Information Technology Fundamentals

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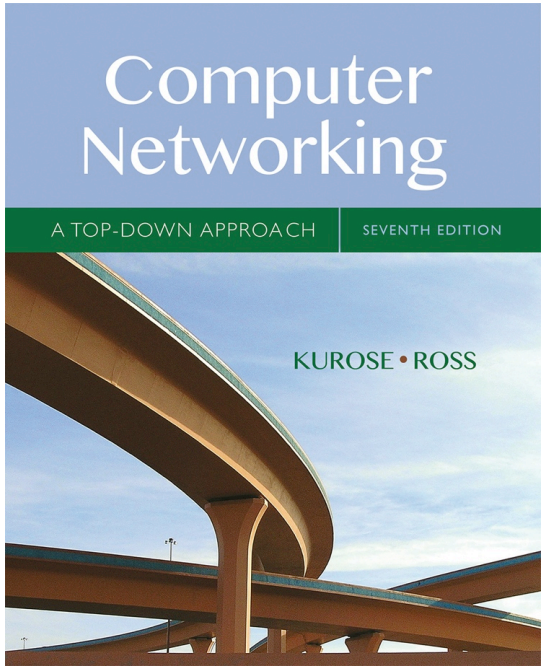
Networking: Cellular Networks
Module 2: Part 3

Reference: Chapter 7 Wireless and Mobile Networks



Computer Networking: A Top Down Approach

7th edition
Jim Kurose, Keith Ross
Pearson/Addison Wesley
April 2016

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Thanks and enjoy! JFK/KWR

Chapter 7 outline

7.1 Introduction

Wireless

7.2 Wireless links, characteristics
- CDMA

7.3 IEEE 802.11 wireless LANs ("Wi-Fi")

7.4 Cellular Internet access
- architecture
- standards (e.g., 3G, LTE)

Mobility

7.5 Principles: addressing and routing to mobile users

7.6 Mobile IP

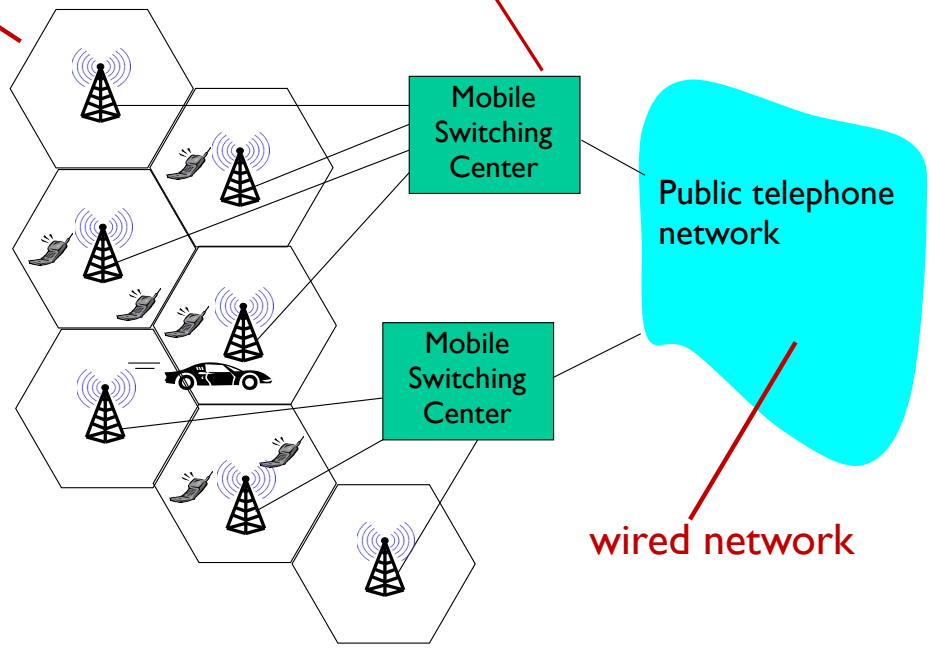
7.7 Handling mobility in cellular networks

7.8 Mobility and higher-layer protocols

Components of cellular network architecture

MSC
- connects cells to wired tel. net.
- manages call setup (more later!)
- handles mobility (more later!)

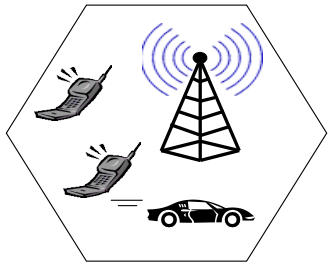
cell
- covers geographical region
- *base station* (BS) analogous to 802.11 AP
- *mobile users* attach to network through BS
- *air-interface:* physical and link layer protocol between mobile and BS

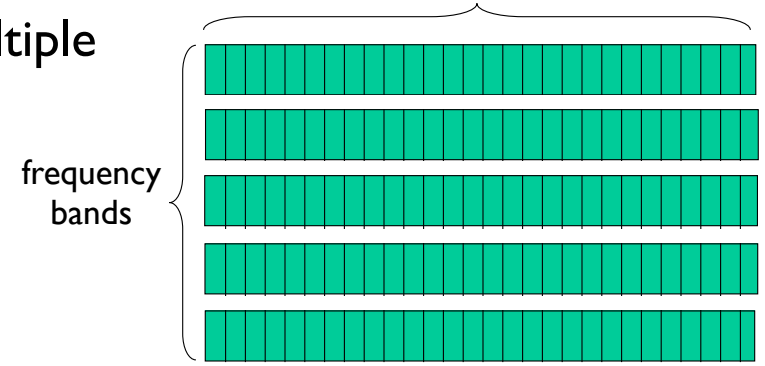


Cellular networks: the first hop

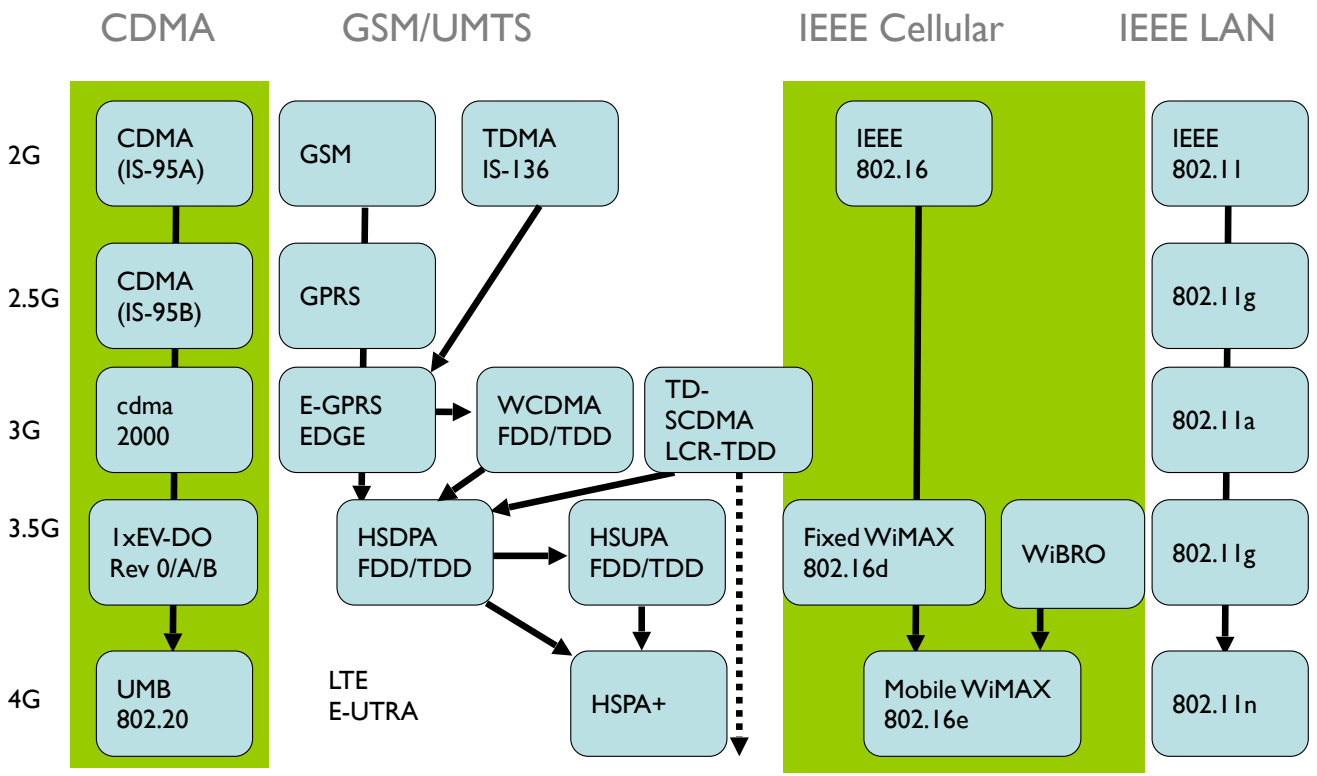
Two techniques for sharing mobile-to-BS radio spectrum

- combined FDMA/TDMA: divide spectrum in frequency channels, divide each channel into time slots
- CDMA: code division multiple access

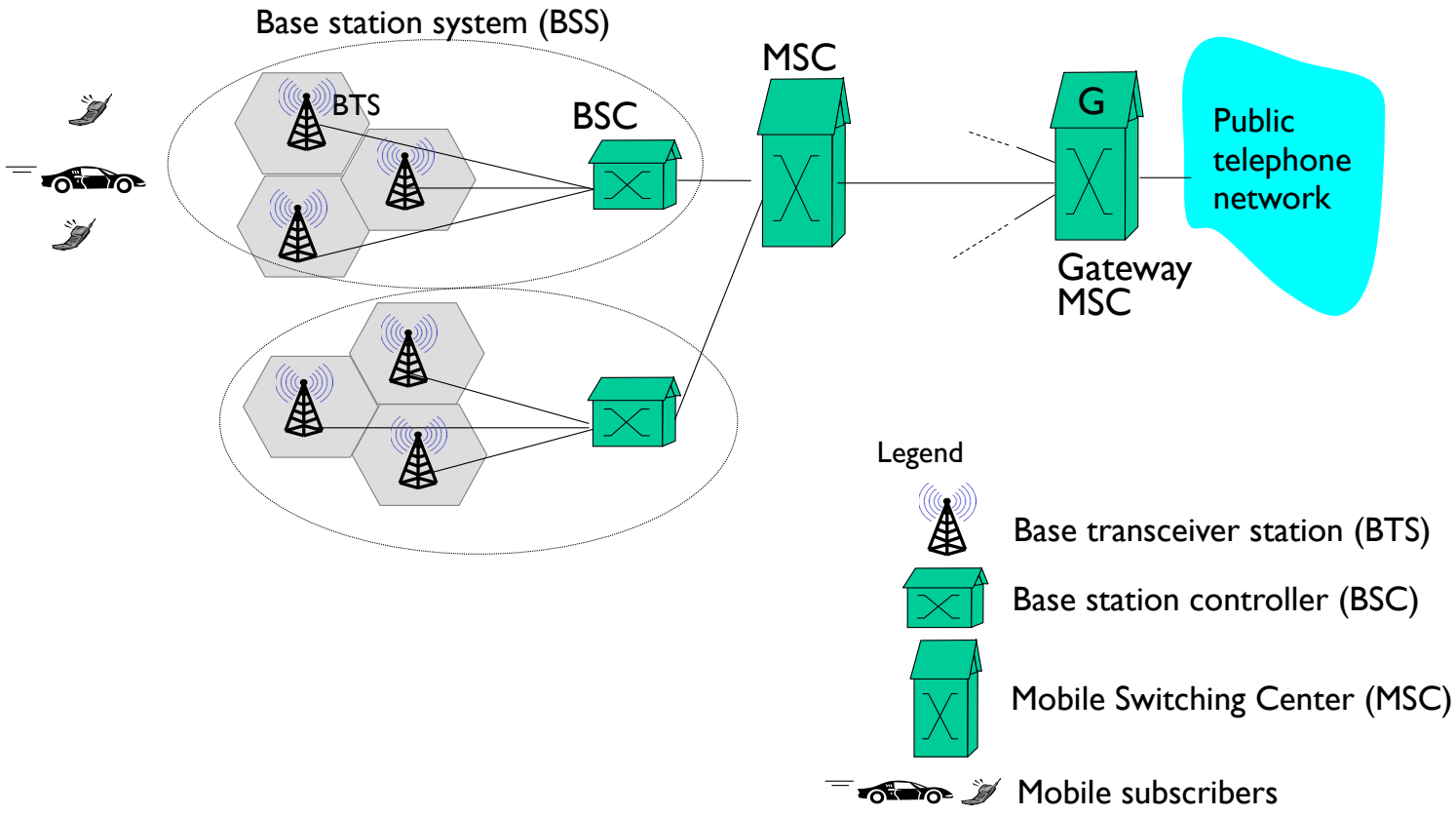




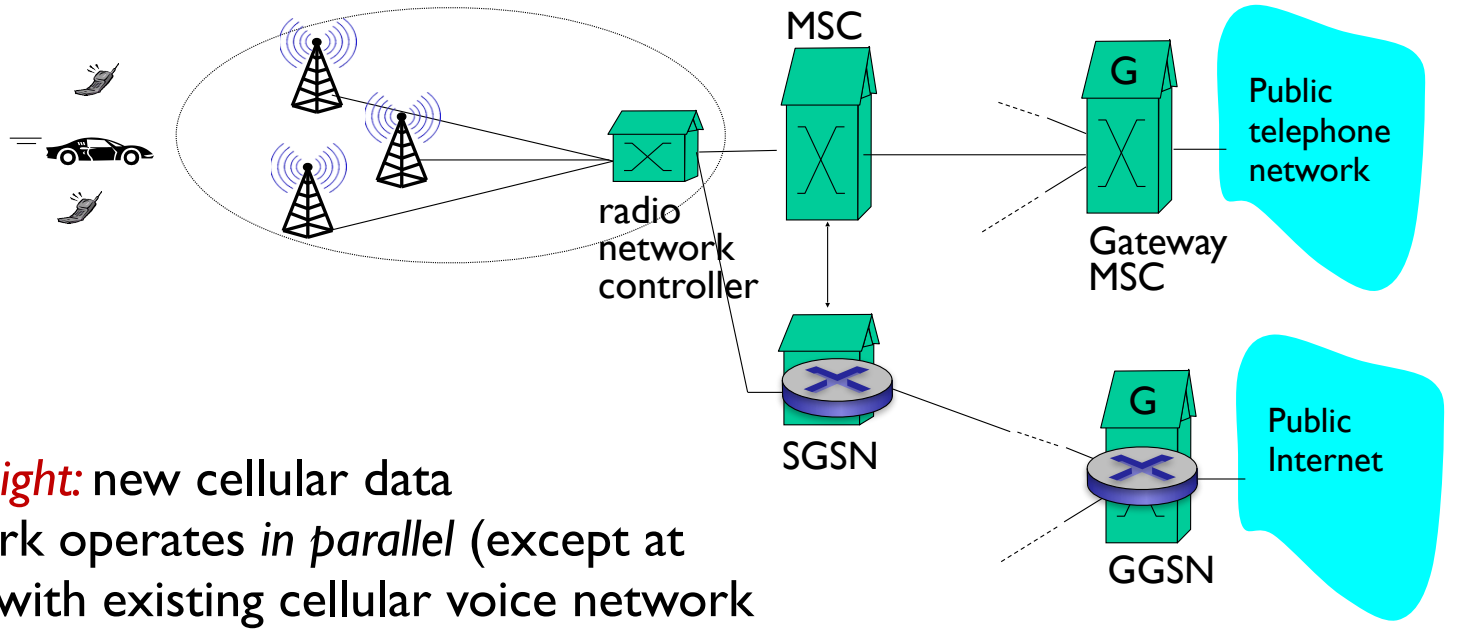
Wireless Technology Evolution to 4G



2G (voice) network architecture



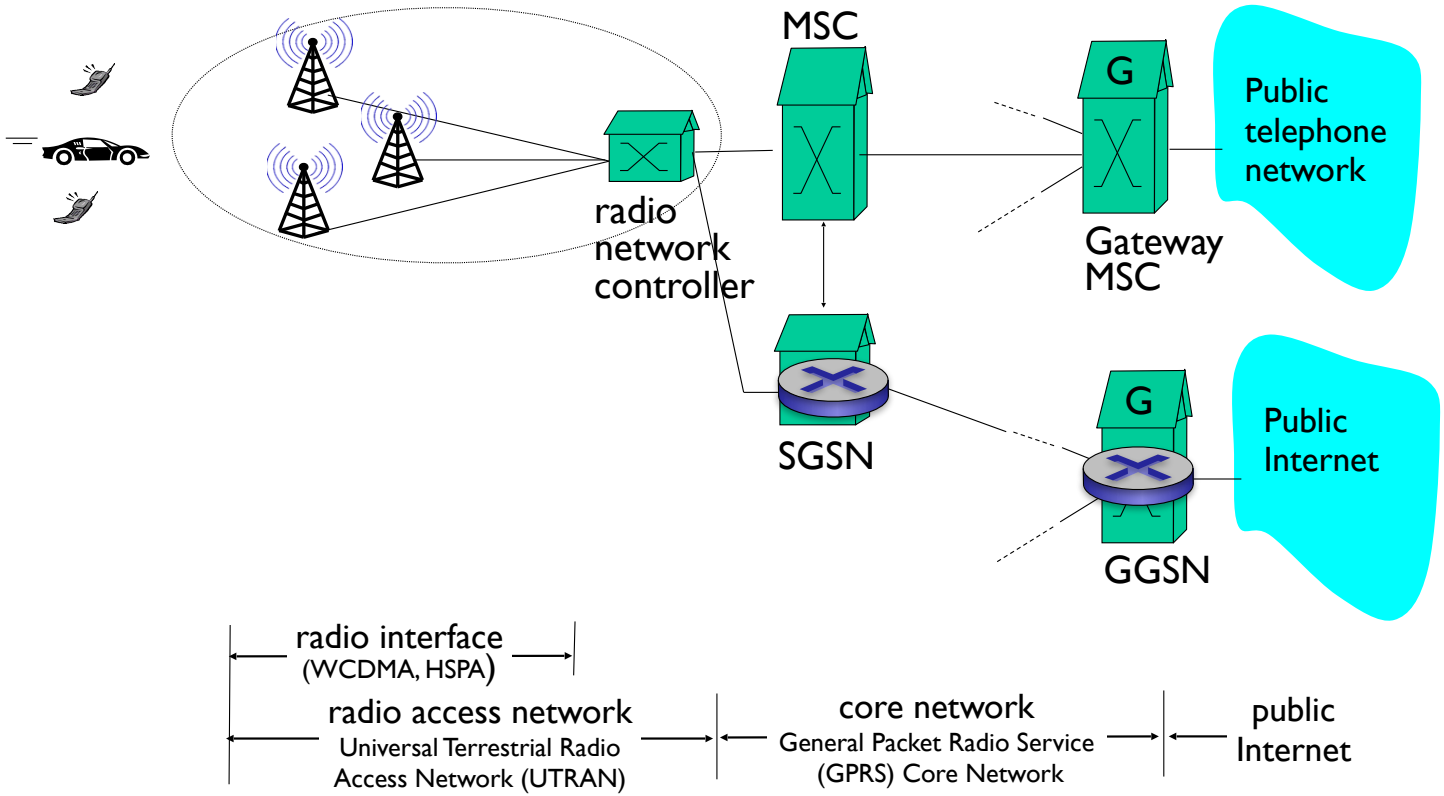
3G (voice+data) network architecture



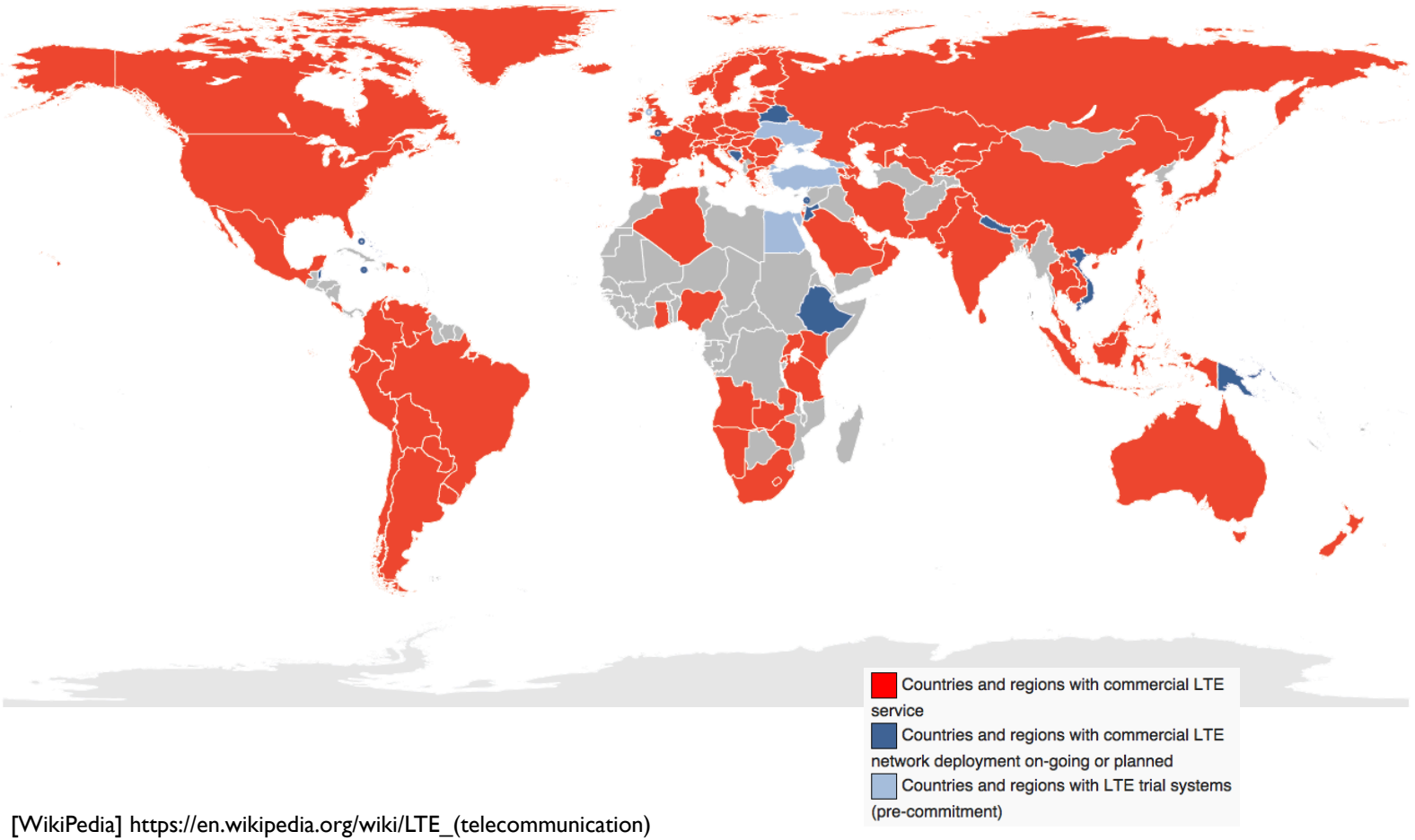
Key insight: new cellular data network operates *in parallel* (except at edge) with existing cellular voice network

- voice network *unchanged* in core
- data network operates in parallel

3G (voice+data) network architecture



LTE (Long Term Evolution) Coverage: 2015



[WikiPedia] https://en.wikipedia.org/wiki/LTE_(telecommunication)

LTE Penetration and Speed

Data speeds of LTE Advanced

	LTE Advanced
Peak download	1 Gbit/s
Peak upload	500 Mbit/s

Data speeds of LTE

	LTE
Peak download	100 Mbit/s
Peak upload	50 Mbit/s

Data speeds of WiMAX

	WiMAX
Peak download	128 Mbit/s
Peak upload	56 Mbit/s

Rank	Country/Territory	Penetration
1	South Korea	97.5%
2	Japan	96.3%
3	Norway	95.5%
4	Hong Kong	94.1%
5	United States	93.0%
6	Netherlands	92.8%
7	Taiwan	92.8%
8	Hungary	91.4%
9	Sweden	91.1%
10	India	90.9%

In February 2007, the Japanese company NTT DoCoMo tested a 4G communication system prototype with 4×4 MIMO called VSF-OFCDM at 100 Mbit/s while moving, and 1 Gbit/s while stationary.

NTT DoCoMo completed a trial in which they reached a maximum packet transmission rate of approximately 5 Gbit/s in the downlink with 12×12.

Handset Evolution to 3G

Introduced	2001	2001	2002	2003	2004	2007	2011
							
Model	Motorola V60	Ericsson T68	Nokia 7210	BlackBerry 7230	Motorola RAZR V3	Apple iPhone 2G	Apple iPhone 4S
Display(s)	Monochrome graphic 96 x 64 pixels Second: monochrome	1.7" STN 256 colors 101 x 80 pixels	1.5" CSTN 4,096 colors 128 x 128 pixels (121 ppi)	2.6" TFT reflective 65,000 colors 240 x 160 pixels (111 ppi)	2.2" TFT 256,000 colors: 176 x 220 pixels Second: CSTN 4,096 colors	3.5" TFT capacitive touchscreen 16,000,000 colors 320 x 480 pixels (165 ppi)	3.5" LED-backlit IPS TFT, capacitive touchscreen 16,000,000 colors 690 x 960 pixels (330 ppi)
Data	2G GPRS 32-40 kbps	2G GPRS 24-36 kbps	2G GPRS 24-36 kbps	2G GPRS (<56kbps)	2G GPRS (38-42 kbps)	2G EDGE (<300kbps) WiFi	3G HSDPA 14.4 Mbps 3G HSUPA 5.8Mbps WiFi
Features	SMS, WAP 1.1 browser, games	SMS, MMS, Email, WAP 1.2.1	SMS, MMS, WAP 1.2.1 browser, games	SMS, Email, BlackBerry HTML browser Qwerty keyboard	SMS, MMS, Email, WAP 2.0/ xHTML browser Video player 0.3MP camera	SMS, Email, HTML Safari Video player 2MP camera 412 MHz CPU	SMS, Email, HTML Safari HD 1080p video @ 30 fps 8MP camera Dual core 1GHz CPU

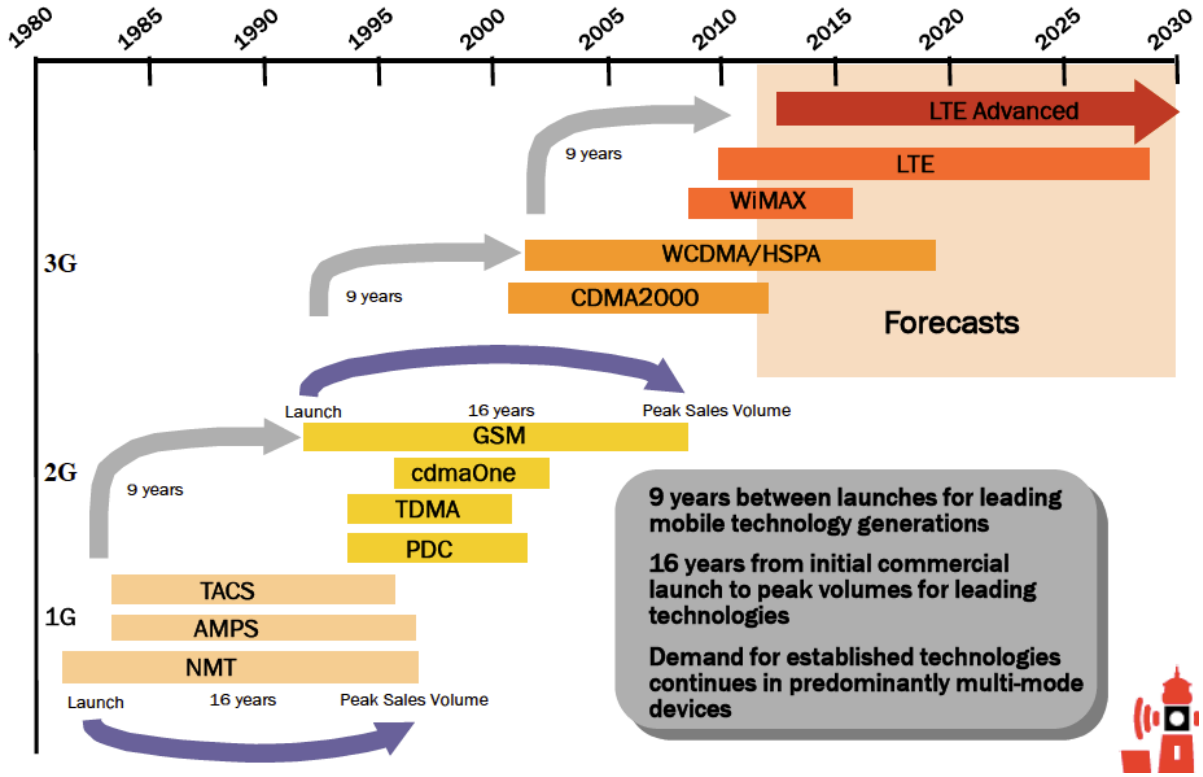
[The Value of 4G: Keith Mallinson]

4G Devices

Introduced	2012	2012
		
Model	Motorola DROID 4	Apple iPad 3
Display	4.00" TFT 16M colors 540 x 960 pixels (275ppi)	9.7" IPS LCD capacitive touchscreen 16M colors 2048 x 1536 pixels (264 ppi)
Processors	Dual core, 1.2GHz TI OMAP4430	Dual core, 1 GHz, Apple A5X and Quad core PowerVR SGX543MP4 for graphics
Data	LTE 700 MHz Class 13, CDMA EV-Do Rev A	LTE 700 MHz Class 17, 1700/2100 MHz HSDPA+ (42.2Mbps), UMTS, EDGE, GPRS
Features	Android 2.3.5, HTML5, Flash, 8MP and 1.3MP cameras, accelerometer, gyroscope and barometer	iOS 5.1, HTML5, 5MP and 0.3MP cameras, accelerometer, gyroscope, compass and voice commands

[The Value of 4G: Keith Mallinson]

Mobile Technology Adoption Lifecycles



[The Value of 4G: Keith Mallinson]