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Unravel the Intricacies of Wireless

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Evolving Wireless Standards

Technology	GSM / GPRS / EDGE	W-CDMA (FDD)	HSDPA / HSUPA	TD-SCDMA	TD-CDMA	TIA / EIA-95A / B	cdma2000 (1xRTT)	1xEV-DO	1xEV-DV	iDEN / WiDEN	TETRA	IEEE 802.15.4 (ZigBee)	*Bluetooth*™ 1.2 / *Bluetooth* EDR IEEE 802.15.1, 1a	IEEE 802.15.3a (UWB) Proposals	WLAN IEEE 802.11a / b / g / h / j / n	IEEE 802.16-2004 and 802.16e (WiMAX)
Description	Global System for Mobile Communications / General Packet Radio Service / Enhanced Data Rates for GSM Evolution	Wideband Code Division Multiple Access (Frequency Division Duplex)	High-speed Downlink Packet Access / High-speed Uplink Packet Access (Enhancements to W-CDMA)	Time Division-Synchronous Code Division Multiple Access	Time Division-Code Division Multiple Access	cdmaOne System Technology	1x Radio Telephone	1x Evolution Data Only High Rate Packet Data	1x Evolution Data and Voice	Integrated Dispatch Enhanced Network / Wideband Integrated Dispatch Enhanced Network	Terrestrial Trunked Radio	Low Data Rate Wireless Personal Area Network (PAN)	Medium-Speed Wireless PAN EDR: Enhanced Data Rate	High-Speed Ultra Wideband PAN	Wireless Local Area Network (LAN)	Wireless Metropolitan Area Network (MAN)
Geography	Worldwide, except Japan and Korea	Worldwide	Japan and USA initially, then Europe	China	Worldwide deployment in various bands	North America, Korea, other Asian countries	Same as IS-95 plus South America, Australia, India China, and some Africa	Same as IS-95 plus South America, Australia, India, China, and some Africa	Same as IS-95 plus South America, Australia, India, China, and some Africa	North America initially; Korea, China, South America to follow	all ETSI countries	Worldwide	Worldwide	Mainly North America and Japan, but worldwide interest	Worldwide	Worldwide
First commercial deployment	GSM 1992, GPRS 2001, EDGE 2002	Japan (FOMA version): 2002 Europe: 2004	HSDPA: 2006 HSUPA: 2007	2005 or later	2003	1995 to 1997	2001	2004 (Rel 0) 2006 (Rel A)	2007	iDEN: 1994 WiDEN: 2005	1997	2005	*Bluetooth*: 2000 *Bluetooth* EDR: 2005	2005 to 2006, depending on spectrum regulations	b: 1999; a / g: 2002 to 2003; h: 2003 to 2004; j: 2004; n: 2006	Fixed access: 2005 to 2006 Mobile access: 2006 to 2007
Frequency range **(UL) = uplink / reverse** **(DL) = downlink / forward** **(BS) = base station** **(MS) = mobile station**	T-GSM 380: 380.2 to 389.8 MHz (UL) 390.2 to 399.8 MHz (DL) T-GSM 410: 410.2 to 419.8 MHz (UL) 420.2 to 429.8 MHz (DL) GSM 450: 450.4 to 457.6 MHz (UL) 460.4 to 467.6 MHz (DL) GSM 480: 478.8 to 486 MHz (UL) 488.8 to 496 MHz (DL) GSM 750: 747 to 762 MHz (UL) 777 to 792 MHz (DL) GSM 850: 824 to 849 MHz (UL) 869 to 894 MHz (DL) P-GSM 900: 890 to 915 MHz (UL) 935 to 960 MHz (DL) E-GSM 900: 880 to 915 MHz (UL) 925 to 960 MHz (DL) R-GSM 900: 876 to 915 MHz (UL) 921 to 960 MHz (DL) T-GSM 900: 870.4 to 876 MHz (UL) 915.4 to 921 MHz (DL) DCS 1800: 1710 to 1785 MHz (UL) 1805 to 1880 MHz (DL) PCS 1900: 1850 to 1910 MHz (UL) 1930 to 1990 MHz (DL)	Band I 1920 to 1980 MHz (UL) 2110 to 2170 MHz (DL) Band II 1850 to 1910 MHz (UL) 1930 to 1990 MHz (DL) Band III 1710 to 1785 MHz (UL) 1805 to 1880 MHz (DL) Band IV 1710 to 1755 MHz (UL) 2110 to 2155 MHz (DL) Band V 824 to 849 MHz (UL) 869 to 894 MHz (DL) Band VI 830 to 840 MHz (UL) 875 to 885 MHz (DL)	Band VII 2500 to 2570 MHz (UL) 2620 to 2690 MHz (DL) Band VIII 880 to 915 MHz (UL) 925 to 960 MHz (DL) Band II is the same as PCS 1900 Band III is the same as DCS 1800 Band VIII is the same as E-GSM	1880 to 1920 MHz 2010 to 2025 MHz 2300 to 2400 MHz	NMT band: 450 to 480 MHz IMT 2000 bands: 1900 to 1920 MHz 2010 to 2015 MHz 2053 to 2082 MHz MMDS / ITFS band: 2500 to 2700 MHz Other bands: 3400 to 3600 MHz	824 to 849 MHz (MS: US, Korea) 869 to 894 MHz (BS: US, Korea) 887 to 925 MHz (MS: Japan) 832 to 870 MHz (BS: Japan) 1850 to 1910 MHz (MS: US) 1930 to 1990 MHz (BS: US) 1750 to 1780 MHz (MS: Korea) 1840 to 1870 MHz (BS: Korea)	IS-95 bands NMT 450 band: 411 to 483 MHz (MS) 421-493 MHz (BS) IMT 2000 band 1920 to 1980 MHz (MS) 2110 to 2170 MHz (BS)	2004 (Rel 0) 2006 (Rel A)	IS-95 bands NMT 450 band: 411 to 483 MHz (MS) 421 to 493 MHz (BS) IMT 2000 band: 1920 to 1980 MHz (MS) 2110 to 2170 MHz (BS)	2007	IS-95 bands NMT 450 band: 411 to 483 MHz (MS) 421 to 493 MHz (BS) IMT 2000 band: 1920 to 1980 MHz (MS) 2110 to 2170 MHz (BS)	800 MHz band 900 MHz band 1.5 GHz band	380 to 390 MHz (MS) 390 to 400 MHz (BS) 410 to 420 MHz (MS) 420 to 430 MHz (BS) 450 to 460 MHz (MS) 460 to 470 MHz (BS) 870 to 915 MHz (MS) 915 to 950 MHz (BS)	898 MHz; 915 MHz; 2.4 GHz ISM	2.4 to 2.4835 GHz (ISM)	North America: > 500 MHz bands in the range 3.1 to 10.6 GHz	b / g: 2.4 to 2.4835 GHz (ISM) a / h / j: 4.9 to 5 GHz (Japan) 5.03 to 5.091 GHz (Japan) 5.15 to 5.35 GHz (UNII) 5.47 to 5.725 GHz 5.725 to 5.825 GHz (ISM, UNII)	Fixed access: < 11 GHz Mobile access: 2 to 6 GHz
Multiple Access Technology	TDMA	CDMA	TDMA / CDMA	TDMA / CDMA	TDMA / CDMA	CDMA	CDMA	CDMA	CDMA	TDMA	TDMA	CSMA-CA (carrier sense multiple access-collision avoidance)	TDMA	CSMA-CA	CSMA-CA	TDMA
Modulation and filter type	0.3 GMSK, 1 bit / symbol EGPRS only: 3π / 8 rotating 8PSK 3 bits / symbol	HPSK with RRC filter (α = 0.22), 1 bit / symbol (UL) QPSK with RRC filter (α = 0.22), 2 bits / symbol (DL)	HPSK with RRC filter (α = 0.22) (UL) QPSK and 16QAM with RRC filter (α = 0.22) (DL)	RRC filter (α = 0.22) QPSK	RRC filter (α = 0.22) QPSK (UL) QPSK, 16QAM (DL)	Chebychev low pass (FIR) OQPSK, 1 bit / symbol (UL) QPSK, 1 bit / symbol (DL)	Chebychev low pass (FIR) QPSK / HPSK, 2 bits / symbol (UL) QPSK, 2 bits / symbol (DL)	Chebychev low pass (FIR) QPSK / HPSK, 2 bits / symbol (UL) QPSK, 8PSK, 16QAM (DL)	Chebychev low pass (FIR) QPSK / HPSK, 2 bits / symbol (UL) QPSK, 8PSK, 16QAM (DL)	iDEN: QPSK, M16QAM WiDEN: QPSK, M16QAM, M64QAM	RRC filter (α = 0.35) π / 4 DQPSK (differential QPSK)	900 MHz: BPSK with RRC filter 2.4 GHz: OQPSK with half sine wave impulse response	*Bluetooth* 1.2: GFSK with bandwidth time (BT) product = 0.5 *Bluetooth* EDR: π / 4 QPSK and 8DPSK (differential PSK)	Filter depends on format: Shaped pulse or frequency switched OFDM	b: Gaussian or vendor specific a / g / h / j / n: Rectangular or vendor specific b: Differential BPSK / QPSK (DBPSK / DQPSK) for 1 and 2 Mbps data rates; CCK with DQPSK modulation for 5.5 and 11 Mbps data rates a / g / h / j: up to 64QAM on 52 OFDM sub-carriers n: up to 64QAM on 108 OFDM sub-carriers (standard not yet defined)	Fixed access: OFDM with BPSK, QPSK, 16QAM, 64QAM Mobile access: OFDMA with BPSK, QPSK, 16QAM, 64QAM
Channel spacing	200 kHz	5 MHz	5 MHz	1.6 MHz	5 MHz (10 MHz*)	1.23 MHz (US cellular band) 1.25 MHz (other bands)	1.23 MHz (US cellular band) 1.25 MHz (other bands)	1.23 MHz (US cellular band) 1.25 MHz (other bands)	1.23 MHz (US cellular band) 1.25 MHz (other bands)	iDEN: 25 kHz WiDEN: Up to 4 x 25 kHz	25 kHz	915 MHz: 2 MHz 2.4 GHz: 5 MHz	1 MHz frequency hopping	MBOA: 528 MHz	b: 25 MHz (non-overlapping), 10 MHz (overlapping) in North America; 30 MHz (non-overlapping), 10 MHz (overlapping) in Europe g: 25 MHz a / h: 20 MHz j: 20 MHz, 10 MHz option n: 20 or 40 MHz (standard not yet defined)	Fixed access: 1.25 to 20 MHz Mobile access: 1.25, 5, 10, 20 MHz
Symbol rate / chip rate	270.833 kbps	3.84 Mcps	3.84 Mcps	1.28 Mcps	3.84 Mcps (7.68 Mcps*)	1.2288 Mcps	1.2288 Mcps	1.2288 Mcps	1.2288 Mcps		18 ksps	900 MHz: 20, 40 ksps 2.4 GHz: 62.5 ksps / 2 Mcps	1 Msps	Depends on format	b: 11 Mchips / sec a / g / h: 250 ksps j: 125 ksps n: standard not yet defined	Up to 87 ksps
Frequency reuse pattern (cell x sector)	4 x 3 EDGE requires adjacent cell timeslot clearing to achieve peak data rates in macro cells	1 x 1	1 x 1	1 x 1	1 x 1	1 x 1	1 x 1	1 x 1	1 x 1			Mesh networking topology	Not applicable	Installation specific	Installation specific	Installation specific
Single user data rate	GSM: 9.6 or 14.4 kbps (single slot) GPRS: Up to 171.2 kbps (21.4 kbps with 8 slots) EDGE: Up to 473.6 kbps (59.2 kbps with 8 slots)	384 kbps (Single code)	HSDPA (DL): Up to 13.976 Mbps HSUPA (UL): Up to 5.76 Mbps	Up to 384 kbps	Up to 3 Mbps	95A: 9.6 or 14.4 kbps 95B: Up to 115 kbps	Up to 153.6 kbps (Rel 0) Up to 307.2 kbps (Rel A)	Up to 153.6 kbps (Rel 0) (UL) Up to 2.5 Mbps (Rel 0) (DL) Up to 1.8 Mbps (Rel A) (UL) Up to 3.1 Mbps (Rel A) (DL)	Up to 1.8 Mbps (Rel D) (UL) Up to 3.1 Mbps (Rel C, D) (DL)	iDEN: 64 kbps WiDEN: Up to 256 kbps	28.8 kbps with no protection	20 to 250 kbps, depending on frequency band	*Bluetooth*: 1 Mbps *Bluetooth* EDR: 2 to 3 Mbps	Greater than 100 Mbps	b: 11 Mbps; a / g / h / j: 54 Mbps n: > 100 Mbps	Up to 75 Mbps
Primary service	High-mobility cellular GSM: Voice, SMS and circuit switched data EDGE and GPRS: Packet switched data	High-mobility cellular Voice, SMS, circuit and packet switched data	High-mobility cellular High speed packet data	High-mobility data and voice	Fixed and mobile data*	High-mobility cellular data and voice	High-mobility data and voice	Always-on mobile packet data	Always-on mobile packet data and voice	High-mobility data and voice and voice	Instant communication for PMR (private mobile radio) and PAMR (public access mobile radio)	Home control, building automation, industrial automation	Low-mobility data and voice	Low-mobility streaming video and data; Wireless USB	Low-mobility data	"Last mile", backhaul, and mobile broadband wireless access
Packet switched or circuit switched	GSM: Circuit switched GPRS / EGPRS: Packet switched	Supports both	Packet switched	Supports both	Packet based	95A: Circuit switched 95B: Supports both	Supports both	Packet switched	Supports both	Supports both	Supports both	Packet based	Packet switched or synchronous	Packet based	Packet switched	Packet switched
Speech CODEC	Full rate = RPE-LTP 13 kbps Half rate = VSELP 5.6 kbps (vector sum excited linear predictor) Enhanced full rate = ACELP 12.2 kbps (algebraic code excited linear pred.) Adaptive multi-rate (full and half rates)	Adaptive multi-rate	Not applicable	China: Full rate, enhanced full rate, or half rate 3GPP: Adaptive multi-rate	Not applicable	8 kbps variable rate CELP; or 13 kbps variable rate CELP; or 8 kbps variable rate EVRC	8 kbps variable rate CELP; or 13 kbps variable rate CELP; or 8 kbps variable rate EVRC	Not applicable	8 kbps variable rate CELP; or 13 kbps variable rate CELP 8 kbps variable rate EVRC	VSELP	ACELP	Not applicable	Log PCM or CVSD (continuous variable slope delta)	Not applicable	Not applicable	Not applicable
Comment	The peak GPRS and EDGE data rates require very good signal to noise ratio typical in micro cell deployment.		The peak data rates require exceptional signal to noise ratio typical of pico cell deployment.	China (CCSA) implementation requires smart antenna, multi-user detection technology, and may initially require a multi-carrier implementation with a different physical layer than 3GPP currently defines.	* Proprietary implementations are also available for higher rate, wide bandwidth, and VoIP systems.		Capacity about 2 x TIA / EIA-95B	Capacity 6 to 10 x TIA / EIA-95B; 3 x cdma2000	cdma2000 Rel C cdma2000 Rel D		Used mostly by public service, health and safety, emergency, and security personnel, construction and transport industries.	ZigBee uses IEEE 802.15.4 PHY layer. Designed to support very low power standby modes and Mesh networking	*Bluetooth* is a trademark owned by *Bluetooth* SIG Inc., U.S.A. and licensed to Agilent Technologies.	OFDM and direct sequence proposals have some similarities to 802.11a and 802.11b but incompatible radios.	Wi-Fi Alliance certifies 802.11a / b / g only. Current 802.11 standards share a similar MAC. DFS (dynamic frequency selection) and TPC (transmit power control) needed for operation in parts of 5 GHz band. 802.11n is still at the proposal stage. MIMO use likely for 802.11n.	802.16e is an IEEE working group that is creating documentation to be added into the 802.16-2004 standard.
Standards development organization	3GPP	3GPP	3GPP	3GPP / CCSA	3GPP	TIA	3GPP2	3GPP2	3GPP2	Motorola	ETSI	ZigBee Alliance and IEEE	*Bluetooth* Special Interest Group (SIG) and IEEE	Multi-Band OFDM Alliance (MBOA), UWB Forum and IEEE	IEEE	IEEE
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