

# Chapter 2

## Modern wireless Communication Systems

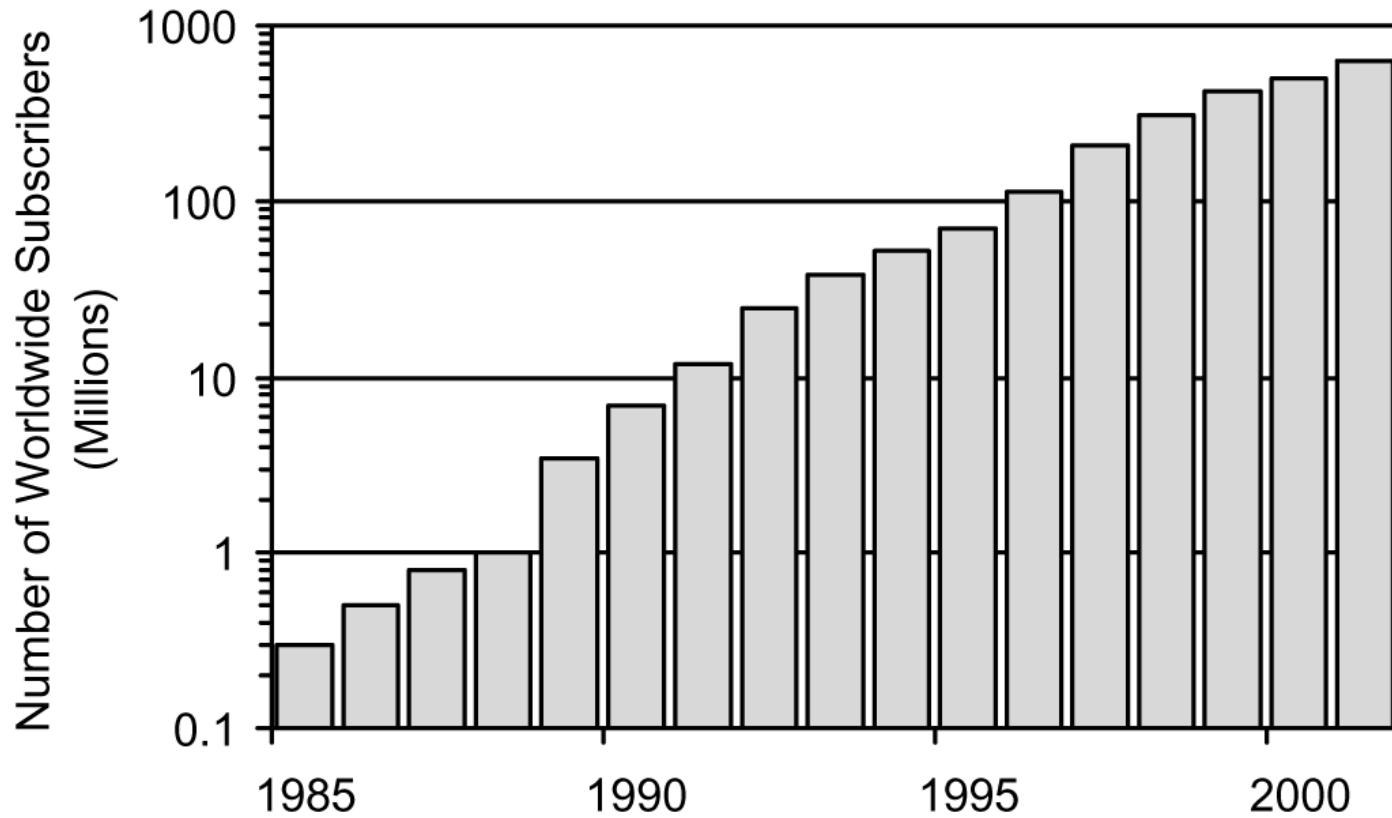
# 1. 2G Cellular Networks

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- **1st generation(1G): analog - voice**
  - AMPS with manual roaming
  - cordless phones
- **2nd generation(2G): digital - voice, data**
  - cellular with seamless roaming (IS-95, IS-136, GSM)
  - multizone digital cordless
  - wireless LANs (802.11), MANs (Metricom), and WANs (CDPD)

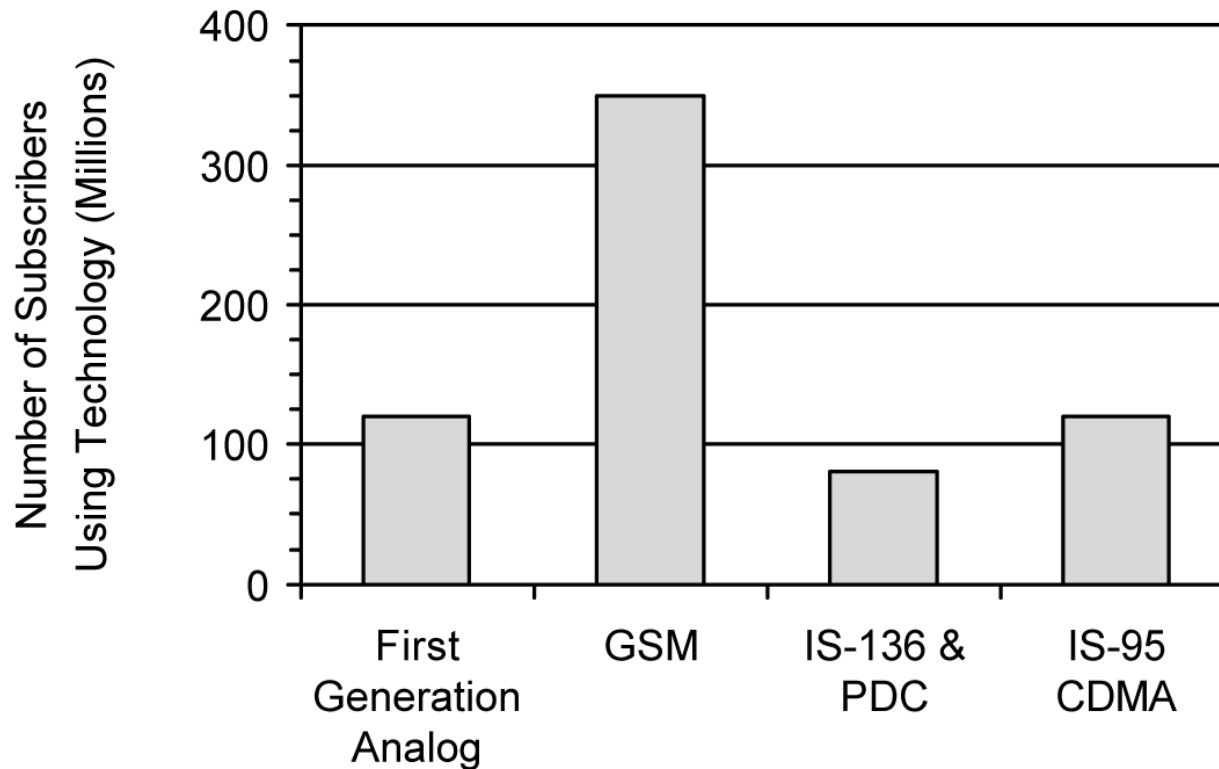


## Growth of Cellular Telephone Subscribers Throughout the World



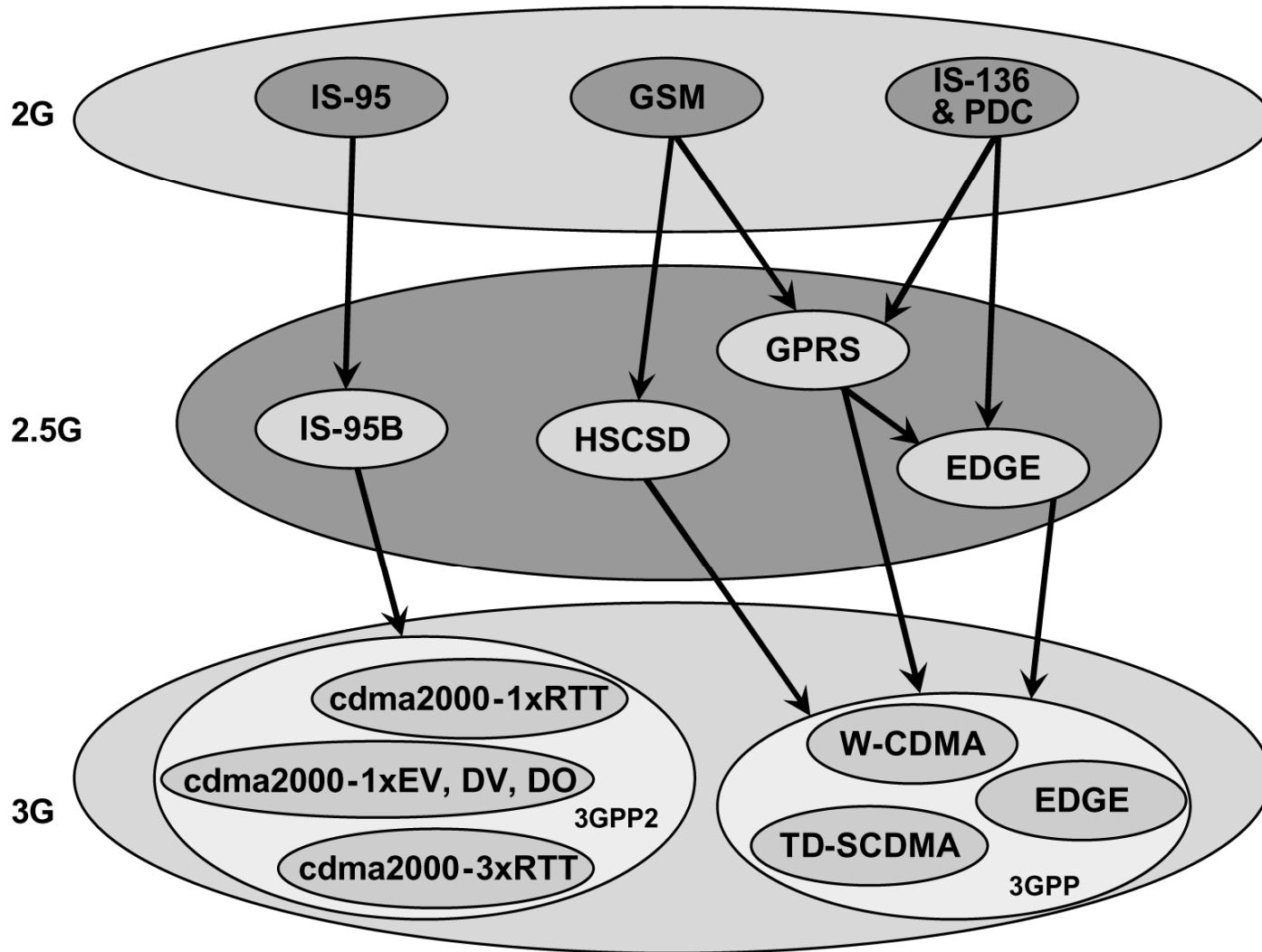


Subscriber Base as a Function of Cellular Technology  
in Late 2001



**Table 2.1** Key Specifications of Leading 2G Technologies (adapted from [Lib99])

	<b>cdmaOne, IS-95, ANSI J-STD-008</b>	<b>GSM, DCS-1900, ANSI J-STD-007</b>	<b>NADC, IS-54/IS-136, ANSI J-STD-011, PDC</b>
Uplink Frequencies	824-849 MHz (US Cellular) 1850-1910 MHz (US PCS)	890-915 MHz (Europe) 1850-1910 MHz (US PCS)	800 MHz, 1500 MHz (Japan) 1850-1910 MHz (US PCS)
Downlink Frequencies	869-894 MHz (US Cellular) 1930-1990 MHz (US PCS)	935-960 MHz (Europe) 1930-1990 MHz (US PCS)	869-894 MHz (US Cellular) 1930-1990 MHz (US PCS) 800 MHz, 1500 MHz (Japan)
Duplexing	FDD	FDD	FDD
Multiple Access Technology	CDMA	TDMA	TDMA
Modulation	BPSK with Quadrature Spreading	GMSK with $BT = 0.3$	$\pi/4$ DQPSK
Carrier Separation	1.25 MHz	200 kHz	30 kHz (IS-136) (25 kHz for PDC)
Channel Data Rate	1.2288 Mchips/sec	270.833 kbps	48.6 kbps (IS-136) (42 kbps for PDC)
Voice channels per carrier	64	8	3
Speech Coding	Code Excited Linear Prediction (CELP) @ 13 kbps, Enhanced Variable Rate Codec (EVRC) @ 8 kbps	Residual Pulse Excited Long Term Prediction (RPE-LTP) @ 13 kbps	Vector Sum Excited Linear Predictive Coder (VSELP) @ 7.95 kbps





## 2. 3G Wireless Networks

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- **Wide-area mobile voice/data**
  - 3G standards: W-CDMA, CDMA2000, TD-SCDMA
- **Fixed Point-to-multipoint broadband wireless access 802.16**
  - LMDS (local multipoint distribution) 24-28GHz
  - MMDS below 5 GHz
- **Higher-speed WLAN**
  - 802.11b (2.4GHz, 11 Mbps), 802.11a (5GHz, 54 Mbps)
- **Personal area Networks**
  - Bluetooth, 802.15

**Table 2.2** Current and Emerging 2.5G and 3G Data Communication Standards

Wireless Data Technologies	Channel BW	Duplex	Infrastructure change	Requires New Spectrum	Requires New Handsets
HSCSD	200 KHz	FDD	Requires software upgrade at base station.	No	Yes New HSCSD handsets provide 57.6 Kbps on HSCSD networks, and 9.6 Kbps on GSM networks with dual mode phones. GSM-only phones will not work in HSCSD networks.
GPRS	200 KHz	FDD	Requires new packet overlay including routers and gateways.	No	Yes New GPRS handsets work on GPRS networks at 171.2 Kbps, 9.6 Kbps on GSM networks with dual mode phones. GSM-only phones will not work in GPRS networks.
EDGE	200 KHz	FDD	Requires new transceiver at base station. Also, software upgrades to the base station controller and base station.	No	Yes New handsets work on EDGE networks at 384 Kbps, GPRS networks at 144 Kbps, and GSM networks at 9.6 Kbps with tri-mode phones. GSM and GPRS-only phones will not work in EDGE networks.
W-CDMA	5 MHz	FDD	Requires completely new base stations.	Yes	Yes New W-CDMA handsets will work on W-CDMA at 2 Mbps, EDGE networks at 384 Kbps, GPRS networks at 144 Kbps, GSM networks at 9.6 Kbps. Older handsets will not work in W-CDMA.
IS-95B	1.25 MHz	FDD	Requires new software in base station controller.	No	Yes New handsets will work on IS-95B at 64 Kbps and IS-95A at 14.4 Kbps. CdmaOne phones can work in IS-95B at 14.4 Kbps.
cdma2000 1xRTT	1.25 MHz	FDD	Requires new software in backbone and new channel cards at base station. Also need to build a new packet service node.	No	Yes New handsets will work on 1xRTT at 144 Kbps, IS-95B at 64 Kbps, IS-95A at 14.4 Kbps. Older handsets can work in 1xRTT but at lower speeds.
cdma2000 1xEV (DO and DV)	1.25 MHz	FDD	Requires software and digital card upgrade on 1xRTT networks.	No	Yes New handsets will work on 1xEV at 2.4 Mbps, 1xRTT at 144 Kbps, IS-95B at 64 Kbps, IS-95A at 14.4 Kbps. Older handsets can work in 1xEV but at lower speeds.
cdma2000 3xRTT	3.75 MHz	FDD	Requires backbone modifications and new channel cards at base station.	Maybe	Yes New handsets will work on 95A at 14.4 Kbps, 95B at 64 Kbps, 1xRTT at 144 Kbps, 3xRTT at 2 Mbps. Older handsets can work in 3X but at lower speeds.



### 3. Wireless Local Loop (WLL)

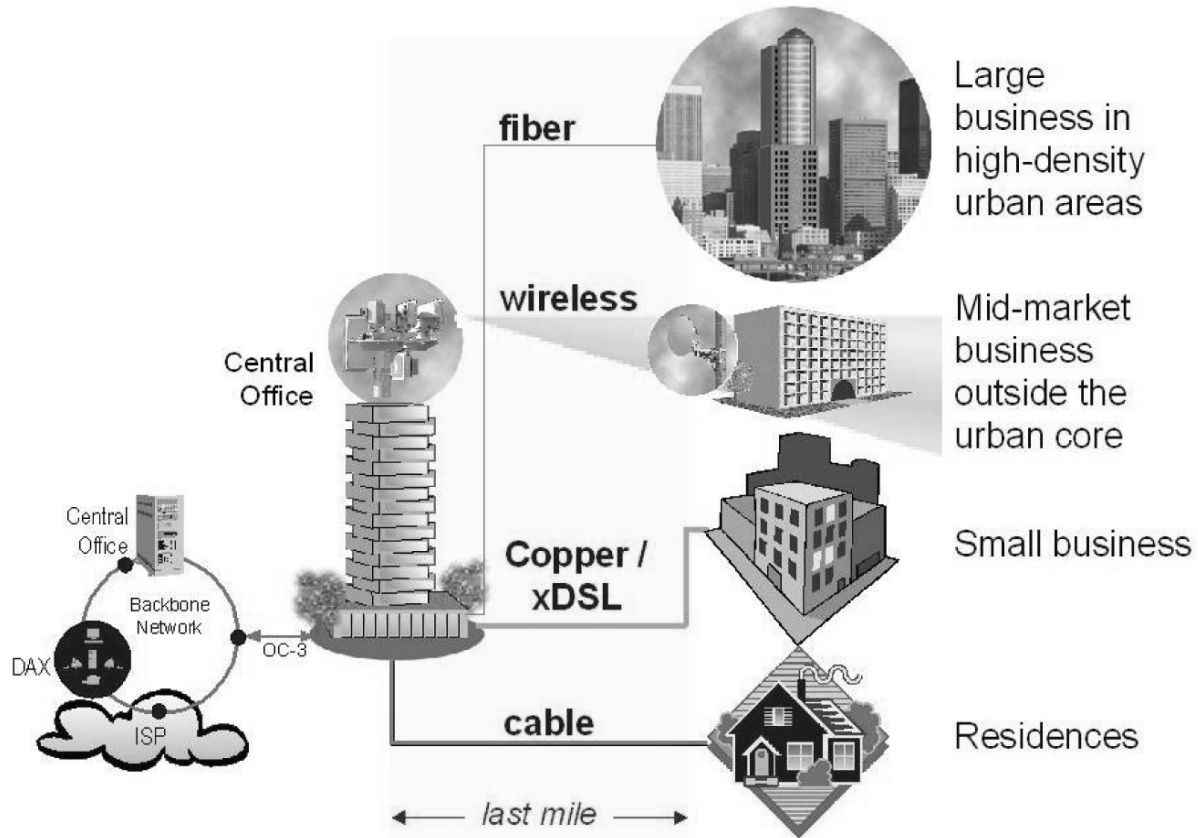
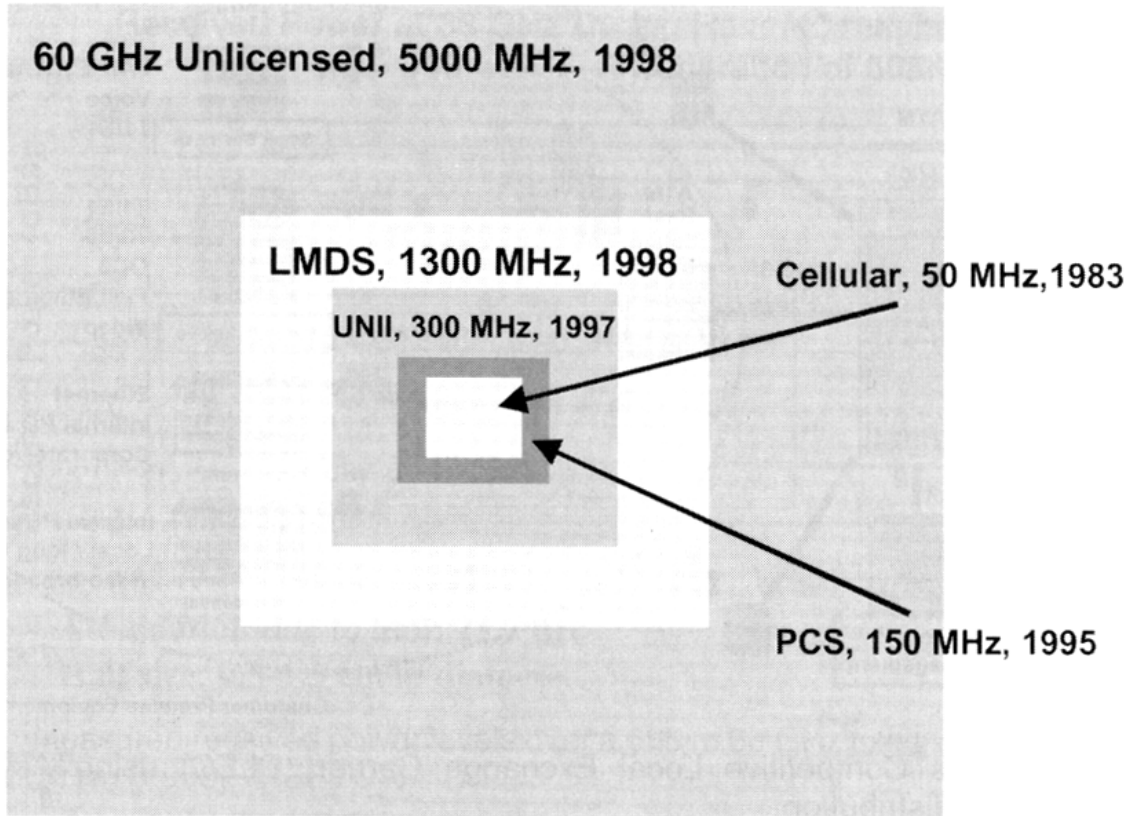


Figure 2.4 Example of the emerging applications and markets for broadband services. (Courtesy of Harris Corporation, ©1999, all rights reserved.)



- A voice channel occupies  $\approx 10$  kHz of spectrum.
- A TV channel occupies  $\approx 5$  MHz of spectrum.

**Figure 2.6** Comparison of spectrum allocations for various US wireless communications services. The areas of the rectangles are proportional to the amount of bandwidth allocated for each service.

## 4. Wireless Local Area Networks (WLAN)

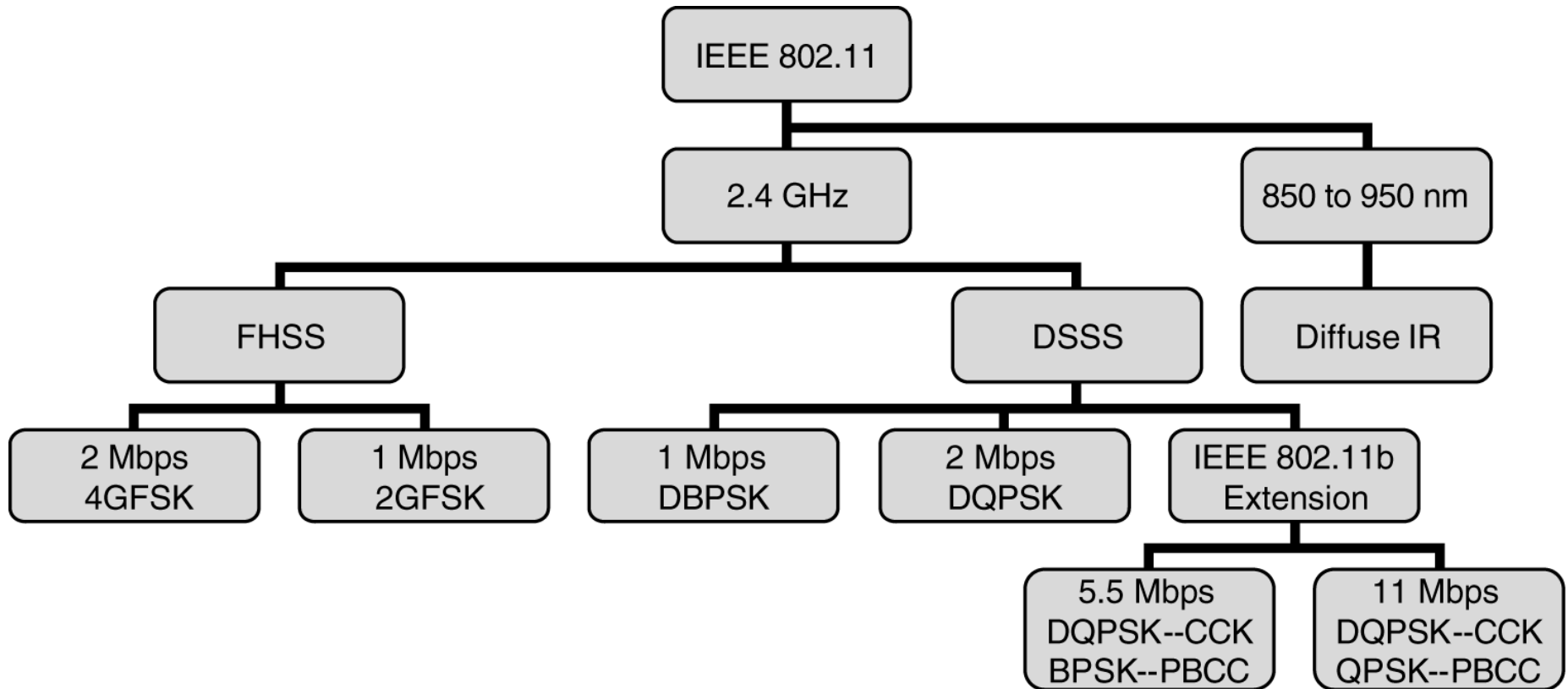
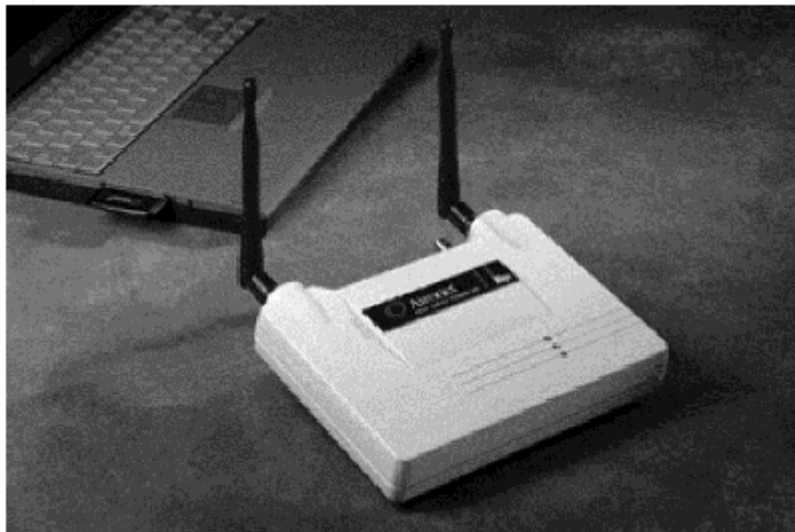


Figure 2.10 Overview of the IEEE 802.11 Wireless LAN standard.



**Figure 2.11 Photographs of popular 802.11b WLAN equipment. Access points and a client card are shown on left, and PCMCIA Client card is shown on right. (Courtesy of Cisco Systems, Inc.)**

## 5. Bluetooth and Personal Area Networks (PAN)

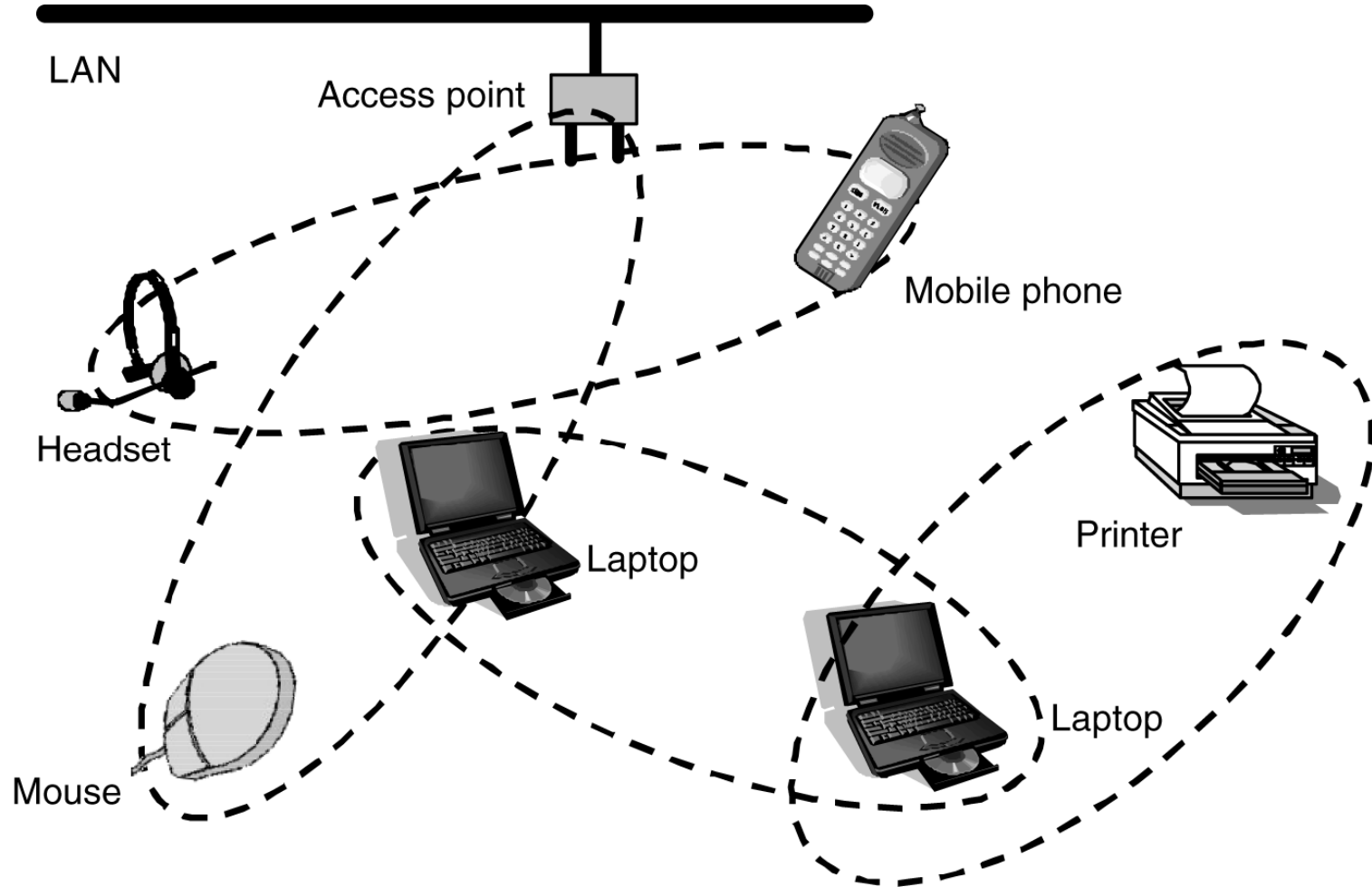


Figure 2.17 Example of a Personal Area Network (PAN) as provided by the Bluetooth standard.