

# 5G Networks

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- Key Technologies behind 5G
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# Introduction



- The fifth generation of cellular wireless network
- Features:
  - Vastly increased capacity,
  - higher speed frequency,
  - lower latencies (which means faster response time)
  - more reliable
- 5G mobile networks deployment has been started in this year 2019
  - Korea being the first country deployed 5G in April 2019
  - Verizon's 5G service in Chicago
- Some of the first real deployments are anticipated in 2020.

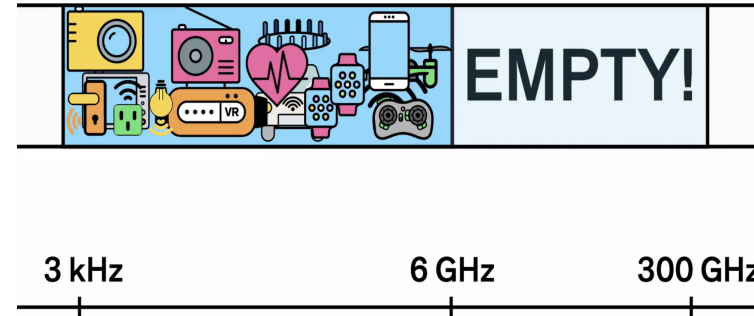
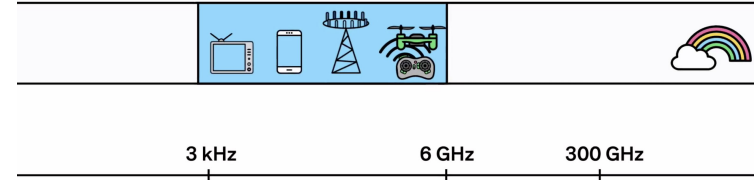


# Technologies applied in 5G

- Millimeter waves
- Small cells
- Massive MIMO
- Beamforming

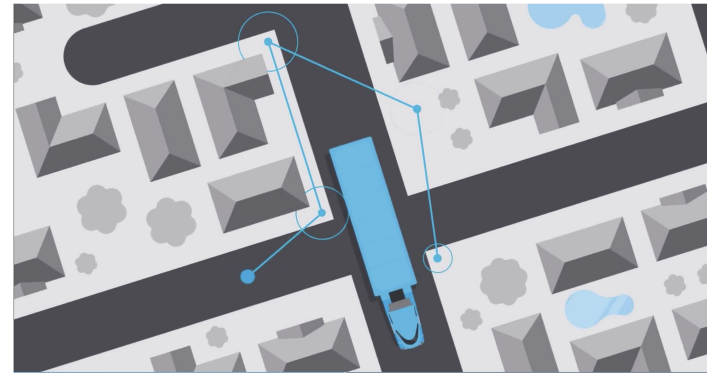
# Millimeter Waves

- High frequency millimeter waves (30 - 300 GHz)
  - <https://spectrum.ieee.org/video/telecom/wireless/5g-bytes-millimeter-waves-explained>
- shorter wavelengths making the beam narrower and make the transmission speed faster.
- Due to the limited range of transmission, it cannot travel through walls and large objects, therefore it needs to operate with small cells



# Small cells

- Foundation of 5G network
- Mini base station
- Small cells densification - efficient and inexpensive solution
  - it requires a large number of small cells covered in the service area.

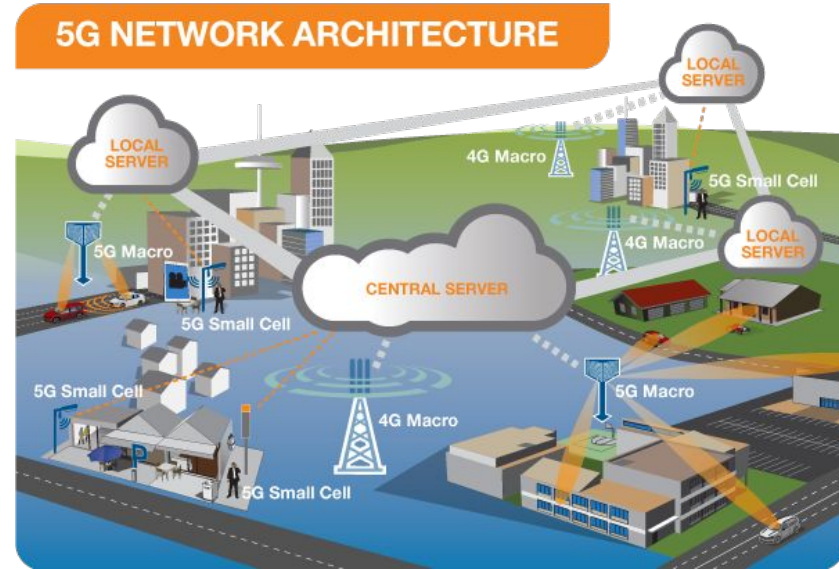


<http://committeeof100.net/uncategorized/5gsmallcell/>

<https://www.qorvo.com/design-hub/videos/5g-why-it-is-massively-awesome>

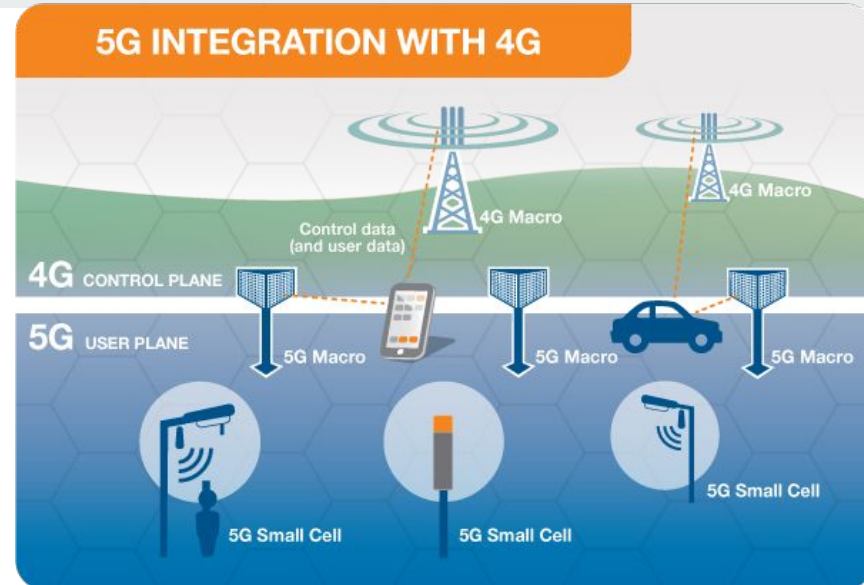
# 5G Network Architecture

- 5G networks performing with 4G networks
- The Radio Access Network
  - Small cells, towers, antennas
- The Core Network
  - Manage all the mobile voice, data and internet connections
  - Has been redesigned to reduce latency
  - Manage network function virtualization and network slicing



# 5G Integration with 4G

- Non-stop connection
- UE (user equipments) will connect to both 4G and 5G network

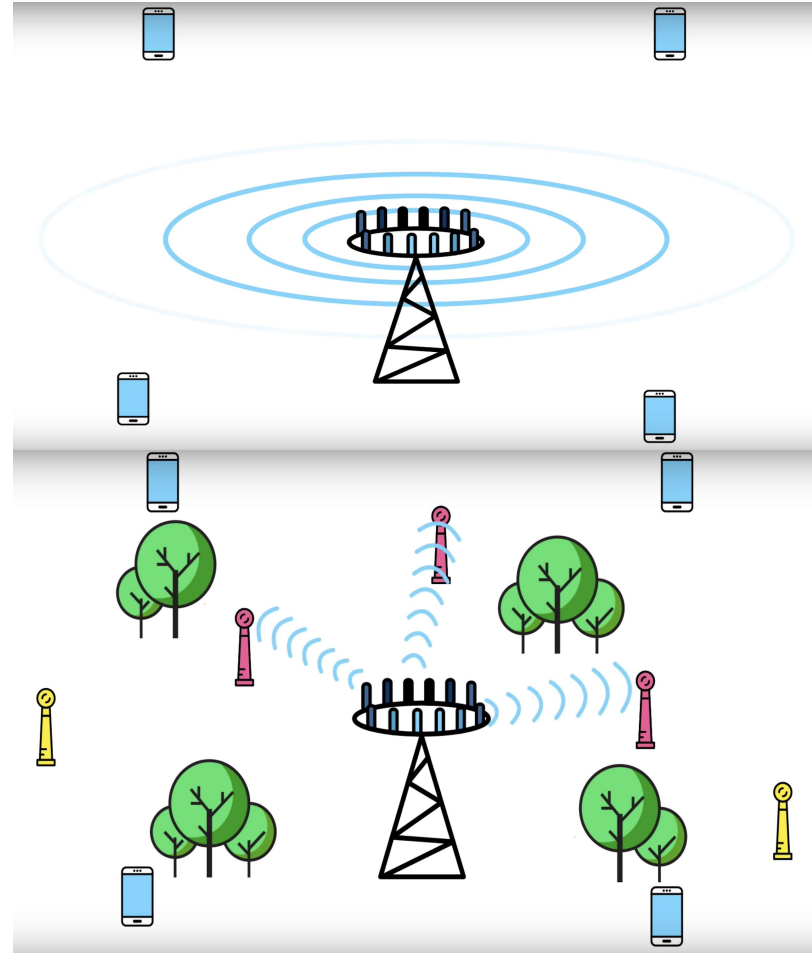




# Comparing 4G to 5G

- millimeter wave band range in 30 - 300 GHZ, with 4G frequencies being below 6 GHZ,
  - Shorter waves
  - significantly reduce traffic
  - allows more users and faster speed
- Lower Latency, meaning shorter response time
  - 5G: 1-5 ms vs 4G: 20-30 ms
- 5g speed 20 Gb/s, 4g: 1 Gb/s
- 20 Gb/s peak data rate vs 1 Gb/s peak data rate for 4G network

[https://www.youtube.com/watch?v=GEx\\_d0SjvS0](https://www.youtube.com/watch?v=GEx_d0SjvS0)



## Massive MIMO

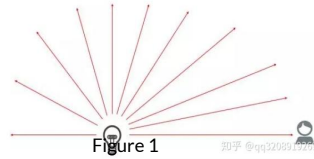


Figure 1

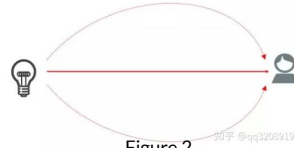


Figure 2

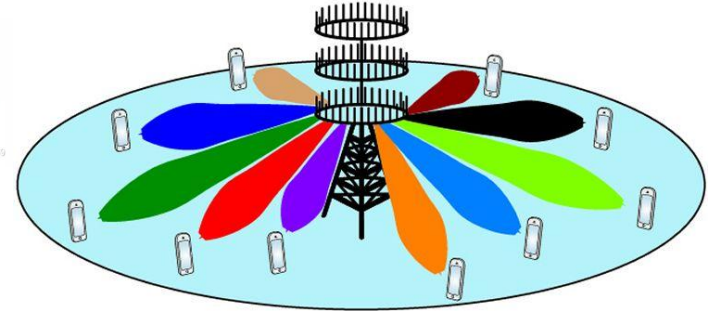


Figure 3

**MIMO** stands for Multiple-Input Multiple-Output. It allows the transmitting and receiving of more than one data signal simultaneously over the same radio channel.

### Contrast

*Before:* **Broadcasting** information in every direction at once, which causes serious interference.

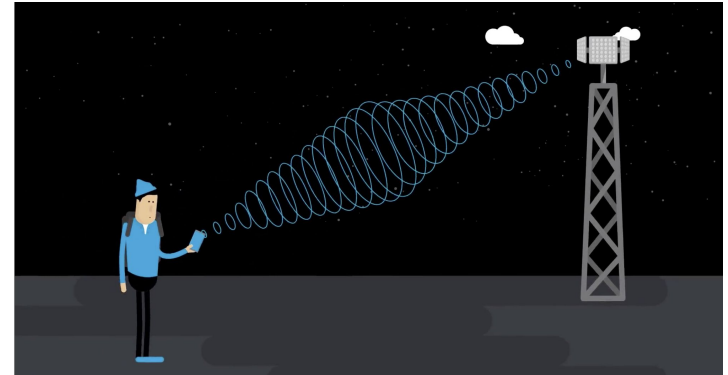
*Now:* **Beamforming**.

Send a focus stream of data to a specific user.

This precision prevents interference, increases cell capacity, and is way more efficient.

### Method

**signal processing algorithms.** Triangulate user's exact position.



<https://www.zhihu.com/search?type=content&q=5g>

<https://www.qorvo.com/design-hub/videos/5g-why-it-is-massively-awesome>

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

# Test

## Korea

- **Samsung** claimed to have supplied **the greatest number of 5G base stations** to South Korean operators, which lit their commercial consumer services on 5 April, 2019.

## US

- **Verizon** announced that it has officially deployed its 5G mobile service in certain parts of Chicago and Minneapolis, which are the first two of **30 cities** where it plans to bring its 5G wireless network this year.

## China

- The **government** controls all three of the country's mobile operators (China Mobile, China Telecom, and China Unicom) and has been “guiding” them to deploy large-scale 5G test networks in dozens of cities, including Beijing, Shanghai, and Shenzhen.
- China Mobile claims that its tests alone represent the world's **largest 5G trial network**

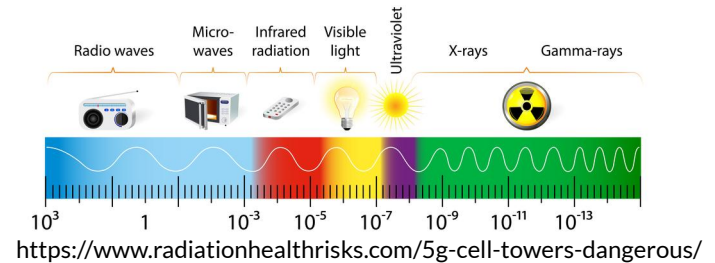


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<https://www.gsmaintelligence.com/research/?file=67a750f6114580b86045a6a0f9587ea0&download>

# Downside

- **Shorter range**
  - a. Millimeter waves tends to be absorbed by rain and plants.
- **Higher cost**
  - a. Verizon says extra \$10 per month.
- **Health issues**
  - a. Radio Frequency (RF) Radiation.
  - b. Ultra high frequency an ultra high intensity.
  - c. densification of small cells deployed around people.
- **Spy activities**
  - a. Not easier to hack, but the huge amount of connections is of great concern.
  - b. Nation's safety.

## THE ELECTROMAGNETIC SPECTRUM



# Future Applications

- Smart phones, mobile devices
- Internet of Things (IoT)
- Automatic car
- VR & AR
- Real time translation



## Enabling

A growing set of consumer and commercial drone |



### Flying cameras

Consumer flying cameras  
Movies and news media  
Real estate



### Delivery

Package delivery  
Transport of medicines and vaccines



### Public safety

Emergency services  
Cellular coverage for first responders  
Search and rescue

# Enabling

A growing set of consumer and commercial drone use cases



## Flying cameras

Consumer flying cameras

Movies and news media

Real estate



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Package delivery

Transport of medicines and vaccines



## Public safety

Emergency services

Cellular coverage for first responders

Search and rescue



## Agricultural

Crop visual inspections

Automated planting

Livestock tracking



## Inspection

Critical infrastructure inspection (e.g. cell towers, bridges)

Inspection of hard-to-reach assets (e.g. oil & gas, wind turbines)

## Korea's new 5G Futuristic Hospital

- Holograms to visit
- AR navigation system
- Facial recognition
- Voice assistant
- 5g quantum cryptography



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## Reference



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