



Mobile System Connectivity

CSE 3203

Overview of Mobile Systems

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Overview



- Connectivity is the foundation of a great mobile experience
- The connectivity layer provides the basic connection infrastructure for mobile systems; this includes:
 - Mobile operators/carriers
 - Connections and networks (standards)
 - Devices for connections

Operators/Carriers



- A mobile network operator or MNO, also known as a carrier, is a provider of wireless communications services that owns or controls all the elements necessary to sell and deliver services to an end user
 - own or control access to a radio spectrum license from a regulatory or government entity
 - own or control the elements of the network infrastructure necessary to provide services to subscribers over the licensed spectrum.
 - https://en.wikipedia.org/wiki/Mobile_network_operator
- Major responsibilities
 - Create and maintain the mobile infrastructure: towers, satellites, cables, access points, etc.
 - Provide connection services and Internet/data services

Top Global Mobile Operators



- Top operators in the world by subscriptions
 - https://en.wikipedia.org/wiki/List_of_mobile_network_operators

Rank	Company	Country	Total subscriptions (in <u>millions</u>)
1	China Mobile	China	901.9 (May 2018)
2	Vodafone	UK	535.8 (March 2018)
3	Airtel	India	450.7 (March 2018)
4	China Unicom	China	297.0 (April 2018)
5	América Móvil	Mexico	279.1 (March 2018)
6	China Telecom	China	276.1 (May 2018)
7	Telefónica	Spain	271.9 (June 2018)

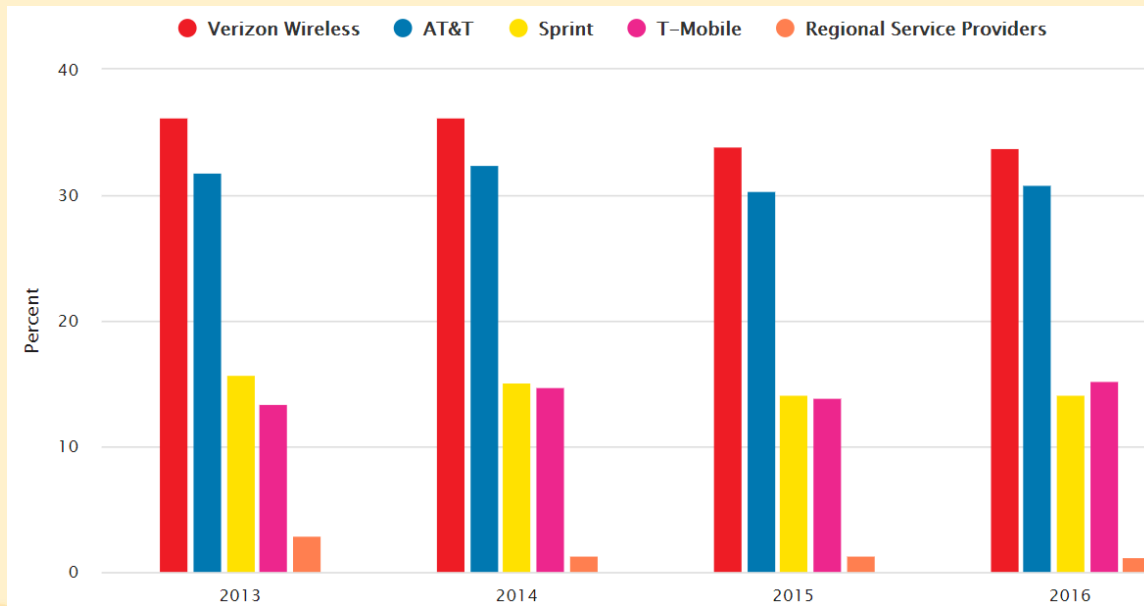
- Also see the top ten by market value
<https://www.investopedia.com/articles/markets/030216/worlds-top-10-telecommunications-companies.asp>

The Big 4 in US



- By subscriptions
 - https://en.wikipedia.org/wiki/List_of_United_States_wireless_communications_service_providers
 - Verizon Wireless: 152.7 million (Q2 2018)
 - AT&T Mobility: 147.3 million (Q2 2018)
 - T-Mobile US: 75.6 million (Q2 2018)*
 - Sprint Corporation: 53.7 million (Q2 2018)*

* T-Mobile and Spring proposed a merger in Jun 2018
<https://www.digitaltrends.com/mobile/t-mobile-sprint-merger/>



Market share:
<https://www.fcc.gov/20th-mobile-wireless-competition-report-quick-facts>

Mobile Virtual Network Operator



- A mobile virtual network operator (MVNO), virtual network operator (VNO), or mobile other licensed operator (MOLO), is a wireless communications services provider that does not own the wireless network infrastructure (and mobile spectrum license) over which it provides services to its customers.
 - https://en.wikipedia.org/wiki/Mobile_virtual_network_operator
- An MVNO enters into a business agreement with a mobile network operator to obtain bulk access to network services at wholesale rates, then sets retail prices independently. An MVNO may use its own customer service, billing support systems, marketing, and sales personnel, or it could employ the services of a mobile virtual network enabler (MVNE).
- MVNOs work independently of mobile network operators (MNOs) and can set their own pricing structure subject to the rates they've agreed to pay MNOs. MVNOs do not own any core mobile network-related infrastructure such as radio access networks or mobile switching centers. MVNOs appear as roaming partners of overseas networks if they own their own home location register. Certain MVNOs also run their own billing and customer care solutions called business support systems.
- Mobile virtual network operators (MVNOs) in the United States lease wireless telephone and data service from major carriers such as AT&T Mobility, Sprint Corporation, T-Mobile US, and Verizon Wireless, as well as regional carrier United States Cellular Corporation for resale. The largest operator of MVNO's is TracFone Wireless with over 25 million subscribers.
- Notable operators
 - Project Fi <https://www.androidcentral.com/project-fi>
 - Xfinity Mobile <http://www.fiercewireless.com/wireless/editor-s-corner-a-look-at-how-comcast-taking-its-xfinity-mobile-mvno-to-market>
 - Metro PCS
 - <https://gazetterevue.com/2017/04/top-10-mvnos-major-cell-provider-alternatives/>

MVNO Types



- **Branded reseller**
 - Sometimes referred to as a "Skinny MVNO", as the reseller almost totally relies on the MNO's facilities. They do not own any network elements, but may own and operate their own customer care, marketing, and sales operations.
- **Service Provider**
 - Sometimes referred to as a "Light MVNO". The service provider operates its own customer support, marketing, sales and distribution operations, and has the ability to set its tariffs independently from the retail prices set by the MNO.
- **Enhanced Service Provider**
 - Sometimes referred to as a "Thick MVNO". The MVNO manages a more complete technical implementations with its own infrastructure which allows the MVNO more control over its offerings. These MVNOs have a heavier focus on branding, customer-ownership, and differentiation through added services like data and SIM applications.
- **Full MVNO**
 - These MVNOs have a network implementation operating essentially the same technology as a mobile network operator. Full MVNOs only lack their own radio networks.
- **See**
 - https://en.wikipedia.org/wiki/Mobile_virtual_network_operator#Types

Goodies



- <https://www.tomsguide.com/us/best-phone-carriers,review-3066.html>
- <https://bestmvno.com/mvnos/>

Connections



- Connection (data transfer) through air and radio waves
- All radio access technologies have to solve the same problems: to divide the finite RF spectrum among multiple users as efficiently as possible.

Major Connection Types

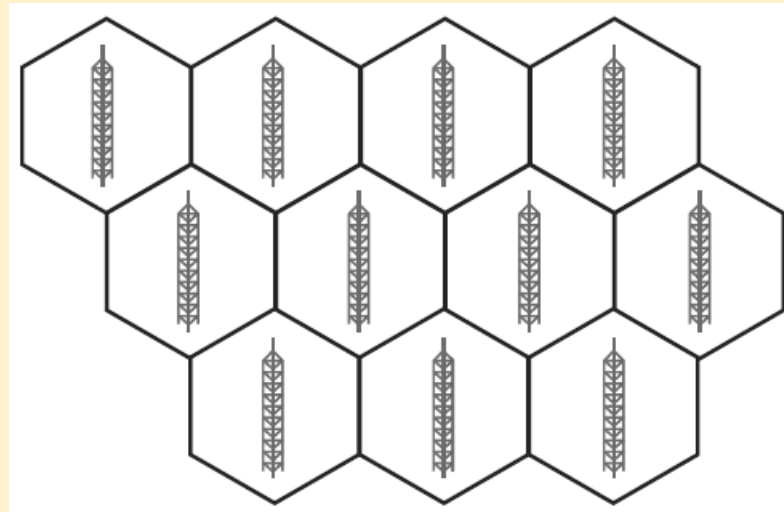


- Wide area (mobile broadband)
 - Cellular networks: GSM, HSPA, LTE: provide direct connection and maintained by mobile operators
 - Wide coverage but lower speed (compared to WiFi)
 - Broadband wireless access https://en.wikipedia.org/wiki/Mobile_broadband
 - Satellite
- Local area
 - Wireless LAN, WiFi, 802.11 family of standards
 - Can be set up by private (home or workplace) or public (mall, airport, etc.) providers
 - High speed but limited coverage
 - Mobile hotspot: WiFi + Cellular
- Wireless near-me or personal area network(WPAN)
 - Direct P2P connections: Bluetooth, NFC
- https://en.wikipedia.org/wiki/Comparison_of_wireless_data_standards

Cellular Network



- In the case of cellular networks, the data is transmitted through a network of transmitters and receivers.
- A mobile phone network is divided into thousands of overlapping geographic areas, or *cells*. A typical cellular network can be envisioned as a mesh of hexagonal cells,



Cellular Network Generations



	1G	2G	3G	4G
Name	1st Generation Mobile Network	2nd Generation Mobile Network	3rd Generation Mobile Network	4th Generation Mobile Network
Introduced in year	1980s	1993	2001	2009
Technology	AMPS, NMT, TACS	GSM , IS-95	IMT2000, WCDMA	LTE, WIMAX
Multiple Address/Access system	FDMA	TDMA, CDMA	CDMA	CDMA
Switching type	Circuit switching	Circuit switching for Voice and Packet switching for Data	Packet switching except for Air Interface	Packet switching
Speed (data rates)	2.4 Kbps to 14.4 kbps	14.4 Kbps	3.1 Mbps	100 Mbps
Special Characteristic	First wireless communication	Digital version of 1G technology	Digital broadband, speed increments	Very high speeds, All IP
Features	Voice only	Multiple users on single channel	Multimedia features, Video Call	High Speed, real time streaming
Supports	Voice only	Voice and Data	Voice and Data	Voice and Data

<https://www.qualcomm.com/documents/evolution-mobile-technologies-1g-2g-3g-4g-lte>

1G to 4G Comparison



Mobile 1G

AMPS, NMT, TACS



Mobile 2G

D-AMPS, GSM/GPRS, cdmaOne



Mobile 3G

CDMA2000/EV-DO, WCDMA/HSPA+, TD-SCDMA



Mobile 4G LTE

LTE, LTE Advanced



N/A

<0.5 Mbps¹

63+ Mbps²

300+ Mbps³

Analog Voice



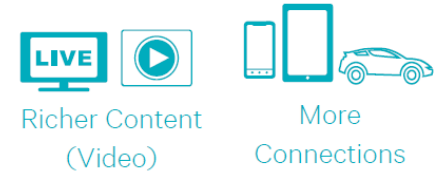
Digital Voice + Simple Data



Mobile Broadband



Faster and Better



Richer Content
(Video)

More
Connections

1



1G established seamless mobile connectivity introducing mobile voice services

3



3G optimized mobile for data enabling mobile broadband services, and is evolving for faster and better connectivity

2



2G digital wireless technologies increased voice capacity delivering mobile to the masses

4

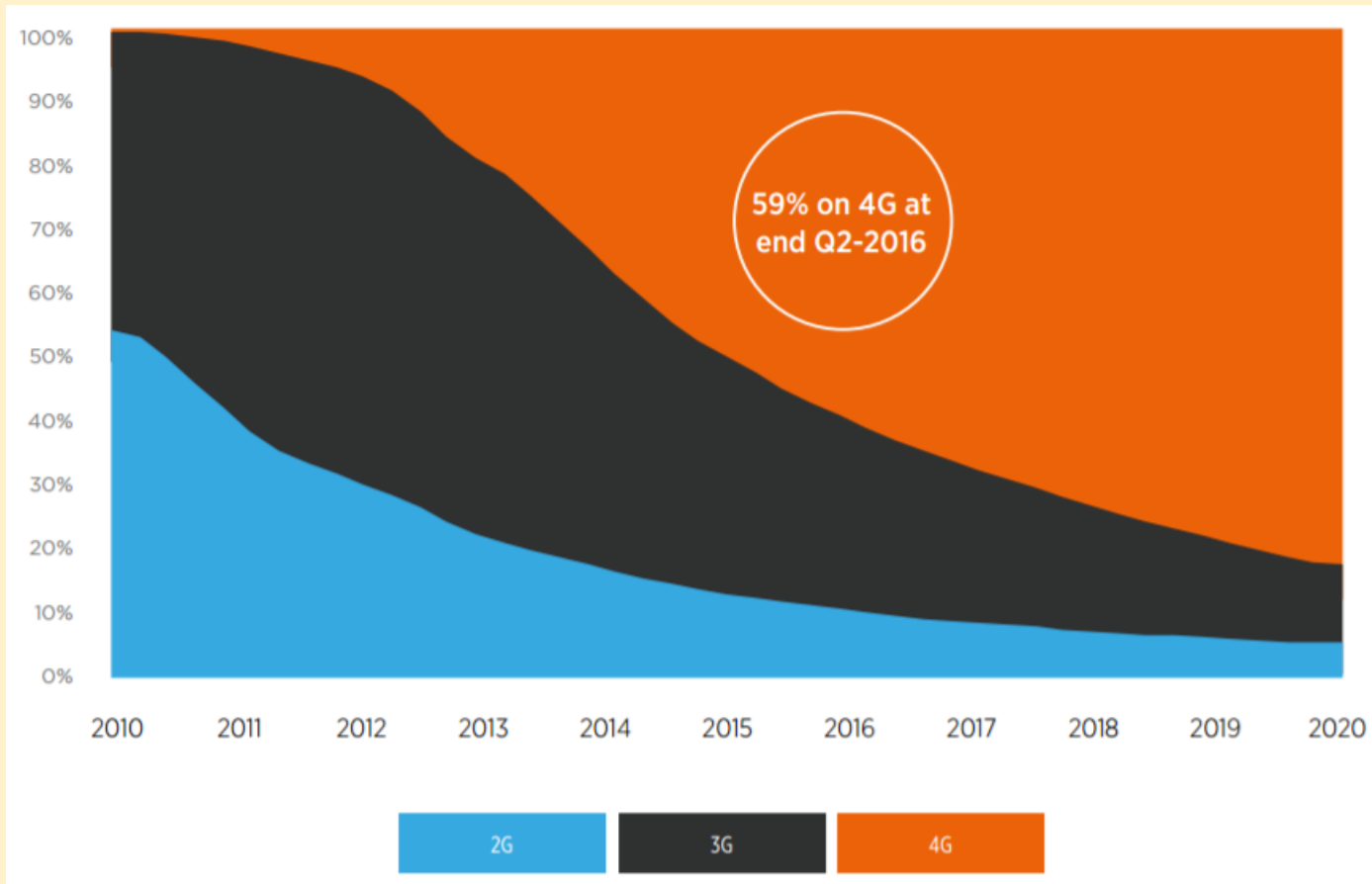


4G LTE delivers more capacity for faster and better mobile broadband experiences, and is also expanding in to new frontiers

Cellular Generation Market



- Generation of cellular connections



<https://www.gsmaintelligence.com/research/2016/11/the-mobile-economy-north-america-2016/587/>

5G



- What is 5G?
 - <https://www.youtube.com/watch?v=2DG3pMcNNlw>
- 5G is the fifth generation of mobile connection technologies defined by 3GPP (3rd Generation Partnership Project) – the standard body that also overlooked the development of 3G UMTS (including HSPA) and 4G LTE standards.
- Currently under development
 - 5G technology is expected to officially launch across the world by 2020
- <https://www.tomsguide.com/us/5g-networking-faq,news-20629.html>

Key Technologies and Standards



- GSM (vs. CDMA)
- CDMA (vs. TDMA)
- HSPA+
- LTE
- See more
 - https://en.wikipedia.org/wiki/Comparison_of_mobile_phone_standards
 - <https://www.pcmag.com/encyclopedia/term/55406/cellular-generations>

Wireless LAN Access Point



- WiFi
 - Wi-Fi is the name of a popular wireless networking technology that uses radio waves to provide wireless high-speed Internet and network connections.
 - Wi-Fi is a trademarked phrase that means IEEE 802.11x family standards.
 - A common misconception is that the term Wi-Fi is short for "wireless fidelity," however this is not the case.
 - http://www.webopedia.com/TERM/W/Wi_Fi.html
- Features
 - Limited coverage for home, workplace, business location, etc.
 - High speed
 - Hardware integrated (almost all these days)

802.11x Comparison



- 802.11 Standards Explained
 - <https://www.lifewire.com/wireless-standards-802-11a-802-11b-g-n-and-802-11ac-816553>
 - <http://www.androidauthority.com/wifi-standards-explained-802-11b-g-n-ac-ad-ah-af-666245/>

	802.11 (legacy)	802.11a	802.11b	802.11g	802.11n	802.11ac
Max Speed	1.2 Mbit/s	54 Mbit/s	11 Mbit/s	54 Mbit/s	150 Mbit/s	800 Mbit/s
MIMO	no	no	no	no	up to 4	up to 8
Frequency	2.4 GHz	5.8 GHz	2.4 GHz	2.4 GHz	2.4 & 5 GHz	5 GHz
Year	1997	1999	1999	2003	2009	2013

<http://www.androidauthority.com/wifi-standards-explained-802-11b-g-n-ac-ad-ah-af-666245/>

Mobile Hotspot



- A device that taps into 3G and/or 4G cellular networks, and then wirelessly shares its data connection with other nearby (within 30 feet or so) Wi-Fi-enabled devices.
 - <http://heresthethingblog.com/2012/01/26/mobile-wi-fi-hotspots-questions/>



- Devices
 - <https://www.pcmag.com/article2/0,2817,2400503,00.asp>

Public Mobile Hotspots



- Operators provide hotspot services
 - <http://hotspots.wifi.comcast.com>
 - <https://money.cnn.com/2014/06/16/technology/security/comcast-wifi-hotspot/index.html>
 - <https://www.xfinity.com/hub/internet/internet-on-the-go>
 - <https://www.att.com/maps/wifi/basic.html>
 - <https://wifispc.com>
 - Google Free Wifi hotspot

WPAN



- Wireless Personal Area Network
 - Bluetooth
 - NFC

Bluetooth



- Bluetooth® is a low-power wireless connectivity technology used to connect devices in short distance.

Bluetooth version	Maximum speed	Maximum range
3.0	25 Mbit/s	10 meters (33 ft)
4.0	25 Mbit/s	60 meters (200 ft)
5	50 Mbit/s	240 meters (800 ft)

- Typical uses
 - Connecting input/output devices like speaker, headset, mouse, keyboard, controller
 - Sharing data and files
- <https://en.wikipedia.org/wiki/Bluetooth>

NFC



- NFC stands for Near Field Communication.
 - A way for phones/devices to interact in close proximity - a radius of about 4 cm
 - allows for two-way communication, with both devices involved being able to send and receive information.
 - does not rely on Wi-Fi, 3G, LTE or otherwise, and it doesn't cost anything to use
- Typical usage
 - Send/share short message or photos
 - Share files directly
 - Payment
 - Sensors objects (vs. QR code)
 - Open doors (cars)
 - <https://www.androidpit.com/what-is-nfc>

NFC vs. Bluetooth



	NFC	Bluetooth
History	2004, initiated by Nokia, Sony, Philips	1994, created by Ericsson
Technology	Radio waves; frequency-hopping spread spectrum	RFID combined with smartcard infrastructure
Standards	ISO, ECMA, ETSI	IEEE Global Standard
Users (in %)	200 million	2 billion
Communication frequency	13.56 MHz	2.04 GHz
Data transfer rate	424 kbits/s	1–3 Mbits/s
Power consumption	Very Less	Less but a bit high compared to NFC
How it works	No pairing required for data transfer	By pairing two devices within a short distance you can transfer data
Accessibility	Tap screen to transfer data (highly intuitive)	Search devices, select the one and start data transfer (no intuitive)
Ease of use	Very easy	Bit difficult compared to NFC
Data exchange over distance	Within 4 cm	Within 32 feet or 10 meters
Data transfer ability	Very fast	Fast
Multi-device connectivity	2 Devices at the same time	Connects up to 8 devices at the same time
Cost-effectiveness	Expensive	Inexpensive
Convenience	High	Not as high as NFC
Social networking ability	Yes	No
Payment transaction	Yes	No
Security	Intermediate; neither high nor low (allows for anti-virus installation)	Low (no option to enhance security)
Benefited Sectors	Electronics, Healthcare, Transport, Payments, Access Control, etc.	Sports & Fitness, Medical, Health & Wellness

Good Resources



- Qualcomm learning resources
 - <https://www.qualcomm.com/wireless-simplified>
 - <https://www.qualcomm.com/wireless-simplified/wireless-fundamentals>
- https://en.wikipedia.org/wiki/Comparison_of_wireless_data_standards
- https://en.wikipedia.org/wiki/Comparison_of_mobile_phone_standards
- FCC Mobile Wireless Competition Reports
 - <https://www.fcc.gov/general/mobile-wireless-competition-reports>
- <https://whatsag.com>