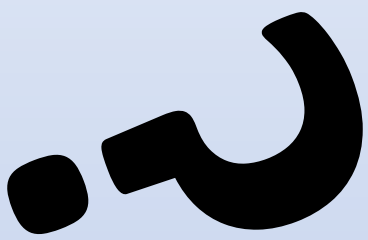
5G (5th Generation) Technology
-- March 20, 2018 --

Thomas Aprille

www.quartomese.com



5G

What is it?

5G

5G

5G (also 3/4G)

- Applies to two major applications
  - Mobile
    - The normal non-stationary cell- and smart-phones
      - Low mobility – pedestrian walking speeds
      - High mobility – moving vehicles
  - Fixed Wireless
    - Fixed location LAN connectivity
      - Rural data connectivity
      - Urbane business environment connectivity

1G to 5G

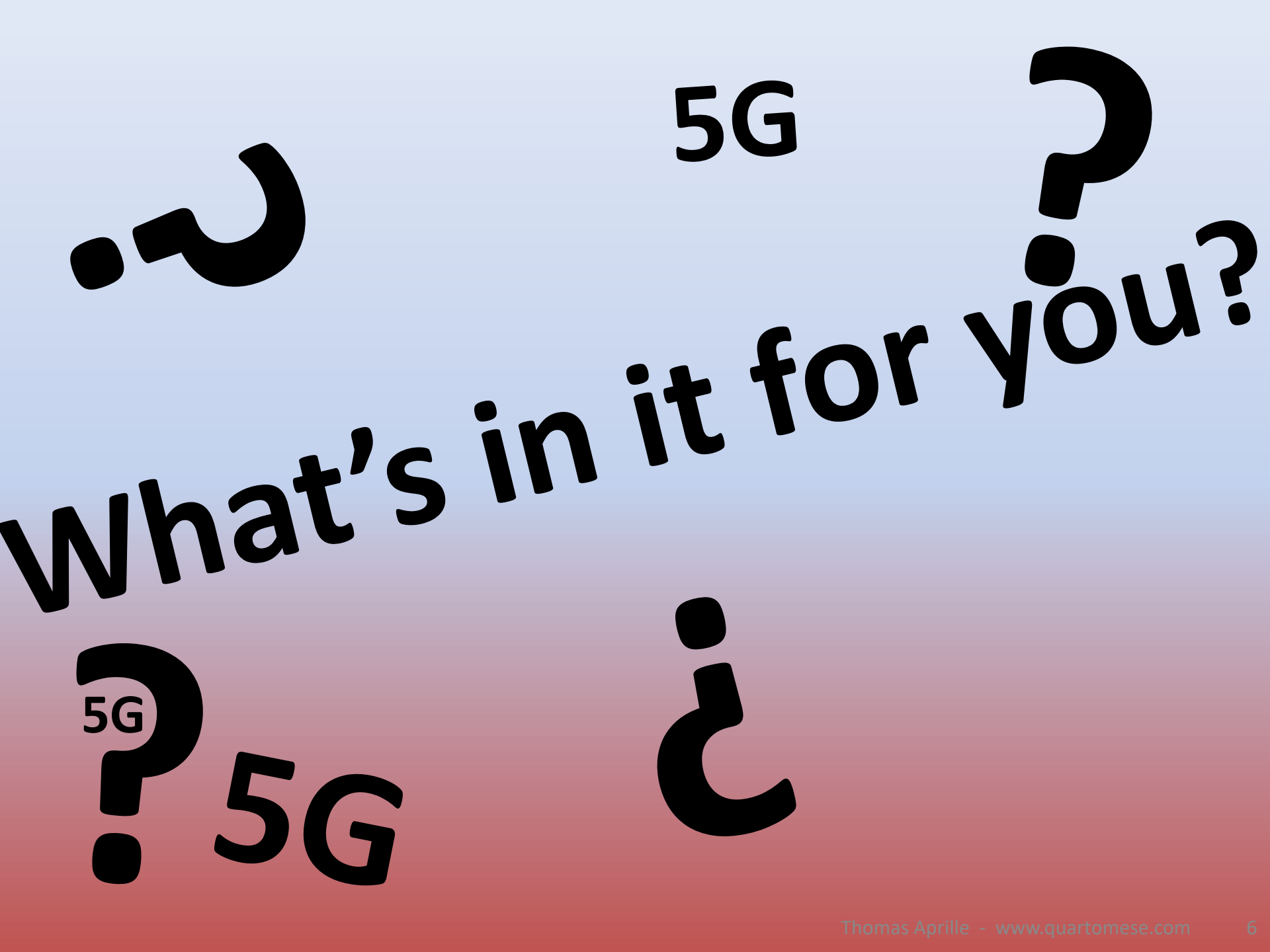
	1G	2G – 2.5G	3G	4G	5G
Available	1970	1980	1990	2000	?
Bandwidth		14-64 Kbps	2Mbps	200Mbps to 1Gbps (low mobility)	>1Gbps
Technology	AMPS	TDMA, CDMA, GSM, GPRS	WCDMA, CDMA-2000, MIMO	OFDMA, MC-CDMA, LMPS, MIMO	CDMA, BDMA, MIMO, etc

TDMA: Time Division Multiple Access
CDMA: Code Division Multiple Access
GSM: Global System for Mobile
GPRS: General Packet Radio Services
WCDMA: Wideband CDMA
OFDMA: Orthogonal Frequency Division Multiple Access
MC-CDMA: Multi Carrier CDMA
MIMO: Multiple Input Multiple Output
M-MIMO: Massive MIMO

5G Over 4G

- 3X improvement in spectral efficiency
- Very low latency (from 100/10 to 1 msec)
- 100X gain in reliability (Ultra-high, 5-9's)
- Increase in peak data rate from 1 to 20 Gbps
- 100X gain in service rate
- Traffic density increase from .1 to 10 Mbps/m^2
- 100X gain in network energy efficiency
- Mobility increase from 250 to 500 Km/h

http://www.ni.com/white-paper/52382/en/
https://www.edn.com/electronics-blogs/5g-waves/4459761/Realizing-5G-New-Radio-massive-MIMO-systems

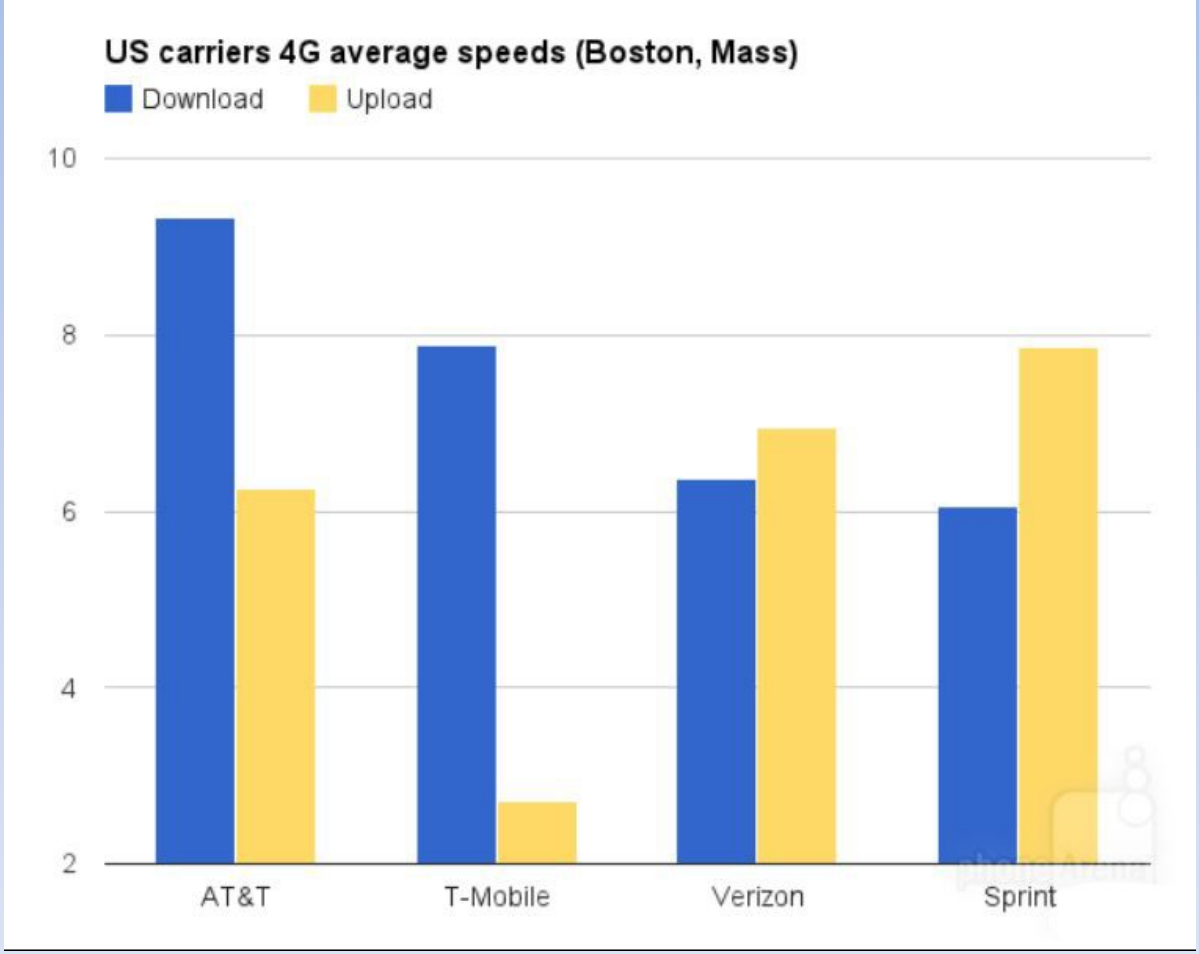

5G
What's in it for you?
5G
5G

Three Benefits of 5G

- Faster mobility speeds
  - 100Mb/s speeds compared to 4G speeds of 10 Mb/s
- Lower latency
  - Netflix movie starts much faster!
  - Server/network latency not clear (understood)
- Increased bandwidth
  - Enough bandwidth to handle everything
    - Self driving cars/trucks/buses, UHD video, IoT

Yahoo Finance: https://finance.yahoo.com/news/5g-will-will-get-181928644.html

Average Boston 4G Speeds

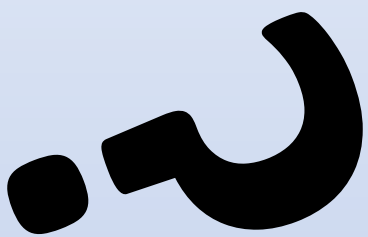


Results from phonearena.com (March 2014)

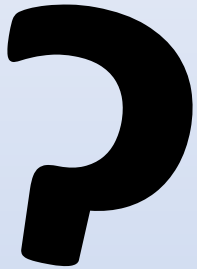
Examples
Low Latency / High Bandwidth Services

- High-usage voice, data, video services in a stadium of 80,000 spectators
- Reliable IoT communications
- Self driving vehicle safety
  - Vehicle to vehicle communications
  - Vehicle to infrastructure
- Drone control & telemetry
- Smart cities
- UHD streaming video
  - Live video streaming
  - Netflex
- Virtual reality
- High-bandwidth gaming

http://www.huawei.com/minisite/5g/img/GSA_the_Road_to_5G.pdf



5G



What's being said ?

5G

5G

Verizon 5G Trials

- Verizon is
  - Working with partners: Ericsson, Intel, Nokia, Samsung, Qualcomm, Apple, Cisco, LG, others
  - Working on standards – none available yet
- Claiming:
  - Benefits of fiber to wireless (???)
  - Antenna innovations: beam-forming, beam tracking, massive MIMO, wideband spectrum

http://www.verizon.com/about/news/verizon-5g-trials-driving-ecosystem-towards-rapid-commercialization

Verizon: 5G Technology

- 3/1/18
  - At Mobile World Congress
    - Verizon has committed to being first to market in the U.S. with both fixed and mobile 5G service.
- 1/11/2018
  - CES: CTO Vestberg Says Verizon will be first to introduce 5 January 11, 2018.
- 12/19/2017
  - Verizon expands 5G & IoT testing … test facility in Bedminster, New Jersey.
- 11/29/2017
  - Verizon to launch 5G residential broadband services in up to 5 markets in 2018
    - 5G will use radio signals, rather than copper or fiber cables, to provide customers with unprecedented wireless speeds for Internet access.
- 10/26/2017
  - Verizon and Ericsson team up to deploy Massive MIMO
    - Verizon and Ericsson … [with] first deployment of FDD Massive MIMO.
- 9/11/2017
  - How the Fourth Industrial Revolution will change the economy
    - A Fourth Industrial Revolution is upon us. … 5G will make the world safer, faster and more efficient.

http://www.verizon.com/about/news/mobile-world-congress-day-4-toby-redshaw-building-5g-ecosystem-potential-change-peoples-lives
http://www.verizon.com/about/news-tag/5g-technology

AT&T 5G Trials

- AT&T trial in Austin
  - Expanding 5G *fixed-wireless* trials to South Bend, Waco & Kalamazoo
    - Partnership with Ericsson, Nokia, Intel & Samsung
  - Austin trial speeds of 1Gbps and latency < 10 msec
- Trials will use
  - Ericsson 28GHz radio, vRAN, 5G virtualised core
  - Intel 5G mobile trial platform
  - Samsung 5G router, 5G RFIC chipset, virtualised core, vRAN
  - Nokia 5G equipment and solutions

http://www.zdnet.com/article/at-t-expands-5g-trials-to-three-more-cities/

Nokia CEO

- 4G equipment demand lessening
  - 5G will increase equipment demand
- Operators saying they see 2018 5G investments
- US and China activity will dwarf Europe

https://finance.yahoo.com/news/nokia-ceo-sees-big-5g-161506732.html?soc_src=mail&soc_trk=ma

5G At The Olympics

- **5G is helping make Pyeongchang the most high-tech Olympics ever**
  - Self-driving cars/buses
  - Smart home devices
  - Virtual reality
  - Smart suit
- **5G Is Making Its Global Debut at Olympics, and It's Wicked Fast**
  - Scare Korea's wild boars
  - 360-degree images
  - Just wait for the 2020 Tokyo Olympics
- Lots of marketing

http://money.cnn.com/2018/02/19/technology/pyeongchang-winter-olympics-5g-intel/index.html
https://www.bloomberg.com/news/articles/2018-02-12/5g-is-here-super-speed-makes-worldwide-debut-at-winter-olympics

US Considers Building 5G Network

- Precipitated by concerns of
  - Similar China government-owned proposal
  - Cybersecurity
    - Huawei, the Chinese network equipment maker
- Decision timeframe of September, 2018

Yahoo Finance – Bloomberg 1/28/18: https://finance.yahoo.com/news/u-considers-building-5g-network-035714135.html

Trump considers nationalizing 5G network

- The U.S. government pays for and builds the single network
  - Government builds network
  - Carriers bind together in a consortium to build the network for the government

Axios Jan 28, 2018 w/talk VGs: https://www.axios.com/trump-team-debates-nationalizing-5g-network-f1e92a49-60f2-4e3e-acd4-f3eb03d910ff.html

Government 5G Network

According to Axios.com, a memo and PowerPoint presentation crafted by an unnamed senior official of the National Security Council urges the Trump administration to take "extraordinary efforts to counter the growing economic and political threat from China's aggressive efforts to develop 5G."

The National Security Council memo reportedly asserts that "China has achieved a dominant position in the manufacture and operation of network infrastructure," and "China is the dominant malicious actor in the Information Domain."

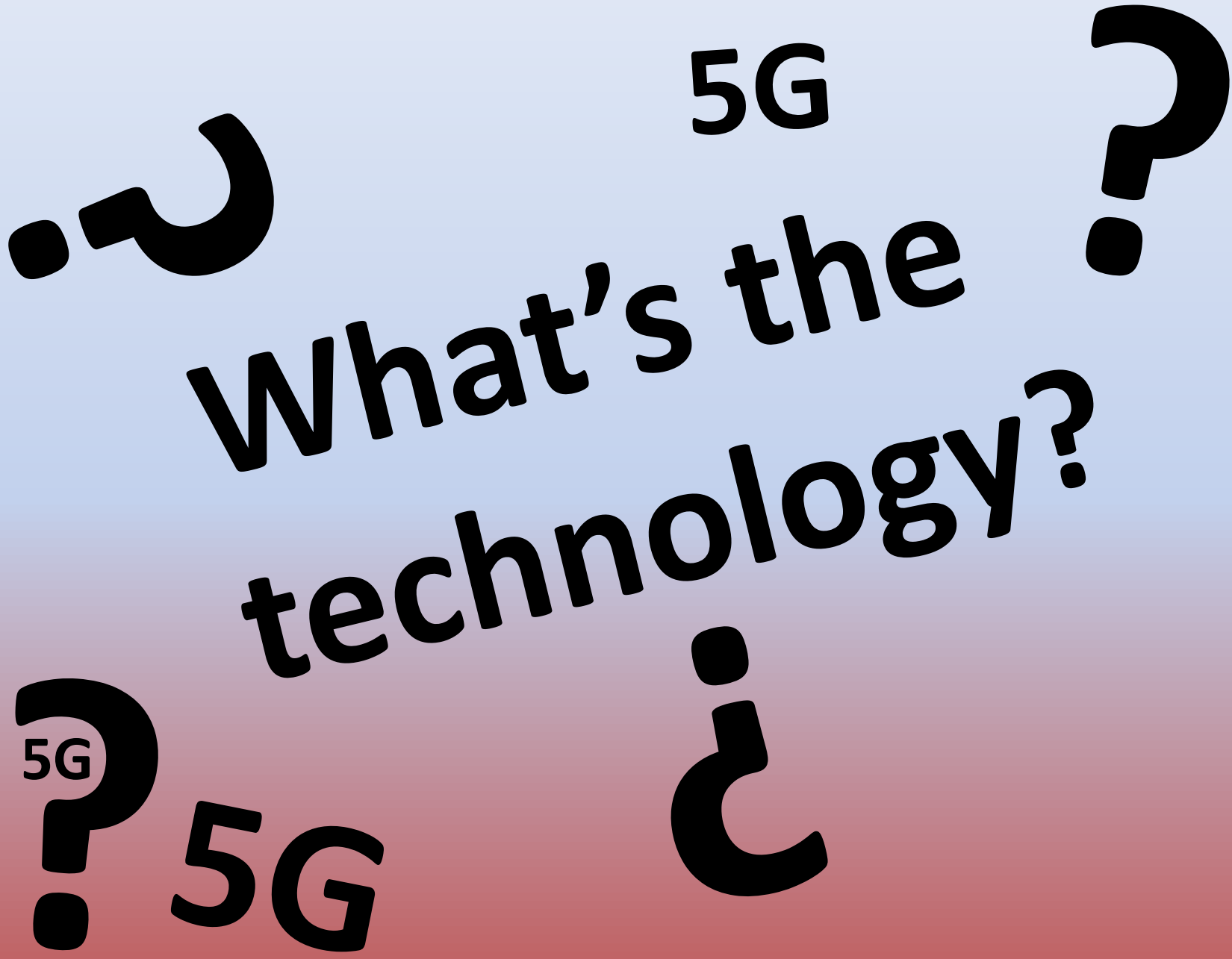
There is no national security risk from a 5G network in China. The real threat to the U.S. is the federal government's failure to secure American telecommunications networks.

Central Mirror Article – Feb. 3, 2018: http://centralmirror.com/this-is-why-the-government-shouldnt-build-its-own-5g-network/
Axios: https://www.axios.com

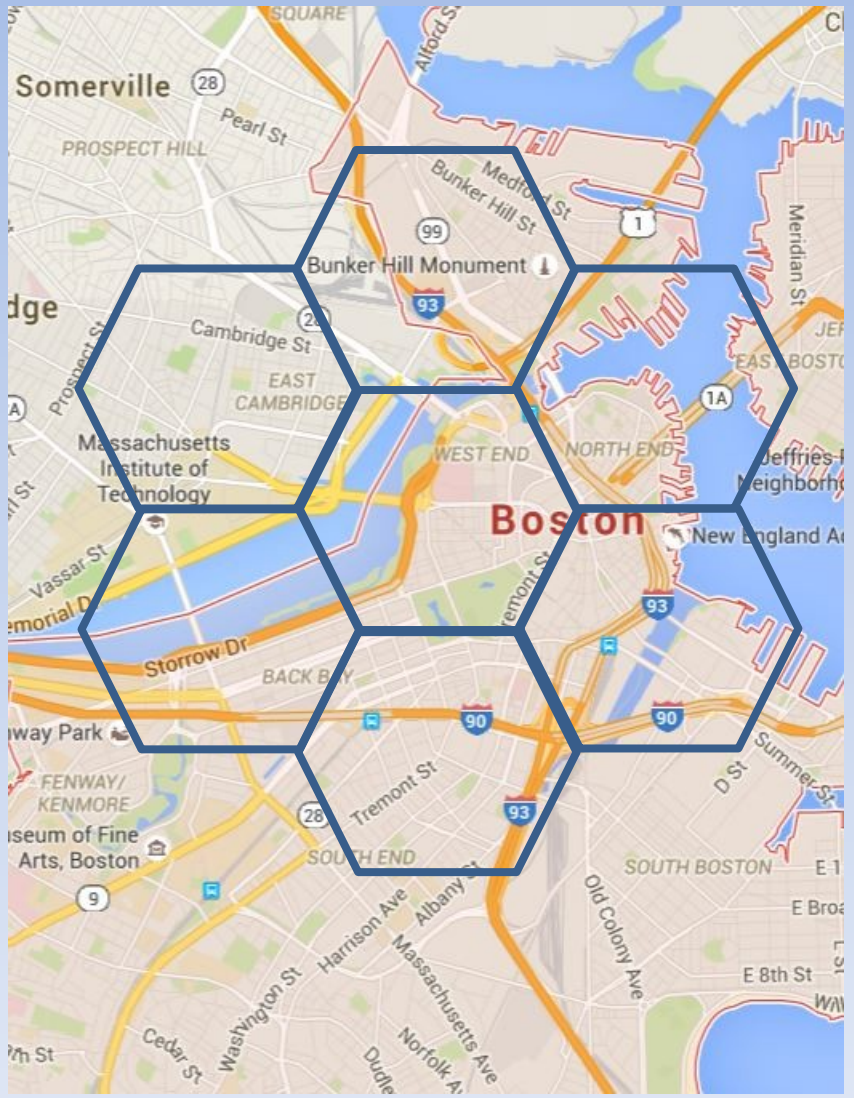
Government 5G Network

Ajit Pai, chairman of the Federal Communications Commission: I oppose any proposal for the federal government to build and operate a nationwide 5G network. The main lesson to draw from the wireless sector's development over the past three decades—including American leadership in 4G—is that the market, not government, is best positioned to drive innovation and investment. … Any federal effort to construct a nationalized 5G network would be a costly and counterproductive distraction from the policies we need to help the United States win the 5G future."

Central Mirror Article – Feb. 3, 2018: http://centralmirror.com/this-is-why-the-government-shouldnt-build-its-own-5g-network/
Axios: https://www.axios.com


5G
What's the technology?
5G
5G

xG Technology



[AMPS: Advanced Mobile Phone Service]

SMS: Short Message Service (Text)

Bands & Wavelength

- US Cellular bands: .85, .9, 1.8, 1.9 GHz
- Fixed Wireless bands: .9, 1.8, 2.4, 5 GHz

- 2GHz → ~5” wavelength
- 5GHz → ~2.4”
- 28GHz → ~0.4”

- Dipole antenna is ½ wavelength fed at center

https://broadbandnow.com/Fixed-Wireless
https://en.wikipedia.org/wiki/Fixed_wireless

5G Technology Options

- Millimeter waves
  - 6 to 100 GHz

5G Technology Options

- Millimeter waves
  - 6 to 100 GHz
- Small cell

5G Technology Options

- Millimeter waves
  - 6 to 100 GHz
- Small cell
- Massive MIMO
  - MIMO in 3/4G
  - Massive MIMO
    - Beam forming
    - Full duplex
    - Etc

Reader Comment On 5G Technology

Reader Comment On 5G Technology

“Cancer! Cancer! Cancer!”

Reader Comment On 5G Technology

“Just imagine downloading an HD movie in under a second

Just imagine hitting your download cap in under a second

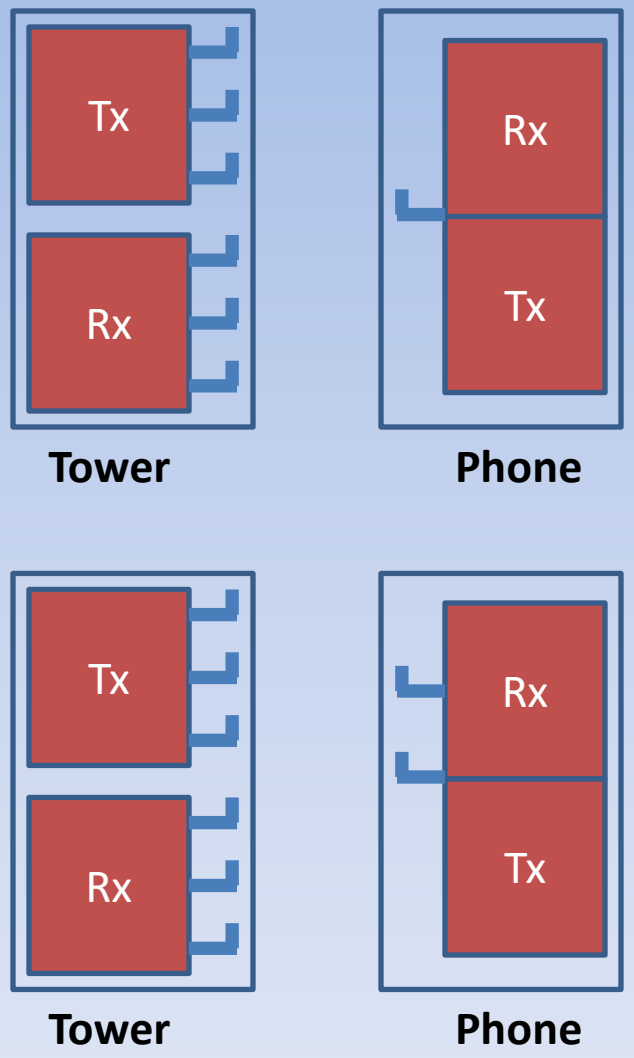
Just imagine racking up additional fees for downloads in under a second"

Reader Comment On 5G Technology

“Mark Twain: ‘It's easier to fool people than to convince them that they have been fooled.’”

4G MIMO

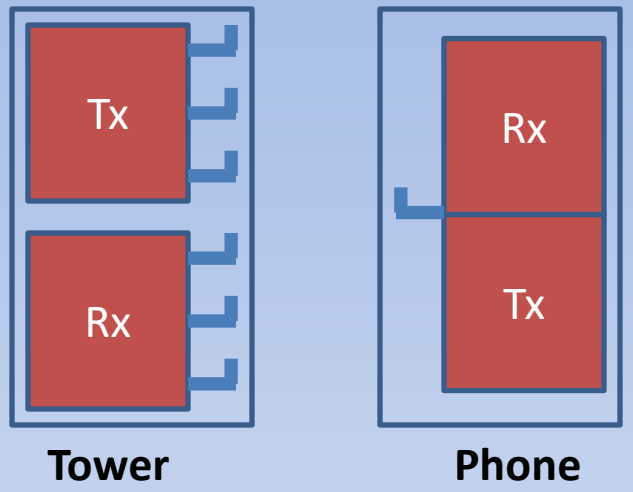
- Tower
  - ≥2 antennas downstream
    - Spatial diversity
    - Spatial multiplexing
    - Cooperative MIMO
    - Etc
- Cell phone
  - 2 receive antenna
    - Switched diversity
    - Combined diversity
    - Etc



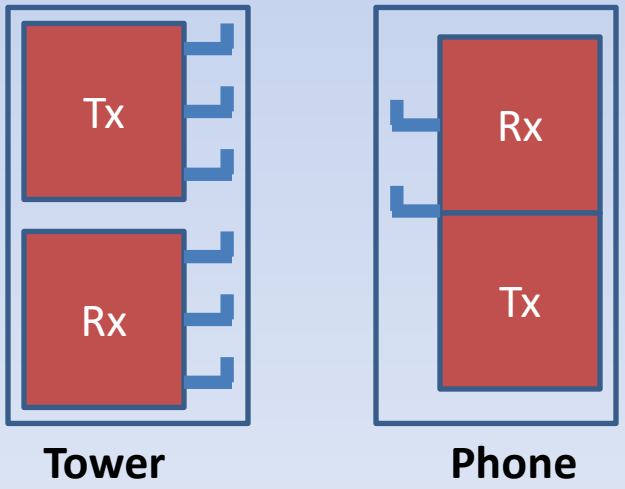
http://www.radio-electronics.com/info/antennas/mimo/formats-siso-simo-miso-mimo.php
https://enterpriseiotinsights.com/20160805/5g/massive-mimo-5g-tag31-tag99

Massive MIMO

- Tower
  - >>2 antennas downstream
  - All the 3/4G schemes
  - Beam forming

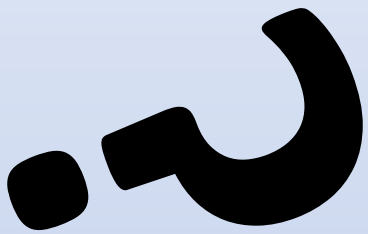


- Cell phone
  - 2 or more receive antenna



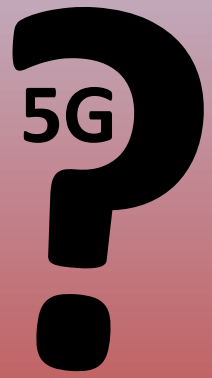
https://5g.co.uk/guides/what-is-massive-mimo-technology/

https://youtu.be/GEx_d0SjvS0



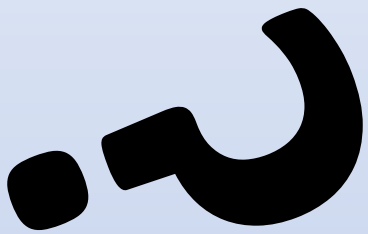
5G

In Summary?



5G

5G



5G

5G: Your Going To Love It

5G

5G

The End !