. 802.11w is considering protection to enable data integrity, data origin authenticity, replay protection, and data confidentiality. Support for 802.11w might be implemented by software.

802.11y (Contention-Based Access – 3650-3700 MHz Operation)
An initiative started in November 2005 to amend 802.11 for operation in the 3650-3700 MHz band that the U.S. FCC made available for public use in July 2005. 802.11y will also provide a standard mechanism for avoiding interference. A likely result is future products that offer optional support for this new frequency range in addition to 2.4 GHz (802.11b/g) and 5 GHz (802.11a). Final approval was expected in the second half of 2008.

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. It is based on a 2.4 GHz radio transceiver using 79 channels with 1 MHz spacing. 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). Version 2.1, adopted in Jul'07, adds some protocol enhancements but no RF changes and is backwards compatible to v1.1. 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, 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.

The next generation, *Bluetooth* 3.0 (*Bluetooth* UWB), will operate with an 8 GHz radio in addition to the traditional 2.4 GHz radio. It will use the WiMedia MAC and PHY standards, enabling data transfers at potential gross data rates of 53.3 to 480 Mbps (480 Mbps over 2 meters or 100 Mbps over 10 meters) – see WiMedia. First products may be available in 2008 or 2009.

A new *Bluetooth* Ultra Low Power (ULP) standard based on Wibree will be called *Bluetooth* Low Energy, with products expected to be available in 2009 (see Wibree). ZigBee is a key competitive low-power technology (see 802.15.4).

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 because of inability to reach consensus on a single standard. This resulted in the consolidation of 23 UWB PHY specifications into two initiatives: Multiband Orthogonal Frequency Division Multiplexing (MB-OFDM) UWB, supported by the WiMedia Alliance, and direct sequence-CDMA UWB (DS-UWB), supported by the UWB Forum. See UWB and WiMedia.

802.15.4 – ZigBee
ZigBee 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. Primary ZigBee applications are in home area networking and home automation, with strong secondary markets in industrial control and commercial building control. 802.15.4 products were first expected in early 2005. ZigBee has a 250 Kbps data rate and operates on 16 channels with 5 MHz spacing in unlicensed bands that include 2.4 GHz globally, 902-928 MHz in the Americas, and 868 Mhz in Europe. The ZigBee Alliance of over 225 companies owns the standard and promotes this technology, and completed the ZigBee 1.0 specification in Dec'04. ZigBee supporters include Johnson Controls, LG, Mitsubishi, Motorola, NEC, Philips, Samsung, and Siemens. Also see Wibree.

802.16 WiMAX (Worldwide Interoperability for Microwave Access)

This IEEE standard defines broadband wireless for the metropolitan area. Potential applications include "last mile" wireless alternatives to wired broadband services such as DSL and cable, mobile connections in large WiMAX hot zones, full roaming not limited to hot zones, and backhaul connections for Wi-Fi that deliver additional bandwidth to WLAN hotspots. Several prominent carriers are seriously considering WiMAX as a 4G technology that could take over 3G cellular networks. Currently WiMAX, which is based on 802.16, supports data rates up to 75 Mbps over the 2-11 GHz frequency range using channel bandwidths of 1.25 to 20 MHz and QAM (16QAM or 64QAM) or QPSK (OFDM) modulation. WiMAX was planned from the beginning to be a service offered by carriers, and 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.

WiMAX standards address the 2-66 GHz frequency range, but only frequencies below 6 GHz reliably support non-line-of-sight operations. In the U.S., such potential frequencies that are available include the Licensed Broadband Radio Service (BRS) 2.5 GHz band, the Unlicensed National Information Infrastructure (I-NII) 5 GHz band, and the Wireless Communication Services (WCS) 2.3 GHz band.

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. Two certification laboratories (in Spain and Korea) have been established, and by May 2006 14 fixed network products had been certified. Public mobile WiMAX Forum PlugFests were held in Sept'06 and March'07, with more than 30 companies participating the second time. 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. Various carriers around the world are currently deploying fixed

WiMAX networks; Sprint is the first major U.S. carrier providing national service, with plans to launch its WiMAX service in Chicago and Washington, D.C., in early 2008.

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 (50 km) 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 practical 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 (**802.16-2004**)
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 – Mobile and Fixed WiMAX
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. It supports mobility up to 65 mph (105 km/hr). Mobile WiMAX uses OFDM modulation in a multiple-access mode called OFDMA (Orthogonal Frequency Division Multiple Access) in which multiple users share the OFDM channel. Fixed WiMAX uses conventional OFDM, giving each user the entire channel for a time period – see OFDM. Mobile WiMAX includes support for Multiple-Input Multiple-Output antenna systems (see MIMO) and beamforming or AAS (see AAS).

802.16e replaces 802.16d (802.16-2004), but does not provide for backward compatibility. Chips for some portable applications were expected in 2006. In April 2008 the WiMAX Forum announced the first mobile WiMAX products (four base stations and four subscriber units for the 2.3 GHz band) to receive certified "Wave 1" approval, which means conformance testing but not product performance or interoperability testing, and does not include MIMO features. Widespread availability and use of 802.16e technology with true mobility (moving between cells at high speed) may be as late as 2009. Regarding handoff methods, see HHO, FBSS, and MDHO. 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.

802.16m WiMAX II

A plan initiated by IEEE in January 2007 to develop a new radio access technology compliant with ITU advanced requirements for 4G while maintaining interoperability with 802.16e Mobile WiMAX. "802.16m" is a tentative name. Its goal is to support fixed data transfer rates up to 1 Gbps and mobile rates up to 100 Mbps, with "improved broadcast and multicast and VOIP performance and capacity." The initial target for standards completion was the end of 2009. Underlying technologies will include both MIMO and AAS multiple-antenna schemes with an OFDM-based radio system – see AAS, MIMO, and OFDM. LTE will be a competitive technology – see LTE.

802.20 MobileFi or Mobile Broadband Wireless Access

An IEEE standards development project established in December 2002 that originally planned to define mobile broadband wireless access (MBWA), with 802.16 (WiMAX) addressing fixed-location access. 802.16e (Mobile WiMAX) is now an alternative service. In June 2006 the IEEE suspended 802.20 activities temporarily because of various irregularities in the proceedings.

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.

A2DP Advanced Audio Distribution Profile

A *Bluetooth* profile (application) describing protocols and procedures for streaming stereo-quality audio, such as from a music phone to headphones. Unlike the Headset and Handsfree profiles, A2DP supports stereo as well as mono and is one-way instead of two-way. In contrast, traditional "Bluetooth audio" defines distribution of narrow-band voice on SCO channels.

AAS Adaptive Antenna Systems

Also known as "beamforming", AAS is a technology using an array of closely-spaced antennas, often in a single package, to enhance transmission performance. It generates a single beam aimed at a specific user, with the goal of improved reach and capacity. In dense environments such as cities where the signal can bounce off buildings, the resulting multiple signal paths make the AAS beam wider and reduce its potential benefits. MIMO (multiple-input multiple-output) is different multiple-antenna technology that benefits from multiple signal paths resulting from such building reflections – see MIMO.

Abis Interface

In a GSM system, Abis is the name of the interface between the BTS (Base Transceiver Station) and the BSC (Base Station Controller), carrying both control and traffic channels.

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.

A-GPS Assisted GPS (Global Positioning System)

A system used by GPS-capable mobile phones in conjunction with assistance server communications over a wireless IP network to enhance the performance of the satellite-based positioning process – see GPS and SUPL (Secure User Plane Location). A key original incentive was the U.S. FCC's 911 mandate requiring cell phones that dial 911 to make their locations available to emergency call dispatchers. The assistance server helps by providing approximate location information for the mobile device since it knows which cell site it is connected to, by having better and more reliable satellite signal reception, and by reducing the amount of processing time and programming required for the mobile device.

aGW Access Gateway

Provides termination of an LTE network bearer. Network elements functions such as the Radio Network Controller (RNC) are distributed between the aGW and the enhanced BTS (eNodeB or eNB). See LTE, BTS, eNB, and UMTS (RNC).

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.

AWS Advanced Wireless Spectrum

Radio frequency bands at 1710-1755 MHz and 2110-2155 MHz auctioned by the U.S. FCC to private companies in August 2006 and intended to be used for next-generation wireless broadband services. Most of the spectrum will be used for 3G mobile phone service based on HSPA or 1xEV-DO (see HSPA, 1xEV-DO).

Beamforming

See AAS (Adaptive Antenna Systems).

BLER Block Error Rate

***Bluetooth*®**

See 802.15.1.

BMC Broadcast/Multicast Control

In a UMTS (3G wireless) system, the BMC protocol handles cell broadcast and multicast services being delivered from the core network to the radio interface.

BS Base Station

The location of the radio equipment for one or more cells. In 3GPP2, a Base Station contains 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.

BWA Broadband Wireless Access

A generic term describing high speed wireless service that could potentially be provided by WiMAX (see 802.16), MobileFi (see 802.20), or various proprietary systems.

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

A method used in digital communications testing to characterize the peak power statistics of a digitally modulated signal by showing the cumulative probability of a particular peak-to-average power occurring. A CCDF curve shows how often a signal is at or above a specific power level, and is typically expressed in dB relative to the average power.

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. Some common cdma2000 frequency bands are:

- 800 and 1900 MHz: U.S., Canada, and most of North and South America (1900 is U.S. PCS)
- 2100 MHz: Future U.S. AWS services
- 800 and 1800 MHz: Korea (1800 is Korea PCS)
- 800 and 2100 MHz: Japan
- 800 MHz: China
- 450 MHz: Africa, Mexico, Eastern Europe

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.

Certified Wireless USB

A wireless extension to the PC industry's Universal Serial Bus (USB) technology promoted by the USB Implementers Forum. It uses short-range ultra-wideband (UWB) communication based on the radio platform developed by the WiMedia Allicance (see WiMedia). Its performance target is 480 Mbps at 3 meters and 110 Mbps at 10 meters, supporting high-speed file transfers and other PC data streaming applications. Other designations for this technology include "Wireless USB" and "WUSB." First silicon chips were developed in September 2007, at which time the technology was still in development.

Cognitive Radio

A type of Software-Defined Radio (see SDR) that can sense its environment and its user's needs, determine what radio networks are available, and modify itself by loading appropriate software to provide radio resources and wireless services most appropriate for those needs and environment.

CPC Continuous Packet Connectivity

A major 3GPP development intended to make network response time on mobile broadband similar to that of DSL by maintaining the "connected" state between a mobile device and its application over a long time period with only occasional periods of active data transmission. Currently, a handset is placed in an Idle state until the user transmits or receives data, necessitating frequent overhead and delays for connection termination and re-establishment. Furthermore, certain applications such as Instant Messaging require continuous connectivity. The main issue with CPC is the amount of battery

power required to maintain connectivity. CPC would be an addition to the concept of HSPA+ for 3GPP Release 7 – see HSPA+.

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.

DigRF Digital Interface Standard

DigRF defines a standard physical interface between baseband and RF ICs within digital cellular terminals (mobile handsets). Its purpose is to increase market competition and standardization by enabling manufactures to select the most appropriate combinations of baseband and radio ICs with the assurance that they will interoperate correctly. The Digital Interface Working Group of interested vendors was incorporated into a MIPI Alliance working group in April 2007. Version 1.2 of the DigRF standard, created before incorporation in the MIPI Alliance, is publicly available and addresses 2G and 2.5G standards including GSM and EDGE. DigRF standard Version 3, available only to members, addresses 2.5G and 3GPP standards including GSM, EDGE, CDMA, cdma2000, and W-CDMA. Also see MIPI.

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 competitors of this technology are MediaFLO (see MediaFLO) and 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 by using less power and allowing the receiving device to move freely. 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 and OFDM. There is helpful DVB-H information on the Nokia mobiletv website. By early 2007, DVB-H trials were in progress in the U.S. and in various European and Asian countries. Also see ISDB.

The major competitors of this technology are Qualcomm's MediaFLO (see MediaFLO) and DMB (Digital Multimedia Broadcasting – see DMB).

EAP Extensible Authentication Protocol

Defined by RFC3748, EAP is a general authentication framework that allows various authentication methods to be used. It applies to both wired and wireless LANS, though it is most often used in wireless LANs. EAP is a framework, so it is neither a specific authentication mechanism nor a wire protocol. EAP typically runs directly over data link layers such as Point-to-Point Protocol (PPP) or IEEE 802, without requiring IP. 802.1x uses EAP (see 802.1x). It was originally proposed by Cisco to improve the security in its proprietary Lightweight Extensible Authentication Protocol (LEAP).

E-DCH Enhanced Dedicated Channel

See HSUPA (High Speed Uplink Packet Access).

EDGE Enhanced Data Rates for GSM (or Global) Evolution

EDGE is a 2.5G technology 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. In actual implementations, speeds around 220 kbps can be reached under good radio conditions. Cingular promised a full deployment by around mid-2004, and AT&T was expected to install EDGE technology in 6500 U.S. cities in 2004. Regarding EDGE Release specifications, see 3GPP. For EDGE frequency bands, see GSM. Also see Evolved EDGE.

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.

eHSPA Evolved High Speed Packet Access

See HSPA Evolution.

eNB Evolved Node B

See eNodeB.

eNodeB Evolved Node B

The single node that interfaces with the UE in an LTE radio network. The eNodeB hosts the Physical (PHY), Medium Access Control (MAC), Radio Link Control (RLC), and Packet Data Control Protocol (PDCP) layers of the network. Also see aGW, LTE, and Node B. Regarding eNodeB applications in the home, see Femtocell.

EPC Evolved Packet Core

The IP-based core network defined by 3GPP for use by LTE and other access technologies – see LTE. The goal of the EPC, also known as the SAE Core, is a simplified network architecture that gives efficient access to various services such as those in the IMS (IP Multimedia Subsystem) – see IMS and SAE. The basic elements of the EPC are:

- MME (Mobility Management Entity): The key LTE access network control node.
- S-GW (Serving Gateway): Routes and forwards user data packets.
- P-GW (PDN Gateway): The UE traffic exit and entry point. A UE may connect simultaneously with more than one P-GW for accessing multiple PDNs.

E-UTRA Evolved UMTS Terrestrial Radio Access

3rd generation radio access technology forming an entirely new air interface for the 3GPP Long Term Evolution (LTE) upgrade path for mobile networks, unrelated to W-CDMA. E-UTRA uses Orthogonal Frequency Division Multiplexing (OFDM) and multiple-input multiple-output (MIMO) antenna technology to support more users – see OFDM and MIMO. E-

UTRA can use 1.25 MHz to 20 MHz bandwidths. For every 20 MHz of spectrum, peak download rates are 326 Mbps (for 4x4 antennas) or 173 Mbps (for 2x2 antennas), and peak upload rates are 86 Mbps. Also see LTE and E-UTRAN.

LTE downlinks use Orthogonal Frequency Division Multiple Access (OFDMA) to achieve high peak data rates in high spectrum bandwidth, and support data modulation schemes QPSK, 16QAM, and 64QAM – see OFDMA. LTE uplinks use SC-FDMA (Single Carrier-Frequency Division Multiple Access) and support BPSK, QPSK, 8PSK and 16QAM modulation – see SC-FDMA.

E-UTRAN Evolved UMTS Terrestrial Radio Access Network

The radio access portion of LTE networks as defined by 3GPP and based on E-UTRA – see LTE and E-UTRA. In the LTE E-UTRAN, the Radio Network Controller (RNC) is eliminated from the data path and its functions are incorporated into the Evolved NodeB (see eNodeB). This structure simplifies network construction to satisfy operators' requirements of low latency, low complexity, and low cost.

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).

Evolved EDGE Evolved Enhanced Data Rates for GSM Evolution

An enhancement to the EDGE standard added in Release 7 of the 3GPP standard – see EDGE. Evolved EDGE introduces 16QAM and 32QAM modulation to achieve reduced latency and potential data rates of 1 Mbps (a potential 4X speed improvement over EDGE).

FBSS Fast Base Station Switching

An optional handoff method In Mobile WiMAX (802.16e-2005) in which a Mobile Station (MS) communicates with only one Base Station (BS) at a time, but maintains an “active list” of other available BS and the signal quality of each. The MS notifies its chosen BS when it needs to execute the handoff. Meanwhile, every BS on the “active list” is receiving transmissions targeted for that MS. Also see the other WiMAX handoff methods – HHO and MDHO. Wireless Broadband also uses FBSS – see WiBro.

FDD Frequency Division Duplex

See UTRA (Universal Terrestrial Radio Access).

Femtocell

A tiny 3G cellular base station, typically supporting 2-5 conventional mobile phones in residential or small business environments, with connection to the service provider’s network via a broadband link such as DSL or cable. The technology allows wireless providers to extend coverage indoors where access would otherwise be limited or unavailable. Femtocells enable delivery of data services at relatively low cost because the traffic is backhauled to the provider’s core network over existing broadband links. The Femto Forum was founded in July 2007 to promote femto technologies as the de facto solution for mobile coverage in the home, and by April 2008 had around 70 members that included many of the world’s largest operators and vendors. In September 2007 Sprint began offering a femtocell service called Airwave to enable cell phone use in low-signal areas such as underground and deep within buildings.

In LTE networks, Femtocells are expected to be defined in 3GPP Release 9 for eNodeB applications in homes and small businesses – see eNodeB.

FMC Fixed-Mobile Convergence

A term that describes removing distinctions between fixed and wireless telecommunication networks to give users a seamless service that combines elements of a fixed communications infrastructure and a core mobile service. One typical example is allowing a cell phone to become an extension on an enterprise PBX.

FOMA Freedom of Mobile Multimedia Access

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

Frequency Bands

See GSM (for GSM, GPRS, and EDGE), HSPA (for HSDPA and HSUPA), and W-CDMA (for W-CDMA).

GAN Generic Access Method

A 3GPP technology for mobile phones that allows seamless roaming and transfer between LANs and wide area mobile phone networks using a dual-mode phone. The goal of GAN is to enable handoffs between LAN and WAN systems to take

place without interrupting the communications session. The process uses unlicensed spectrum with technologies such as *Bluetooth*, Wi-Fi, GSM, and GPRS. See UMA.

GCF Global Certification Forum

GCF (www.globalcertificationforum.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.

Gi Interface

In a GPRS (GSM) network, Gi is an IP-based interface between the mobile network and the Internet or some other external packet data network.

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).

Gn Interface

Within a single GPRS (GSM) core network, Gn is an IP-based interface between network nodes. The GPRS Tunneling Protocol (GTP) is used over the Gn interface.

Gp Interface

In a GPRS (GSM) network, Gp is an IP-based interface between the mobile network and a roaming partner network. The GPRS Tunneling Protocol (GTP) is usually used over the Gp interface.

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. For GPRS frequency bands, see GSM.

GPS Global Positioning System

A global navigation system based on 24 to 32 medium-earth-orbit satellites transmitting microwave signals that enable receivers to determine location, time, direction of movement, and velocity. GPS was developed by the United States Department of Defense and is officially named “NAVSTAR-GPS”. A GPS receiver determines its position from at least three satellite signals by using the satellite locations and arrival times of the messages to measure its distance from each satellite. Using four or more satellite signals allows the receiver to determine the time accurately as well. Also see A-GPS.

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.

GSM, GPRS, and EDGE frequency bands are defined by 3GPP standard TS 45.005:

System	Band (MHz)	Uplink (UE Transmit)	Downlink (UE Receive)
T-GSM 380	380	380.2 - 389.8 MHz	390.2 - 399.8 MHz
T-GSM 410	410	410.2 - 419.8 MHz	420.2 - 429.8 MHz
GSM 450	450	450.4 - 457.6 MHz	460.4 - 467.6 MHz
GSM 480	480	478.8 - 486.0 MHz	488.8 - 496.0 MHz
GSM 710	710	698.0 - 716.0 MHz	728.0 - 746.0 MHz
GSM 750	750	747.0 - 762.0 MHz	777.0 - 792.0 MHz
T-GSM 810	810	806.0 - 821.0	851.0 - 866.0
GSM 850 (or “GSM-800”)	850	824.0 - 849.0	869.0 - 894.0
P-GSM 900 (Primary)	900	890.0 - 915.0	935.0 - 960.0
E-GSM 900 (Extended)	900	880.0 - 915.0	925.0 - 960.0
R-GSM 900 (Railway)	900	876.0 - 915.0	921.0 - 960.0
T-GSM 900 (Tetra)	900	870.4 - 876.0	915.4 - 921.0

DCS 1800	1800	1710.0 - 1785.0	1805.0 - 1880.0
PCS 1900	1900	1850.0 - 1910.0	1930.0 - 1990.0

Common GSM frequency band usage is:

- 850 and 1900 MHz: U.S., Canada, and most of North and South America.
- 900 and 1800 MHz: Most of the rest of the world including Europe and most of Asia.
- 450 MHz: Primarily in the Nordic countries, Eastern Europe, and Russia

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.

HHO Hard Handoff (Hard Handover)

A mandatory handoff method In Mobile WiMAX (802.16e-2005) in which a Mobile Station (MS) ends one Base Station (BS) connection before switching to another BS. This is a “break-before-make” method. HHO is more bandwidth-efficient than Soft Handoff (see SHO), but causes longer delay. An optimized HHO system developed for Mobile WiMAX is intended to keep HHO delay less than 50 ms. Also see the other WiMAX handoff methods – FBSS and MDHO.

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 12 defined categories of service having peak data rates of 900 kbps to 14 Mbps (and 20 Mbps for MIMO systems). Its maximum effective data rate is 10.8 Mbps over a 5 MHz bandwidth, although actual user throughputs now are often around 1 Mbps. For example, T-Mobile’s 2008 U.S. announcement said it expects its HSDPA services to offer data speeds of 600 kbps to 1 Mbps. An adaptive modulation feature in HSDPA 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. For HSDPA frequency bands, see HSPA.

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 planned 2006 roll outs -- NTT DoCoMo, for example, planned a 2H’06 launch. UMTS World has a helpful HSDPA overview. Also see HSUPA.

HSPA High Speed Packet Access

A UMTS Forum generic term that refers to improvements in the UMTS Radio Interface in 3GPP Standard Release 5 and Release 6. HSPA refers to both the improvements made in the UMTS downlink (HSDPA) and the improvements made in

the uplink (HSUPA). See HSDPA, HSUPA. For basic W-CDMA frequency bands, see W-CDMA; HSDPA and HSUPA frequency bands are:

Band	Upstream (UE Transmit)	Downstream (UE Receive)
VII	2500-2570 MHz	2620-2690 MHz
VIII	880-915 MHz	925-960 MHz
IX	1749.9-1784.9 MHz	1844.9-1879.9 MHz
X	1710-1770 MHz	2110-2170 MHz

HSPA+ HSPA (High Speed Packet Access) Evolution

See HSPA Evolution.

HSPA Evolution

The name given to a 3GPP study item whose goal was to define an optimized version of HSPA based on the 3GPP Release 7 standard, with incremental improvements such as reduced latency that allow existing networks to achieve increased voice capacity and higher broadband data speeds. The data rate potential of HSPA Evolution is 42 Mbps downlink and 22 Mbps uplink, attaining performance comparable to LTE in 5 MHz of spectrum. It intends to be backward compatible with previous systems and allow both voice and data operation in a packet-only mode. See HSPA and LTE. For HSPA Evolution frequency bands, see HSPA. First commercial launches of HSPA Evolution were planned for late 2008.

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. For HSUPA frequency bands, see HSPA.

HSUPA uses an uplink enhanced dedicated channel (E-DCH). 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., with recent products that support 1xEV-DO data speeds as well as iDEN operation. Anritsu products currently do not support iDEN. Also see PTT.

IMEI International Mobile Equipment Identity

A unique number for each GSM, UMTS, and iDEN mobile phone as well as some satellite phones that is usually printed on the phone under the battery. IMEI numbers are used by a GSM network to identify valid devices, and can be used to stop access by stolen phones. The IMEI number identifies the device, not the subscriber – also see IMSI (International Mobile Subscriber Identity).

IMS IP Multimedia Subsystem

An undertaking by 3GPP and 3GPP2 to create standards for all-IP wireless and wireline networks with end-to-end QoS (Quality of Service) for transporting voice and data sessions, 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. As of September 2006, Yankee Group says there are 100 IMS trials underway around the world. The MultiService Forum (MSF) is a global association of service providers, system suppliers, and test equipment vendors interested in supporting IMS. Its GMI October 2006 event is dedicated to testing multi-vendor interoperability to achieve Fixed-Mobile Convergence supporting the IMS service framework.

IMSI International Mobile Subscriber Identity

A unique number for each mobile phone user on any GSM or UMTS network. It is stored in the phone's SIM and is sent by the phone to the network. The IMSI is usually 15 digits long: the first three digits are the Mobile Country Code; next is the Mobile Network Code (two digits for Europe or three digits for North America); the remaining digits are the network's mobile station identification number (MSIN) for the customer. Also see IMEI (International Mobile Equipment Identity) and SIM (Subscriber Identity Module).

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 Integrated Services Digital Broadcasting

The Japanese standards for digital television (DTV) and digital radio broadcasting within Japan, maintained by the Japanese Association of Radio Industries and Businesses (ARIB). The ISDB group of standards includes ISDB-S (satellite television), ISDB-T (terrestrial), ISDB-C (cable), and are all based on MPEG-2 video and audio compression. See ISDB-T and DVB-H.

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 provides service for mobile phones, laptop computers, and vehicles. It is applicable to all 6, 7, and 8 MHz bandwidth systems. The Digital Broadcasting Experts Groups Web site has helpful ISDB-T information. Also see SBTVD-T (the similar standard used in Brazil.)

ISDB-TB

See SBTVD-T.

LMR **Land Mobile Radio**

A type of wireless communications system intended for terrestrial users in vehicles or on foot to coordinate people and materials, meet safety and security needs, and provide quick response during emergencies. Typical users are emergency first responder organizations, local governments, public works organizations, utilities and railroads, and companies with large vehicle fleets or numerous field staff. The Land Mobile Radio System (LMRS) is also the United States Department of Defense's new state-of-the-art communication system. Government contractors provide LMRS technology to the government and military. Also see P25 (Project 25 – the U.S. public safety communications standard).

LTE **Long Term Evolution of Universal Terrestrial Radio Access Network (UTRAN)**

A mobile technology upgrade project for 3G networks initiated in 2004 to provide faster data speeds and new services through new radio access technology optimized for IP-based traffic. LTE is part of the GSM evolutionary path beyond 3G, following EDGE, UMTS/W-CDMA, and HSPA. Performance targets included average downlink user throughput of 100 Mbps (3X-4X Release 6 HSDPA levels) and 50 Mbps average uplink throughput (2X-3X HSUPA levels). The LTE architecture is called EPS (Evolved Packet System), and includes E-UTRAN (Evolved UTRAN) for access and EPC (Evolved Packet Core) in the core – see E-UTRAN and EPC.

LTE downlinks use Orthogonal Frequency Division Multiple Access (OFDMA) to achieve high peak data rates in high spectrum bandwidth, and support data modulation schemes QPSK, 16QAM, and 64QAM – see OFDMA. LTE uplinks use SC-FDMA (Single Carrier-Frequency Division Multiple Access) and support BPSK, QPSK, 8PSK and 16QAM modulation – see SC-FDMA. E-UTRA defines the radio interface – see E-UTRA.

The first LTE standards were approved by the 3GPP in January 2008, to be included in 3GPP Release 8. Some operators are planning to deploy their first LTE networks in 2010, but most LTE deployment is not expected to begin until 2011. LTE systems will coexist with 2G/3G systems including GSM, EDGE, and UMTS. Multimode devices will likely function across LTE/3G or even LTE/3G/2G, depending on market circumstances. There is helpful LTE information on the 3GPP website.

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 capability with new Broadcast Mode and Multicast Mode services introduced in 3GPP Release 6. It 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, either as a stream played back at the receiver in near-real-time or as one or more files downloaded to the device for playback later. It includes an option to use an uplink channel for interaction between a recipient and the service. The first mobile terminals supporting MBMS may be available by 2008.

MBWA **Mobile Broadband Wireless Access**

See BWA and 802.20.

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.

MDHO **Macro Diversity Handover**

An optional handoff method In Mobile WiMAX (802.16e-2005) in which multiple Base Stations (BS), called the "diversity set", communicate with a Mobile Station (MS). The MS is responsible for combining the separate data streams, and the BS are responsible for selecting the best uplink stream. The MS notifies its chosen BS when it needs to execute the handoff. MDHO is also used in W-CDMA and cdma2000. Also see the other WiMAX handoff methods – HHO and FBSS.

ME **Mobile Equipment**

Also see MS (Mobile Station) and UE (User Equipment).

MediaFLO

MediaFLO technology, developed and licensed by Qualcomm, is one of several alternatives for mobile TV, adapting conventional video broadcasting to the unique needs of handheld, battery-powered receivers by using less power and allowing the receiving device to move freely. "FLO" stands for "Forward Link Only", indicating that this is a one-way broadcast technology. Qualcomm's MediaFLO website describes this technology, which uses frequency spectrum around 700 MHz that was previously allocated to UHF TV. Its major competitors are the ETSI DVB-H standard (Digital Video Broadcasting-Handheld – see DVB-H) and DMB (Digital Multimedia Broadcasting – see DMB).

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. Forms 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). Airgo Networks was the first company to produce chipsets supporting MIMO (see 802.11n and 802.16). Also see Tx Diversity.

Mobile WiMAX (802.16e) includes support for both Open Loop MIMO (designated Matrix A and Matrix B) and Closed Loop MIMO (Transmitter Adaptive Antenna techniques known as AAS or beamforming). In WiMAX Matrix A MIMO, a single data stream is transmitted in parallel over two transmitter antennas to two receiver antennas. The data streams encoded so they are orthogonal to each other for better noise performance. In Matrix B MIMO, also called Spatial Multiplexing MIMO (SM-MIMO), independent data streams are sent over each antenna. For two antennas and excellent signal conditions, the resulting data rate could be doubled. Also see AAS, which is a different multiple-antenna technology supported by Mobile WiMAX. The WiMAX.com website has a helpful primer on MIMO and AAS (beamforming).

MIPI Mobile Industry Processor Interface

The Mobile Industry Processor Interface (MIPI) Alliance is an organization of companies in the mobile industry with the objective of defining and promoting open specifications for hardware and software interfaces between the processors and peripherals in mobile terminals. See www.mipi.org.

Mitola Radio

See Cognitive Radio.

MME Mobility Management Entity

A major element of the LTE Evolved Packet Core – see EPC.

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.

MobileFi

See 802.20.

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 is intended for consumer electronics, mobile devices, and PCs. It uses magnetic induction to let devices establish a peer-to-peer network when they are touching or very close together (0 to 20 cm). NFC provides a data rate of 212 kbps and uses a center frequency of 13.56 MHz. NFC is promoted by the NFC Forum, an industry alliance having over 130 members, and is based on RFID technology – see RFID.

NGMN Next Generation Mobile Networks

An initiative started in September 2006 by China Mobile Communications, KPN Mobile, NTT DoCoMo, Orange, Sprint Nextel, T-Mobile, and Vodafone to provide a vision for technology evolution beyond 3G for the competitive delivery of broadband wireless services. Technical goals include creation of a mobile network with latencies that are low like wired networks, an IP packet switched architecture, and smooth migration from existing 2.5G and 3G networks by working with existing standards groups. The target for deployments is 2010. The NGMN.org website has helpful information.

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

OFDM Orthogonal Frequency Division Multiplexing

A radio wave modulation technique that divides the original signal into sub-signals transmitted to the receiver simultaneously using different frequencies in which the sub-carriers are orthogonal to each other and modulated with a conventional modulation scheme such as QAM. It adapts to severe channel conditions, reduces the amount of crosstalk, and provides very efficient use of its frequency spectrum. OFDM modulation is used in 802.11a and 802.11g Wireless LANs, 802.16 WiMAX, and DVB (see 802.11, 802.16e, and DVB-H). See OFDMA.

OFDMA Orthogonal Frequency Division Multiple Access

OFDM modulation in a multiple-access mode in which multiple users share the OFDM channel (see Mobile WiMAX – 802.16e). OFDMA data transmission systems use many narrow-band sub-carriers simultaneously – for example, 512 or 1024. The transmission speed on each sub-carrier is much lower than total data rate because many bits are sent in parallel. This reduces the effect of multipath fading resulting from the signal arriving at different times from different directions. See OFDM.

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).

P25 Project 25

A U.S. public safety communications standard whose goal is fast, secure, and interoperable communications between local, state, and federal agencies performing life-saving or damage-control activities as first-responders at the scene of an emergency or disaster situation. The Project 25 standard organization is comprised of the Association of Public Safety Communications Officials (APCO), the National Association of State Telecommunications Directors (NASTD), and the U.S. Federal Government. The P25 suite of standards involves digital Land Mobile Radio (LMR) services for local, state, and national (federal) public safety organizations and agencies. Aeroflex's P25 website and the P25 Technology Interest Group website have helpful information. See LMR.

PAN Personal Area Networking

See 802.15.

PAPR Peak-to-Average Power Ratio

The ratio of a signal's peak power to its average power over time. Nonlinear power amplifiers in transmitters can distort signals with high PAPR, such as OFDM-modulated signals, leading to significant performance loss. In general, signals with low PAPR extend the battery operating time of a mobile device. WiMAX uplinks use OFDMA, which is fast but has a high PAPR. To extend mobile device operating time, LTE uplinks use SC-FDMA, which is also fast but has a lower PAPR (see SC-FDMA).

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.

P-GW PDN Gateway

A major element of the LTE Evolved Packet Core – see EPC.

PHS Personal HandyFone System

PHS is a Japan-based 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. Now the majority of PHS users are in China. See XG-PHS.

PICS Protocol Implementation Conformance Statement

For protocol conformance testing, PICS is a structured document containing information regarding the protocol that provides the basis for determining which test cases are applicable. It includes statements about what is supported on the system under test, such as "supports broadcast data link," and enables test cases to be configured prior to their execution. Also see PIXIT and TTCN.

PIXIT Protocol Implementation eXtra Information for Testing

For protocol conformance testing, PIXIT contains necessary information regarding the physical test configuration that is not part of the protocol, such as telephone numbers and the hardware of the unit under test. PIXIT information supplements what is provided by the Protocol Implementation Conformance Statement (PICS), and enables test cases to be configured prior to their execution – see PICS and TTCN.

PNA Personal Navigation Assistant

See PND.

PND Personal Navigation Device (or Portable Navigation Device)

A portable electronic product that combines navigation functions with positioning information that is typically based on GPS (Global Positioning System) satellite data.

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).

PRBS Pseudo-Random Bit Sequence

Data test patterns utilized in bit error rate testing of SONET, SDH, and other communication links.

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.

QoE Quality of Experience (or Quality of User Experience)

A subjective measure of a customer's experiences with a vendor. In the case of VoIP and IPTV services, for example, QoE is a customer's perception of how good a job the service provider is doing delivering these services.

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 required its top suppliers to provide RFID tagging for pallets or cases starting in January'05, and the U.S. Dept. of Defense began to make similar requirements for its suppliers, so 2005 was expected to be the first year for significant RFID use.

There are over 140 different ISO standards for RFID, applied to a broad range of applications. 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 10 mm to 5 m, 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 often 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 Global 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.

SAE System Architecture Evolution

A 3GPP project to develop a new UMTS core network architecture that: (a) is consistent with the long-term evolution of the radio interface (LTE); (b) enables a cost-efficient and mass-market all-IP network; and (c) supports mobility and service

continuity between heterogeneous access networks such as 2G/3G and non-3GPP access systems such as Wi-Fi and WiMAX. See LTE and EPC (Evolved Packet Core).

SBTVD-T ***Sistema Brasileiro de Televisão Digital-Terrestre***

The standard for digital television service in Brazil, launched in December 2007. It is based on ISDB-T but uses an H.264 video codec instead of MPEG2 (see ISDB-T). ISDB-TB is another designation for SBTVD-T.

SC-FDMA Single Carrier-Frequency Division Multiple Access

Like OFDMA data transmission systems, SC-FDMA uses many narrow-band sub-carriers simultaneously. However, instead of grouping 4 bits to form the signal for one sub-carrier, such as in OFDMA 16QAM modulation, SC-FDMA spreads the information of each bit over all the sub-carriers using FFT (Fast Fourier Transform) technology. Consequently, SC-FDMA is sometimes called "FFT-spread OFDM." SC-FDMA adds complexity in both the transmitter and receiver, but the 3GPP standard for LTE uses SC-FDMA uplinks because of their low Peak-to-Average Power Ratio (PAPR). Low PAPR is important to reduce the power consumption of mobile devices (see PAPR).

SDMA Space Division Multiple Access

As applied to cellular mobile radio, SDMA is a technique that increases system capacity by taking advantage of the spatial separation between users. The base station does not transmit the signal to the entire cell area, as in conventional access techniques, but concentrates the transmitted power in the direction of the mobile unit for which the signal is directed and reduces it in the directions where other units are present. SDMA allows the same frequency to be used at the same time in different cells. Cells using the same frequency can't be next to each other, and are typically separated by two cells

SDR Software-Defined Radio

A wireless communication device (a radio) that uses computer-based software control for transmitter modulation, receive demodulation, and possibly security functions, rather than a traditional and inflexible hardware-based architecture. 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. Also, see Cognitive Radio.

SFN Single Frequency Network

A broadcast network in which all the transmitters operate on the same nominal carrier frequency and send the same signal. To avoid interference, the transmitters and receivers are usually synchronized, using GPS or a signal from the main station or network as a reference clock.

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.

S-GW Serving Gateway

A major element of the LTE Evolved Packet Core – see EPC.

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. Also see HHO.

SIM Subscriber Identity Module

A removable module in mobile phones and other mobile telephone devices (such as computers) used to securely store the IMSI code identifying the network user – see IMSI (International Mobile Subscriber Identity). A user can change phones by removing the SIM from one mobile phone and placing it into another one.

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.

SOHO Small Office/Home Office

A market segment that includes small businesses and business-at-home users, often demanding the latest and fastest technology.

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).

SUPL Secure User Plane Location

A standard developed by the Open Mobile Alliance that uses Assisted Global Positioning Systems (A-GPS) technology to support highly accurate location-based services. It allows any A-GPS-capable mobile handset client and a location server to communicate position data and requests for position data over existing wireless IP networks. See A-GPS.

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 including Agere Systems, Atheros, Cisco, Infineon, Intel, Mitsubishi, Nokia, Nortel, Panasonic, Philips, Qualcomm, Samsung, Sony, and Toshiba formed to develop a proposal for high-performance wifeless networks in conjunction with IEEE 802.11n. Some key technical features included use of MIMO technology to support 315 Mbps with two antennas and seamless Interoperability with 802.11a/b/g products. This ultimately became the 802.11n standard – 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. A TTCN-specified test suite is a collection of test cases with all the declarations and components that are needed. Anritsu's MX785201A W-CDMA (UMTS) Protocol Test System (PTS) provides an environment that supports TTCN. Also see PICS and PIXIT.

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. ME (Mobile Equipment) is now a more appropriate term. "UE" is a 3G term normally used only in connection with W-CDMA, and typically only in Europe. (See MS.)

UICC **Universal Integrated Circuit Card**

See USIM.

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. The UMA Today website has information about the technology. In April 2005 this technology was formally renamed Generic Access Method (GAN), but "UMA" is still widely used as a marketing term – see GAN.

UMB **Ultra Mobile Broadband**

A brand name used by the CDMA Development Group (CDG) to describe advanced technologies and services that will be supported by the cdma2000 1xEV-DO Rev C standard (see 1xEV-DO Rev. C). UMB uses OFDMA technology and advanced antenna techniques, with maximum theoretical rates of 288 Mbps downlink and 76 Mbps uplink. The 3GPP2 UMB standard was first published in April 2007, with commercialization expected by 2009 or 2010. Qualcomm is a key supporter.

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. For W-CDMA frequency bands, see W-CDMA. Common UMTS/W-CDMA frequency bands are:

- 850 and 1900 MHz: U.S.
- 2100 MHz: Europe, Japan, China

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

USIM **Universal Subscriber Identity Module**

A removable UICC (Universal Integrated Circuit Card) with an embedded IC chip and software application that provides key access information enabling a UMTS/W-CDMA mobile phone to interface to an operator network. It stores subscriber data including the mobile phone number and contains authentication information. It may provide storage up to several hundred kilobytes for a phone directory and other applications.

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. For W-CDMA frequency bands, see W-CDMA. Regarding LTE, see E-UTRA.

UTRAN UMTS Terrestrial Radio Access Network

See UMTS, UTRA. Regarding LTE, see E-UTRAN.

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).

VHT Very High Throughput (Gigabit Wi-Fi)

In 2008 the IEEE 802.11 Working Group began planning for a committee that would begin drafting a new standard for Wi-Fi technology expected to be called VHT that implements gigabit data transmission speeds. Two VHT frequency bands are being considered: the 60 GHz band for short-range applications, and the 6 GHz band for longer ranges similar to those available with current 802.11 networks. VHT is expected to be backward compatible with current 802.11 standards. Early goals called for competing standardization by 2013.

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 were leaders in planning W-CDMA service in the U.S. W-CDMA provides a maximum data rate of 2 Mbps. See UMTS.

W-CDMA frequency bands are defined by UTRA (Universal Terrestrial Radio Access), the UMTS radio interface standard:

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

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 a static 40 or 104-bit key. WEP has been criticized for its relatively weak RC4-type encryption and lack of user authentication, and is widely acknowledged to be inadequate for enterprise applications. The "Security of the WEP algorithm" paper by UC Berkeley addresses some of the security concerns with WEP. An interim improvement to WEP is Wi-Fi Protected Access (see WPA); other alternatives include 802.1x, TKIP, and VPN technology (see 802.1x, TKIP, and VPN). The 802.11i WPA2 standard is expected to provide a long-term solution (see 802.11i).

Wibree

Ultra low power wireless technology originally developed by Nokia and announced in October 2006 that enables tiny button cell battery power devices such as watches and sports sensors to connect to mobile phones or personal computer host devices that are nearby (10 meters/30 ft). Wibree has a 1 Mbps data rate and operates at 2.4 GHz over 40 channels, using FSK modulation with limited frequency hopping. Wibree utilizes dynamic packet lengths, making it effective in situations needing bursty data transfers. It seems likely that Wibree is intended to compete with ZigBee (see 802.15.4). In June 2007 the Wibree Forum merged with the Bluetooth SIG in an agreement making the Wibree specification part of the *Bluetooth* specification, designating it *Bluetooth* Ultra Low Power (ULP) and then *Bluetooth* Low Energy (see 802.15.1). Besides Nokia, Wibree backers included Broadcom, CSR, Epson, and Nordic Semiconductor. The *Bluetooth* Low Energy website provides helpful information. The first products are expected in 2009.

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 is the Korean service name for 802.16e Mobile WiMAX. WiBro provides 30-50 Mbps data throughput with Quality of Service (QoS) capability, and uses the Fast Base Station Switching handoff method – see FBSS. Base stations covering 1-5 km are expected to be widespread, rather than in localized hotspots like Wi-Fi networks. WiBro uses a subset of the 802.16e Mobile WiMAX physical layer interface, which it will supposedly interoperate with – see 802.16e. 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 planned to roll out WiBro networks in mid-2006. Two Korean service providers launched the first WiBro services in Seoul in June '06.

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.

Wi-Fi Protected Setup

See WPS.

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) technology 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 gross data rates of 53.3 to 480 Mbps (480 Mbps over 2 meters or 100 Mbps over 10 meters). It has 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.

The WiMedia MAC and PHY standards are mandated by the Certified Wireless USB, the wireless extension to USB for the PC industry that Microsoft said it will support in the Vista operating system. These WiMedia MAC and PHY standards were also selected for next generation high speed *Bluetooth* (*Bluetooth* UWB).

Wireless USB
See Certified Wireless USB.

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.

WMN Wireless Mesh Network
A networking scheme in 802.11 wireless LANs where communication takes place over radio links among a mesh of network nodes, rather than between each network node and a single Access Point (see AP). Objectives include higher reliability and performance through the use of routing to avoid failed access points and to balance traffic loading. WMNs are a relatively new concept and there is currently no standard for creating the mesh, so WMMs produced by different vendors typically cannot be interconnected. See 802.11s.

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 uses RC-4 encryption via TKIP, a 128-bit encryption key that is changed for every packet, 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. See 802.11i.

WPAN Wireless Personal Area Network
See 802.15.

WPS Wi-Fi Protected Setup
A certified technology independently developed by the Wi-Fi Alliance and introduced in Nov'05 that is intended to make it easier for home and small office PC users to set up security-enabled Wi-Fi networks. WPS technology will be incorporated in Windows Vista and will operate in conjunction with computers, peripherals, and various consumer electronics.

WSM Wireless Scheduled Multimedia
See 802.11e.

WUSB
See Certified Wireless USB.

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.

XG-PHS

An OFDMA standard to enable advanced network services and higher speeds for the TDMA-based PHS Personal HandyFone System (see PHS). By using 256 QAM modulation, data rates could be as high as 20 Mbps. In May'08 Wilcom and Wavesat announced plans to cooperate on deploying an XG-PHS network in Japan, operating on the 2.5 GHz spectrum set aside for WiMAX and similar broadband wireless networks. Likely applications for XG-PHS are in Japan and China, where the majority of PHS users are located.

Xohm **Sprint Commercial WiMAX Service**

The name of the Sprint Nextel commercial WiMAX service, formally announced in August'07 (pronounced "zome," rhyming with "home"). The performance plan is 3-5 Mbps downstream, and 1-2 Mbps upstream. Primary strategic alliance partners include Intel, Motorola, Nokia, Nokia Siemens Networks, and Samsung. Commercial Xohm service was initially expected to begin in April'08 in some U.S. cities.

ZigBee **Wireless Personal Area Networking**

See 802.15.4 and Wibree.