

WIRELESS COMMUNICATIONS AND NETWORKING

An Overview of Wireless Systems

黎玉線 博士

Outline

1. Introduction

2. Course Description

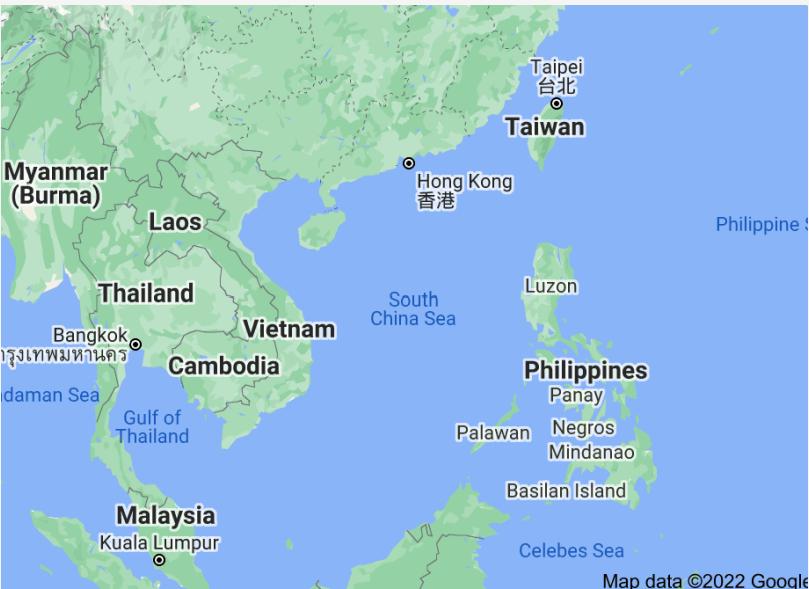
3. What is Mobile Communication

4. What is Wireless communication?

5. Key Enabling Technologies for 5G and Beyond Networks

6. Machine Learning and Deep Learning for Massive MIMO Systems

PERSONAL INFORMATION



EDUCATION

2011-2015	NATIONAL KAOHSIUNG UNIVERSITY OF SCIENCES and TECHNOLOGY, Kaohsiung, Taiwan Degree of Doctor of Philosophy In Electronic Engineering
2006-2008	LE QUY DON TECHNICAL UNIVERSITY, Hanoi, Vietnam Master Degree of Computer Science
1992-1996	HANOI NATIONAL UNIVERSITY OF EDUCATION Hanoi, Vietnam Bachelor of Mathematics



WORK EXPERIENCE

2018/8-2021/12	Assistant Research Fellow, Institute of Photonics Engineering, National Kaohsiung University of Science and Technology, Taiwan
2015/09-2018/07	Assistant professor, Faculty of Information Technology, Hung Yen University of Technology and Education, Khoai Chau, Hung Yen, Vietnam
2008/09-2011/08	Researcher, Institute of Information Technology, Vietnam Academy of Science and Technology

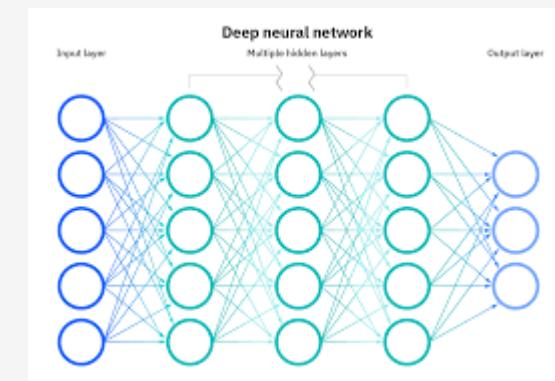
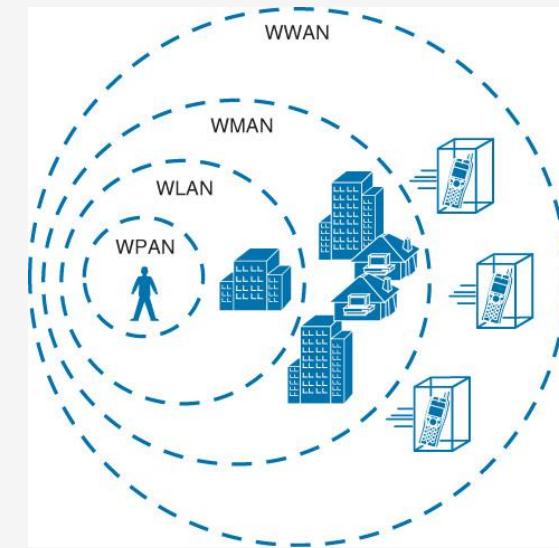


An Overview of Wireless Systems



Course Description

- Provide students an understanding of cellular and wireless networks' structure, system aspects, and protocols. The focus is on the generations of cellular networks (WWAN), WMANs, WLANs, and WPANs.
- Combining the content of technology and practice covers the fundamental theory and technical issues associated with wireless communications systems.
- The concepts are explained through specific examples, and the formulas are programmed through the python programming language.



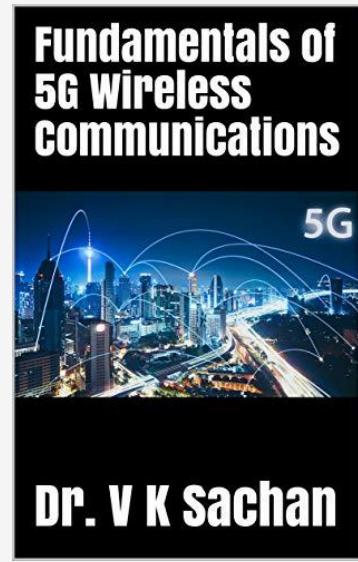
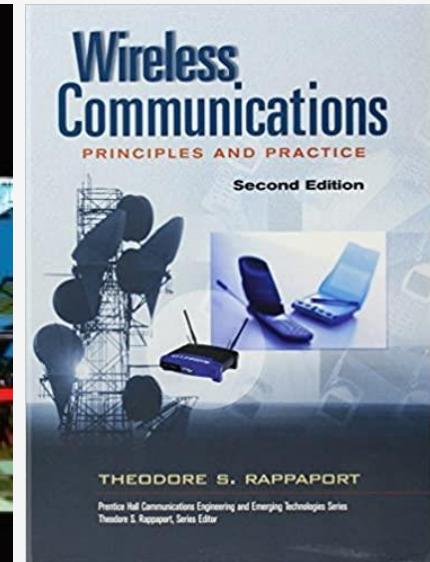
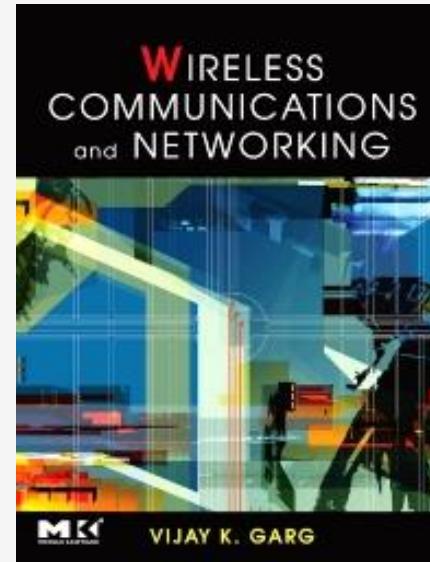
Course Materials

1. Required text:

- Wireless Communications & Networking, 1st edition, Vijay Garg.
- Wireless communication principles and practice. 2nd edition, Rappaport.
- Self-made teaching material.

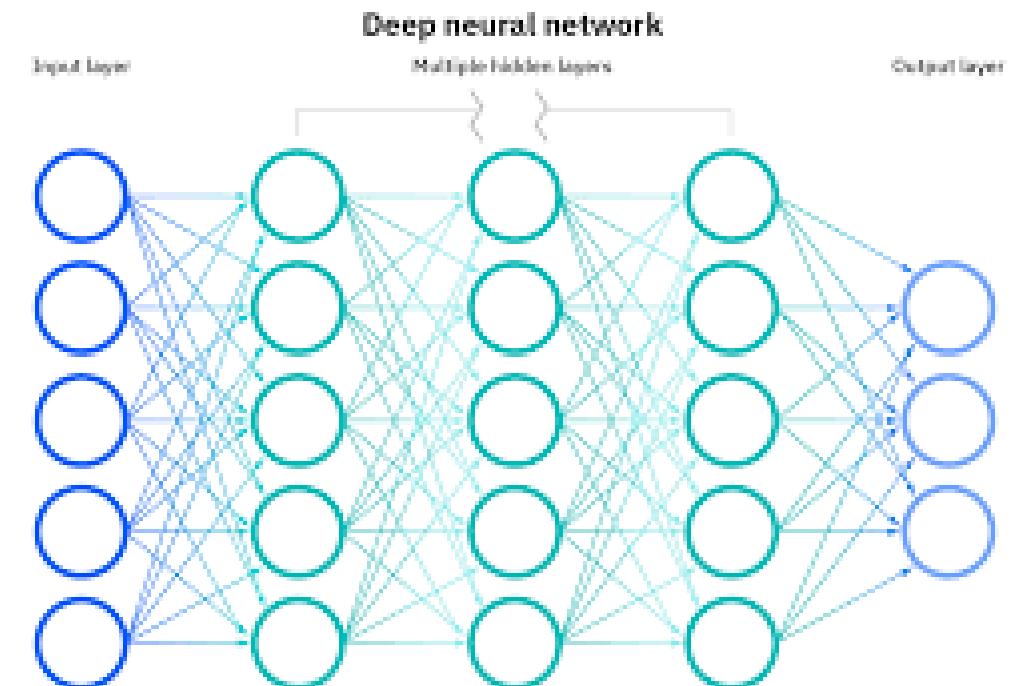
2. Suggested additional readings

- Fundamentals of 5G Wireless Communications, Sachan Book 82, V K Sachan
- Reading papers.



Pre-required course

- Programming Techniques (Python)
- Neuron network (Deep learning)



What is Mobile?

Mobile simple describes a computing device that is not restricted to a desktop. Mobile device may be a "smart" cell phone, a laptop computer, or any one of numerous other devices that allow the user to complete computing task without being connected to a any Network.

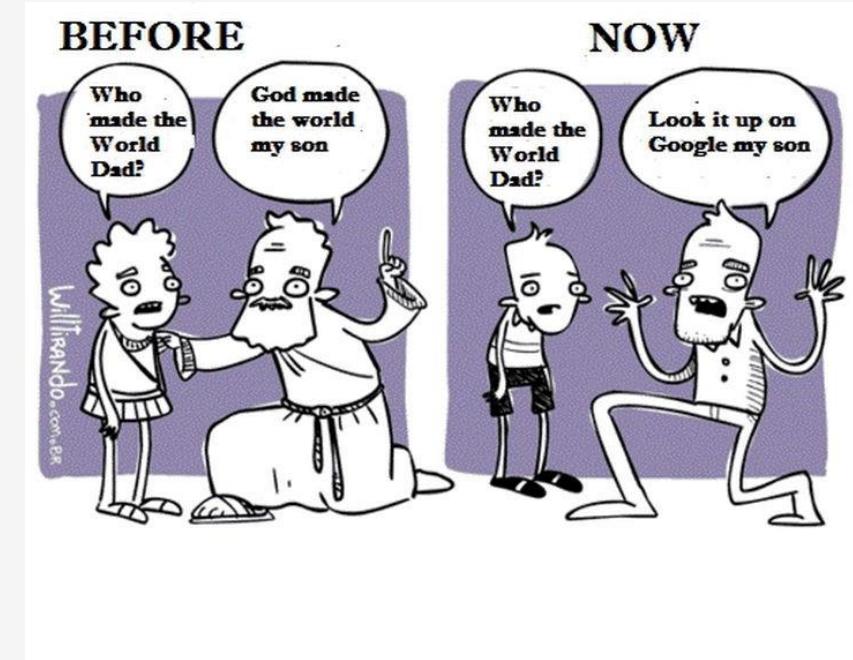


<https://jquerymobile.com/>

What is Mobile Communication?

We understand by **mobile communication** as the use of **technology** that allows us to communicate with others in different locations without the use of cables. **Mobile communication** makes our life easier, saves time and effort [*]

A **mobile phone** (also called mobile cellular network, cell phone or hand phone) is an example of mobile communication (wireless communication). It is an electric device used for full duplex two way radio telecommunication over a cellular network of base stations known as cell site.



<https://tech.tl/how-technology-has-made-our-lives-easier/>

[*]. <https://www.javatpoint.com/mobile-communication-introduction>.

What is Mobile Communication

Mobile communication allows broadcast of voice and multimedia data via a workstation or a **mobile** device exclusive of having connected to any physical or fixed connection. **Mobile communication** is growing day by day and has become a must have for every person. **Mobile communication** is the exchange of voice and data using a **communication** facility at the same time without any physical link [*]

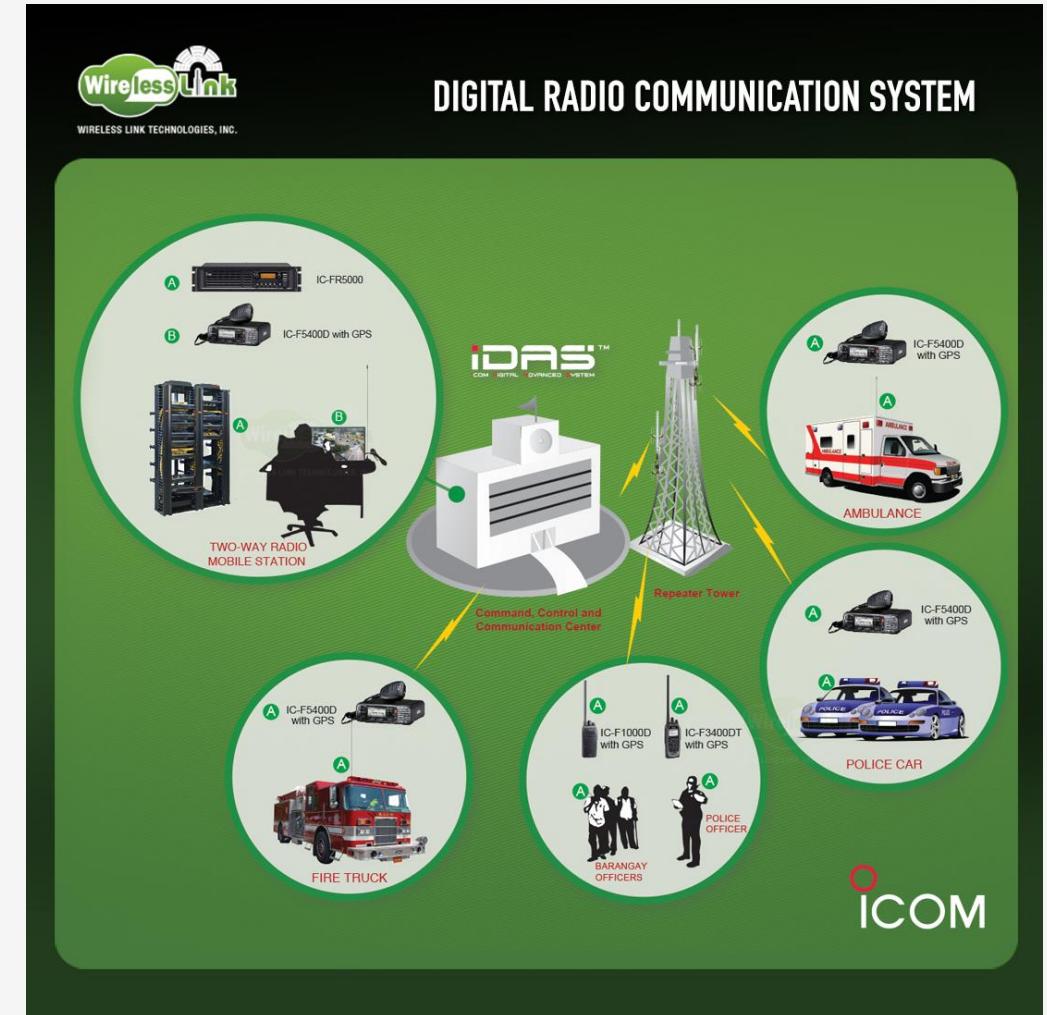


What is Wireless?

Wireless refers to the method of transferring information between computing devices, such as a personal data assistant (PDA) and a data source such as an agency database server, without a physical connection or wires. The distances involved may be short (a few meters as in television remote control) or long (thousands or millions of kilometers for radio communications).



television remote control



What is Wireless communication?

Wireless communication is simply data communication without the use of landlines. This may involve cellular telephone, two-way radio, fixed wireless (broadband wireless), laser (free space optics), or satellite communications.



Satellite communications (SpaceNews)



cellular telephone



two-way radio



NASA Laser Communications

The Different Types of Wireless Communication

1. Satellite Communication

Satellite communication is a crucial form of wireless communication. By means of satellites, people all over the earth can communicate with each other.

It may not be possible to send a signal to another country because, well, the curvature of the earth is in the way. This is one reason why satellites are orbiting the earth because they can send a signal amongst themselves and eventually to the distant country. All of this at an incredibly fast speed.

[NASA and other space agencies](#) make regular use of this type of technology. Of course, sending a satellite into the atmosphere is not cheap. Therefore the technology involved must be subjected to [significant testing](#) before launch.



Satellite communications (SpaceNews)

The Different Types of Wireless Communication

2. Infrared Communication

Infrared communication is present in most homes in the form of a television remote control. However, how does it work?

IR transmits information by means of invisible light. This means that on the electromagnetic spectrum it lies between microwaves and visible light.

Infrared communication requires a transmitter and a photoreceiver to receive the light beam. Since any disruption to the light will result in the photoreceiver not receiving it, IR will only function when there is a line of sight visibility. That means that if you stand between the transmitter and receiver it will probably not work.



mjginfologs.com

The Different Types of Wireless Communication

3. Broadcast Radio

The most famous form of wireless transmission on our list, broadcast radio, was probably the first kind of wireless communication.



Radio broadcast (The British Library)

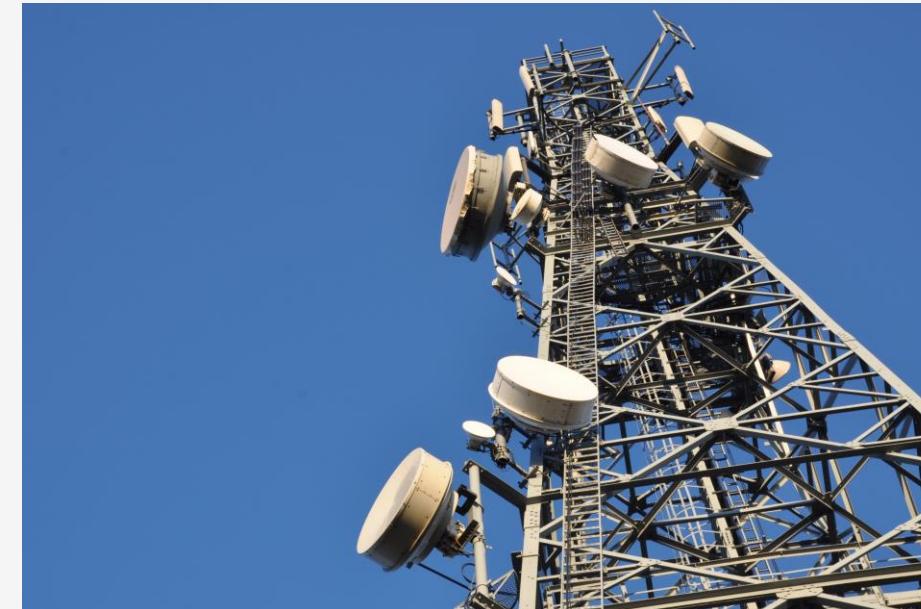
The Different Types of Wireless Communication

3. Broadcast Radio

Radio transmitters send out data in the form of radio waves to receiving antennae. Radio waves are forms of electromagnetic signals. Signals are relatively narrow, and waves can be sent across various frequencies. This is why your car radio is able to receive signals from many different radio stations.



Transmitter

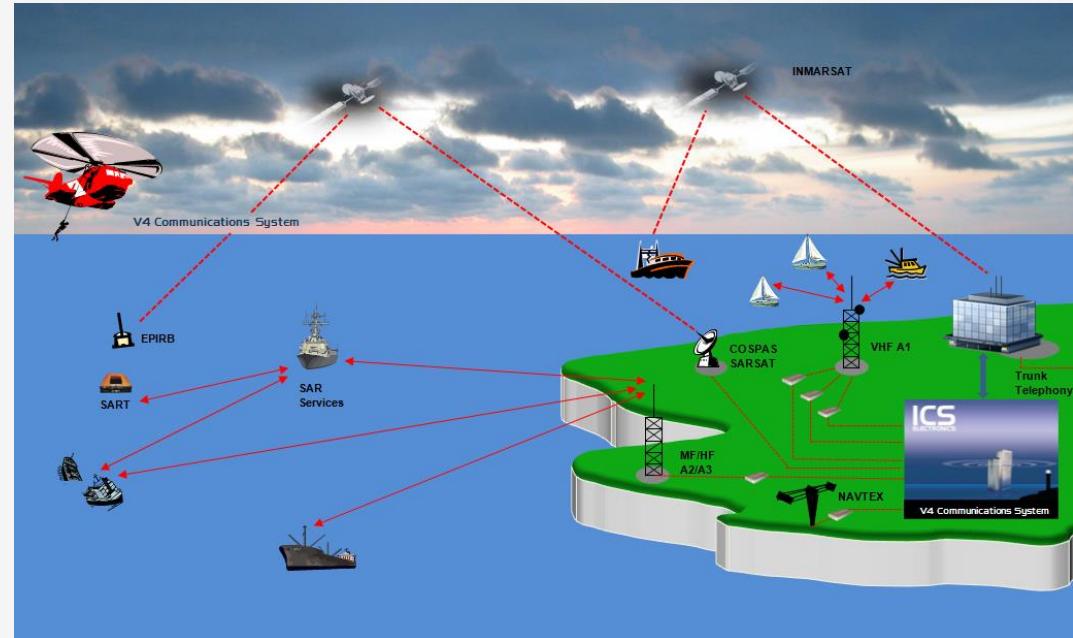


Transmitter Station

The Different Types of Wireless Communication

3. Broadcast Radio

There are many types of users of radio communication. Radio stations that send out informative and entertaining programs. Maritime radio channels allow ships to communicate with each other and the shore. Ham radio enthusiasts are able to communicate and use radio communication for personal use.



The Different Types of Wireless Communication

4. Microwave Communication

Microwave technology is an effective type of communication that is used globally. This technology can be broken down into 2 types

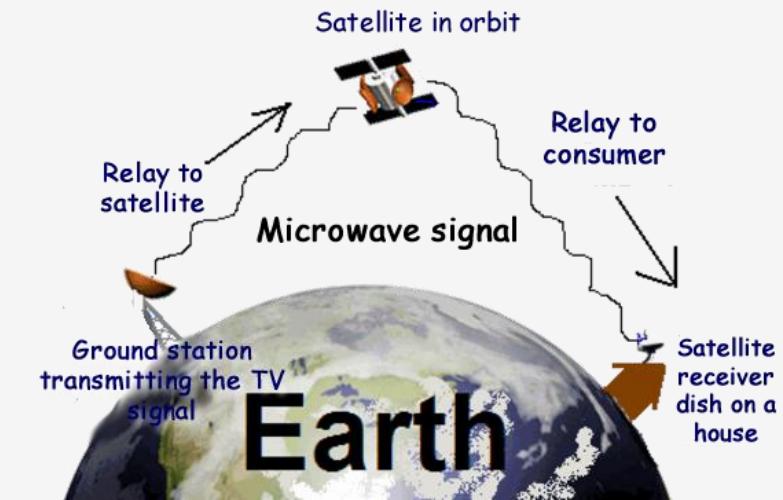
Satellite Microwave Communication

This is the most effective method of transmitting microwaves globally. Like Infrared technologies, Microwave technologies require a clear line of sight. This means that if you want to send a signal over a long distance, sending it up to a satellite first is a good idea.

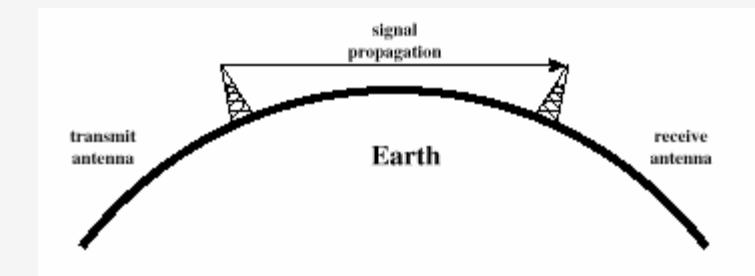
The only problem is that in very dense cloudy weather the signal to the satellite can be blocked by atmospherics.

Terrestrial Microwave Communication

Microwave technologies can be a very secure form of communication. If a signal needs to be transmitted over a short distance, it can be enough to erect two antennae with a clear line of sight. The signal can then be transmitted between the two receivers. This negates the need to connect to an outside network.



Satellite Microwave Communication

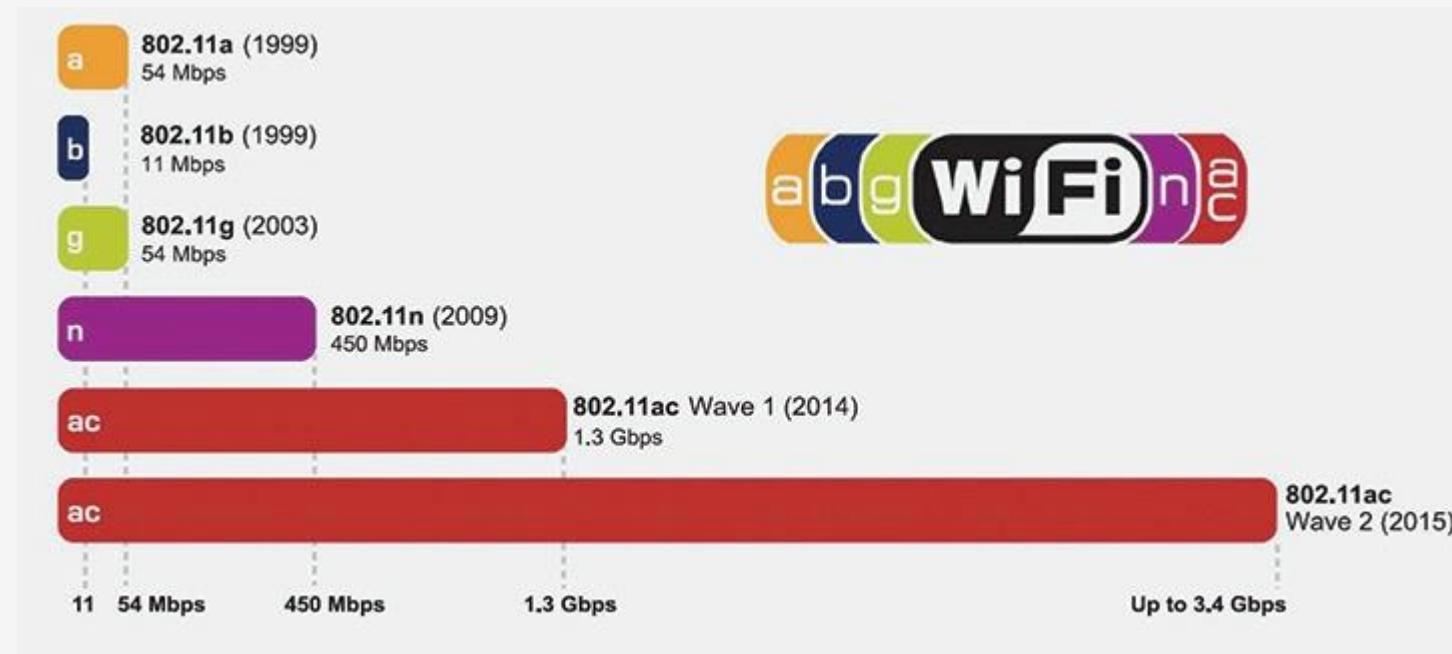


Terrestrial Microwave Communication

The Different Types of Wireless Communication

5. Wi-Fi

Wi-Fi internet is a low powered wireless electronic network. These are available in almost every shopping mall and cafe in the world. Essentially a physical wired network is connected to a router. This creates a highly localized and low power wireless network.



The Different Types of Wireless Communication

6. Mobile Communication Systems

The burgeoning mobile phone industry uses similar technology to Wi-Fi but on a much grander and safer scale. Mobile phone companies provide coverage to customers nationwide or even international scale.

They do this by means of a complex blend of local networks and transmitters together with satellite support.



Teo Technologies

The Different Types of Wireless Communication

7. Bluetooth Technology

Bluetooth is a relatively new technology but is becoming more and more prevalent. It is essentially a simple method to send information across a short distance. However, this information can include either messages or even files.

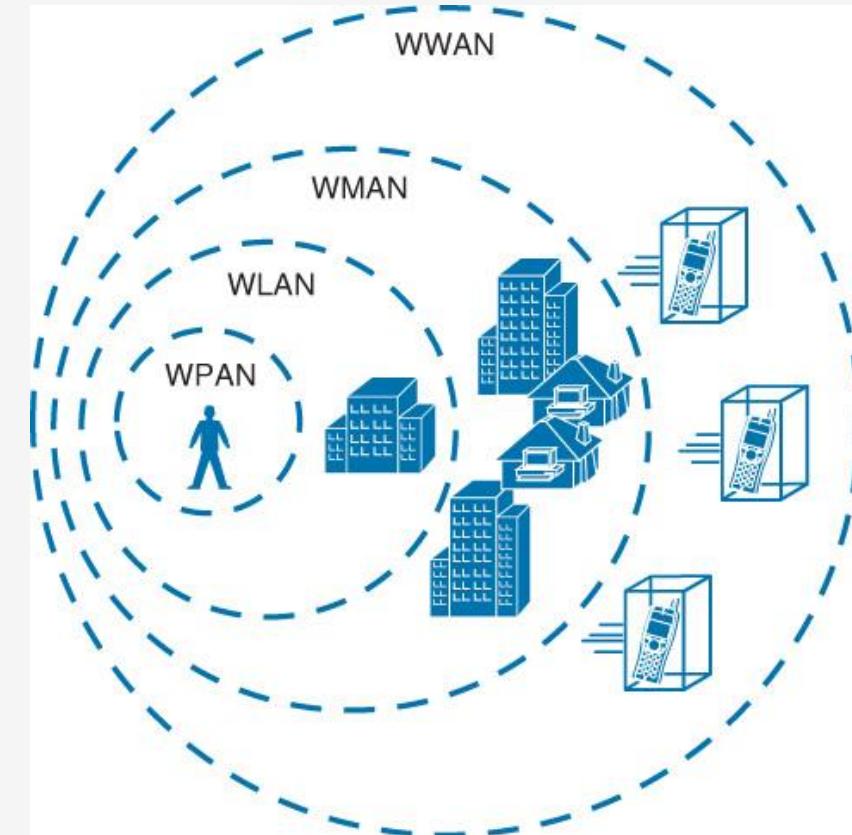
[Bluetooth technology](#) was originally designed to be a replacement for physical cables. However, it does have its downsides. It has a maximum reach of 30 feet. This can be reduced further, but not entirely blocked by walls and other solid items.



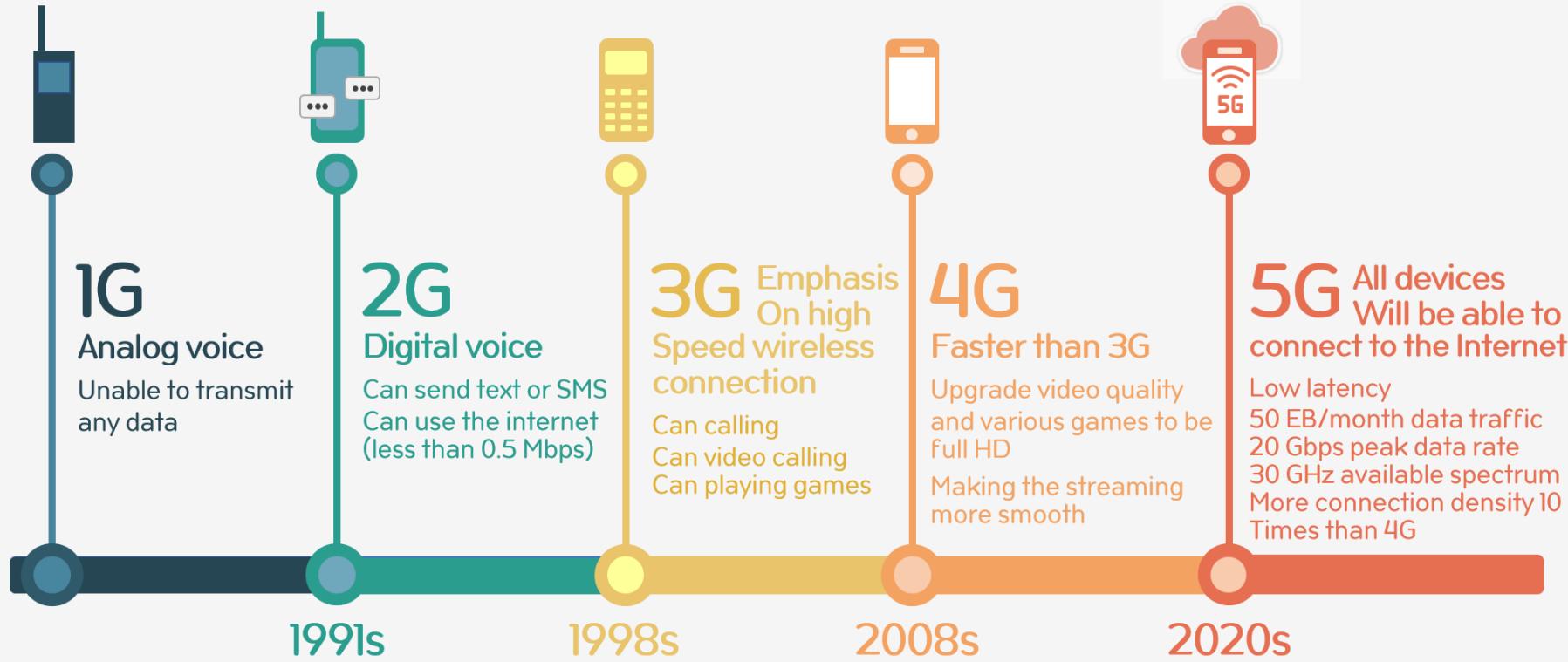
dailyexcelsior

Types of Wireless Networks

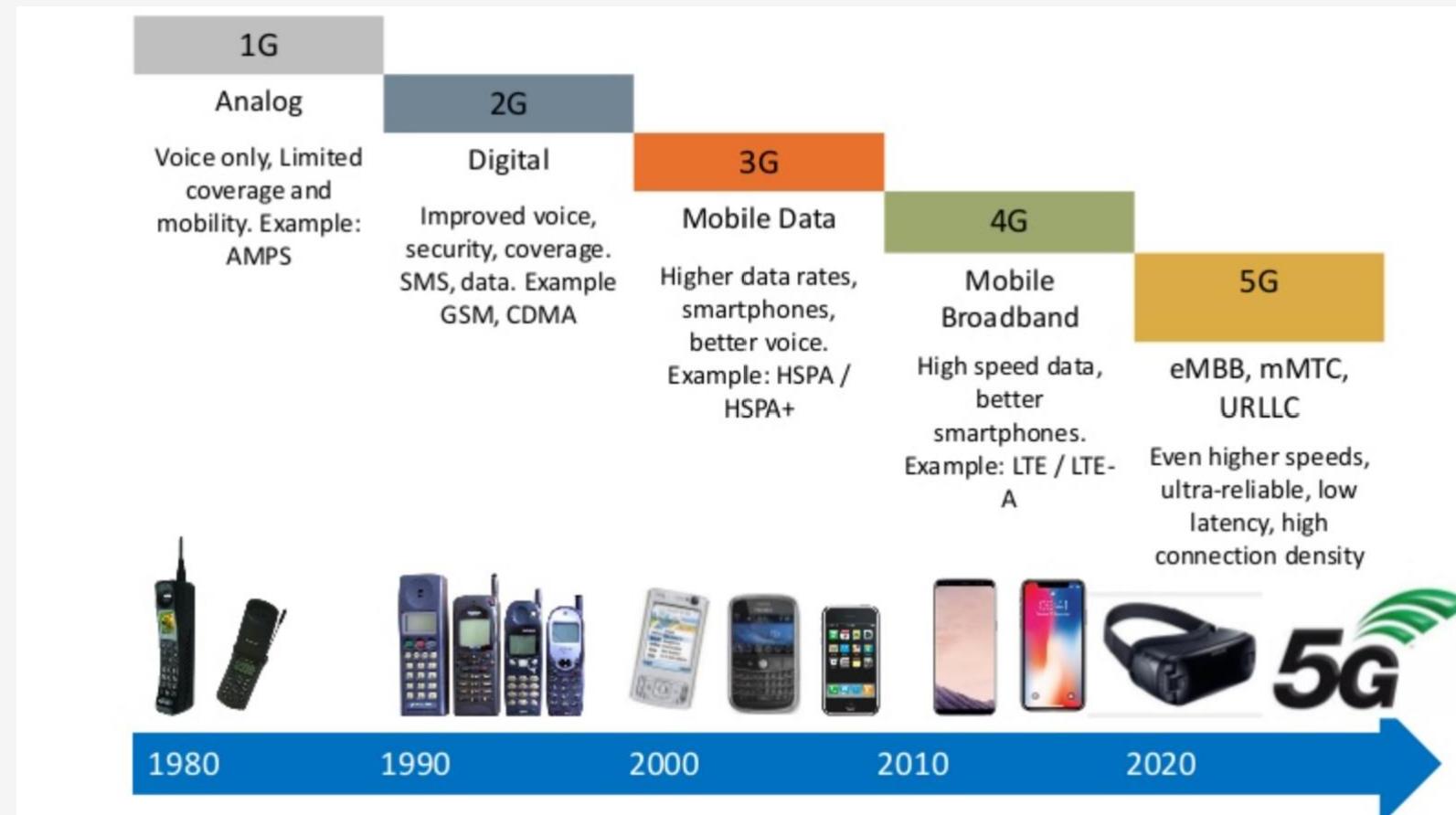
Type	Range	Applications	Standards
Personal area network (WPAN)	Within reach of a person	Cable replacement for peripherals	Bluetooth, ZigBee, NFC
Local area network (WLAN)	Within a building or campus	Wireless extension of wired network	IEEE 802.11 (WiFi)
Metropolitan area network (WMAN)	Within a city	Wireless inter-network connectivity	IEEE 802.15 (WiMAX)
Wide area network (WWAN)	Worldwide	Wireless network access	Cellular (UMTS, LTE, etc.)



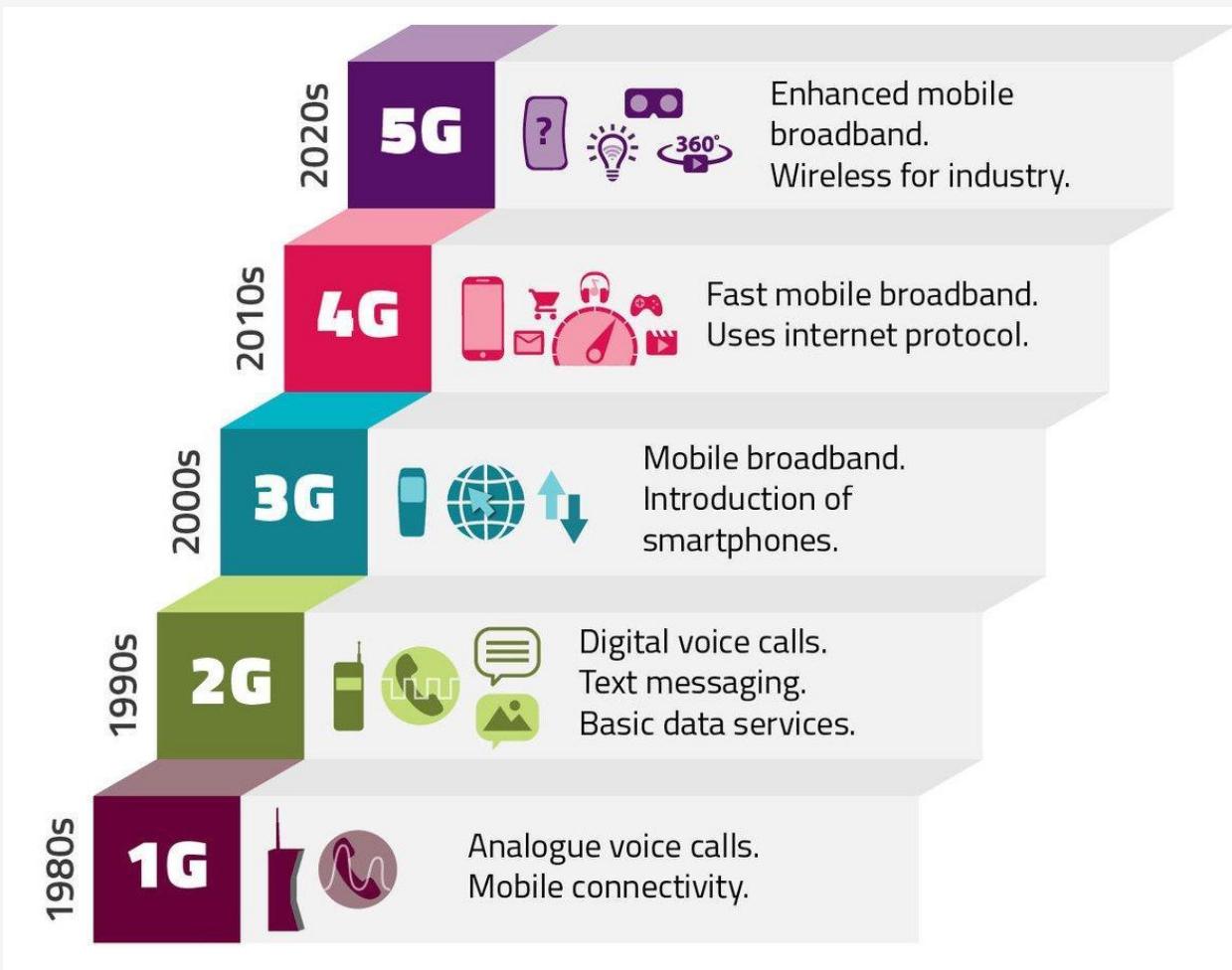
Evolution of Mobile generation from 1G to 5G



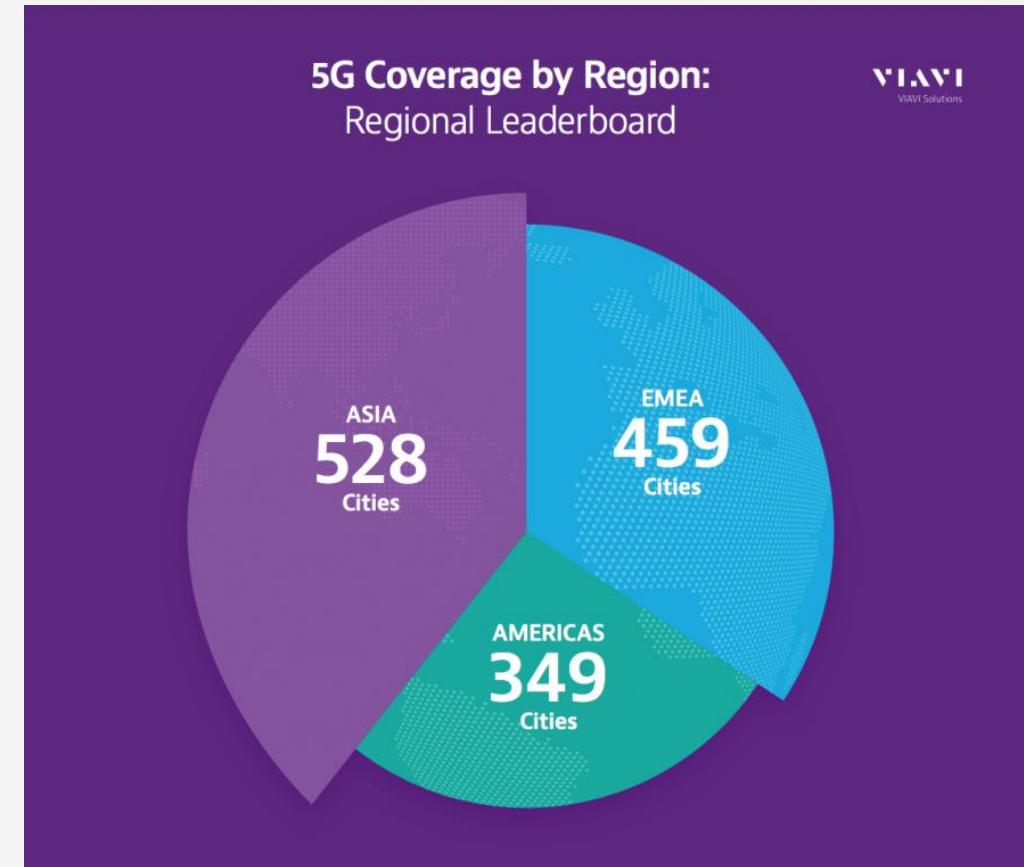
Evolution of Mobile device generation from 1G to 5G



Evolution of Mobile generation from 1G to 5G



Distribution of 5G in cities and Countries worldwide



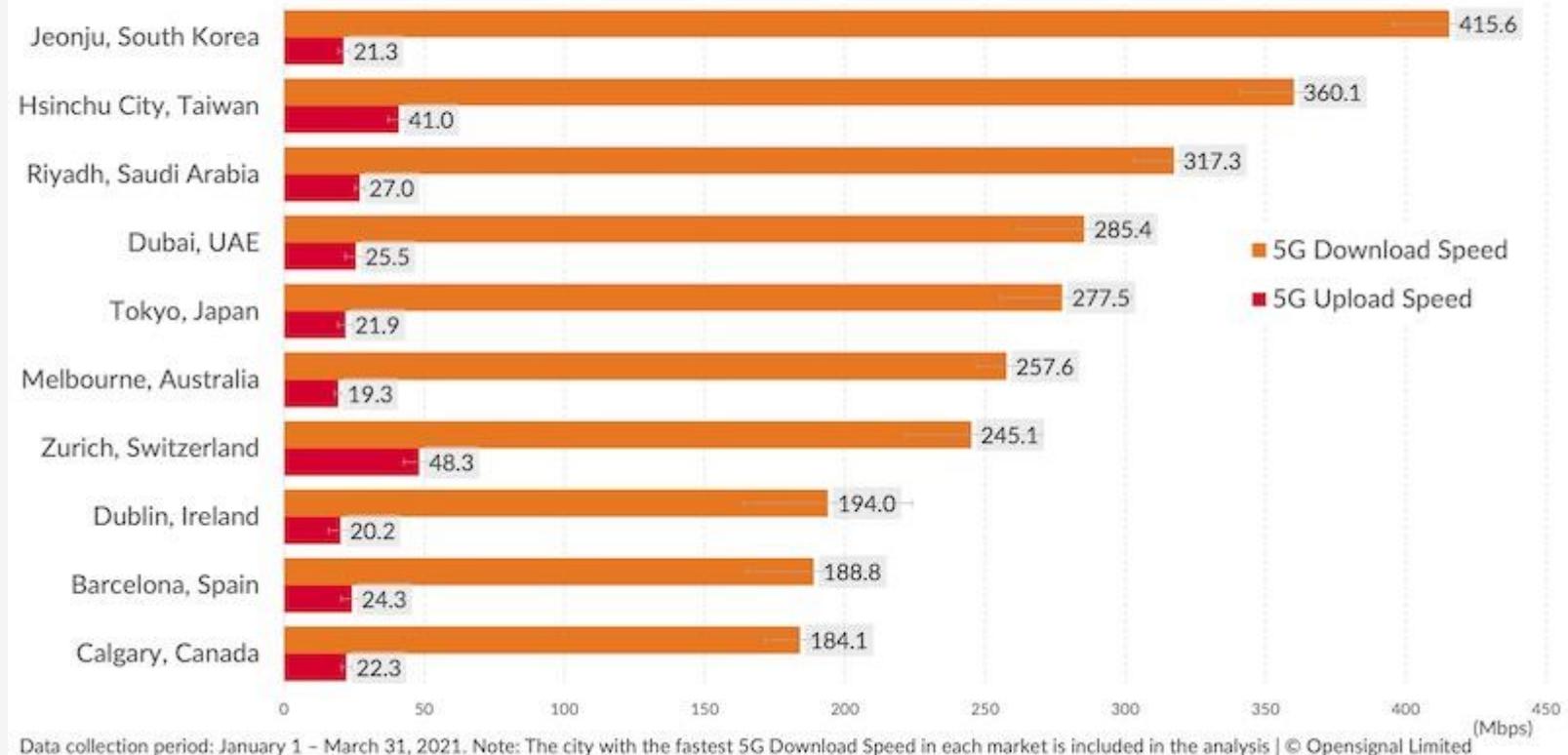
EMEA (Europe, Middle East and Africa).

Distribution of 5G in cities and Countries worldwide



5G Global Top 10: Cities

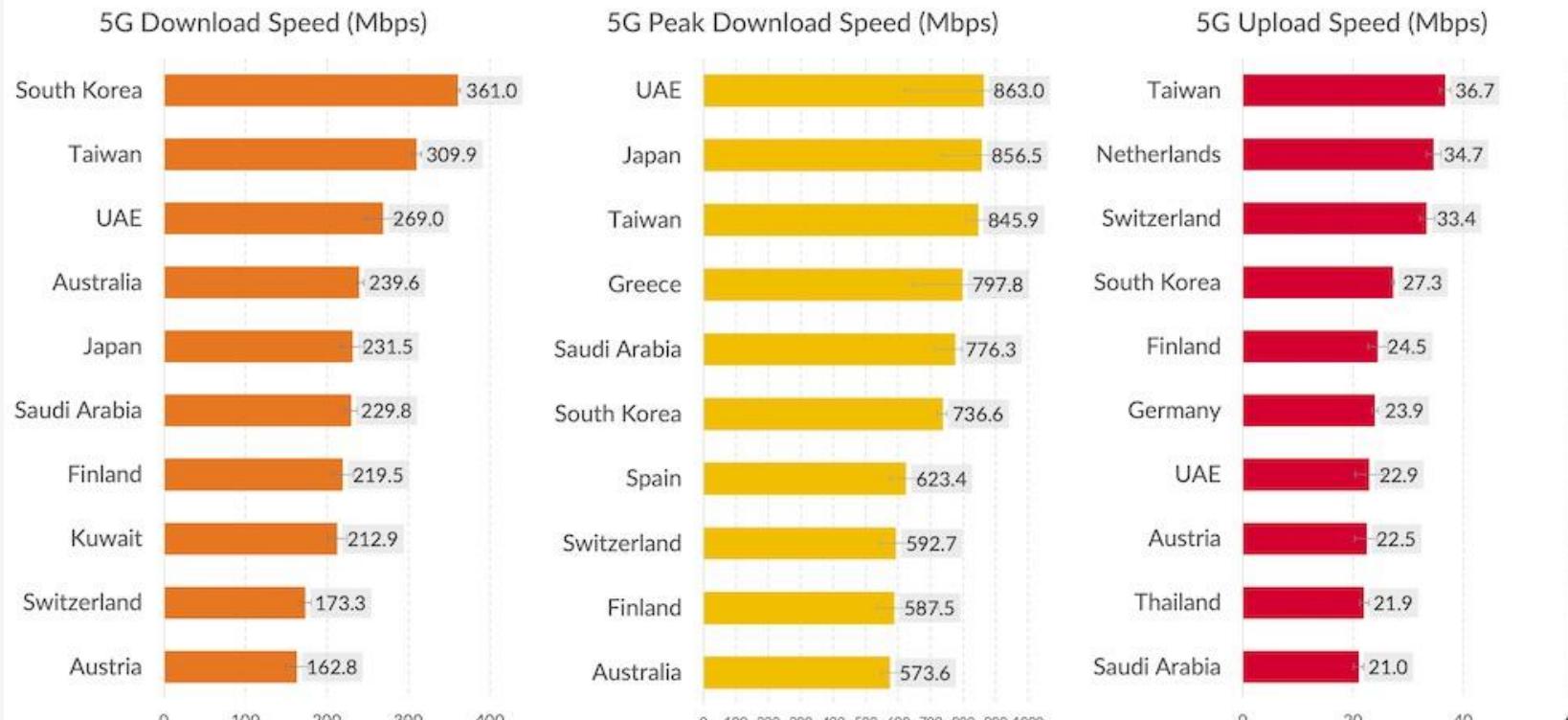
OPENSIGNAL



Distribution of 5G in cities and Countries worldwide

5G Global Top 10: Speed

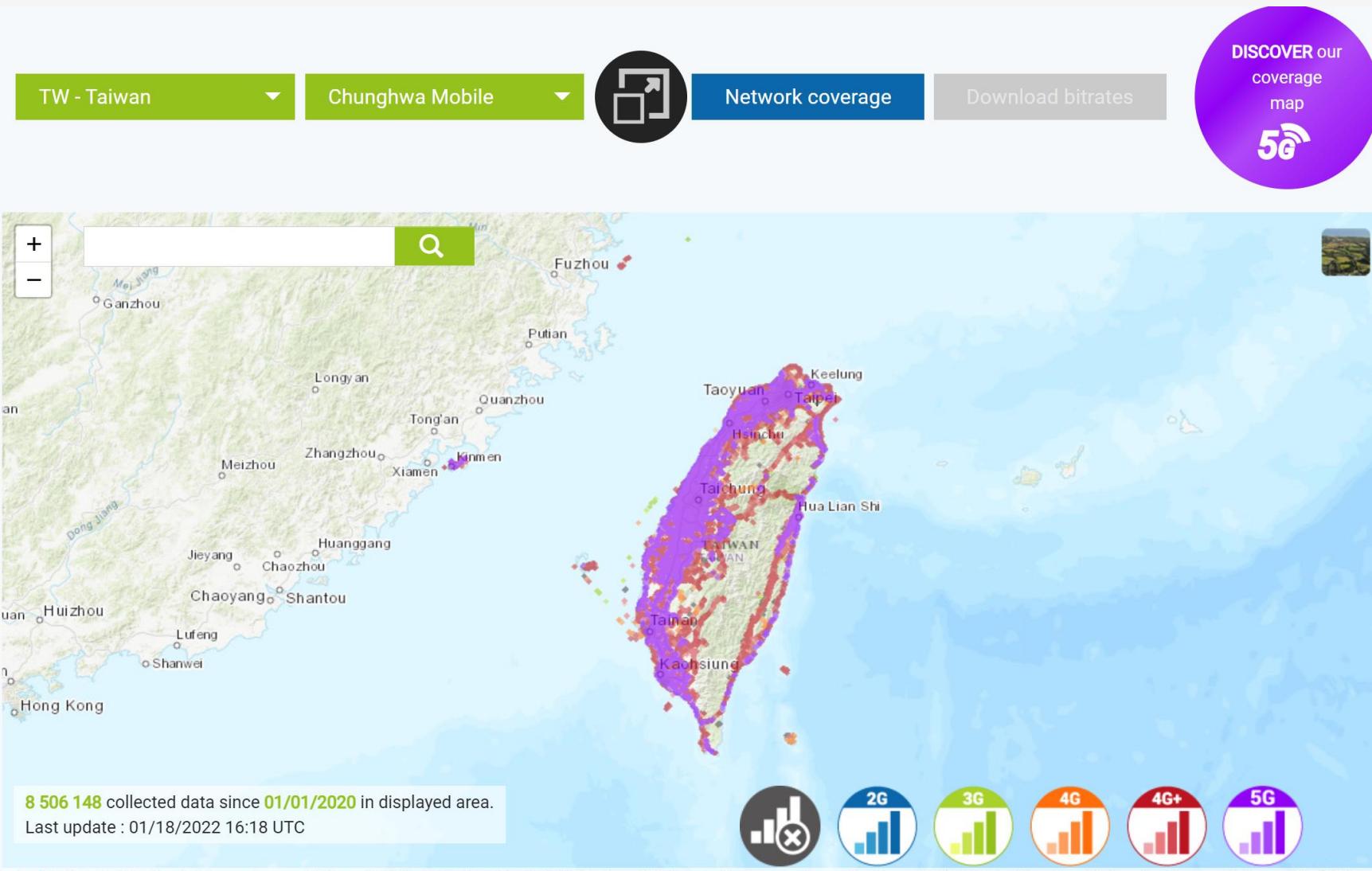
OPENSIGNAL



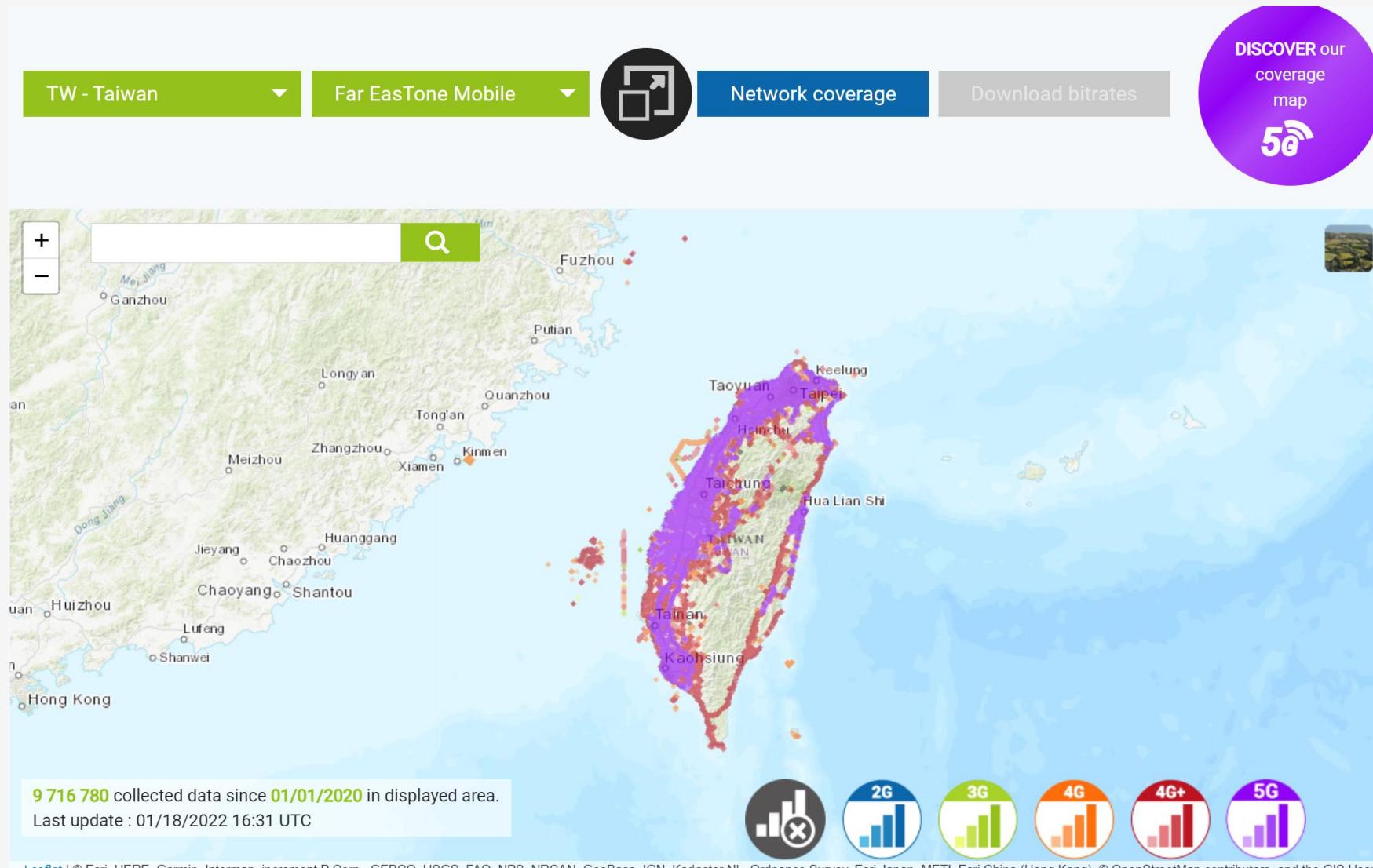
Data collection period: January 1 - March 31, 2021 | © Opensignal Limited

The nations with the fastest 5G

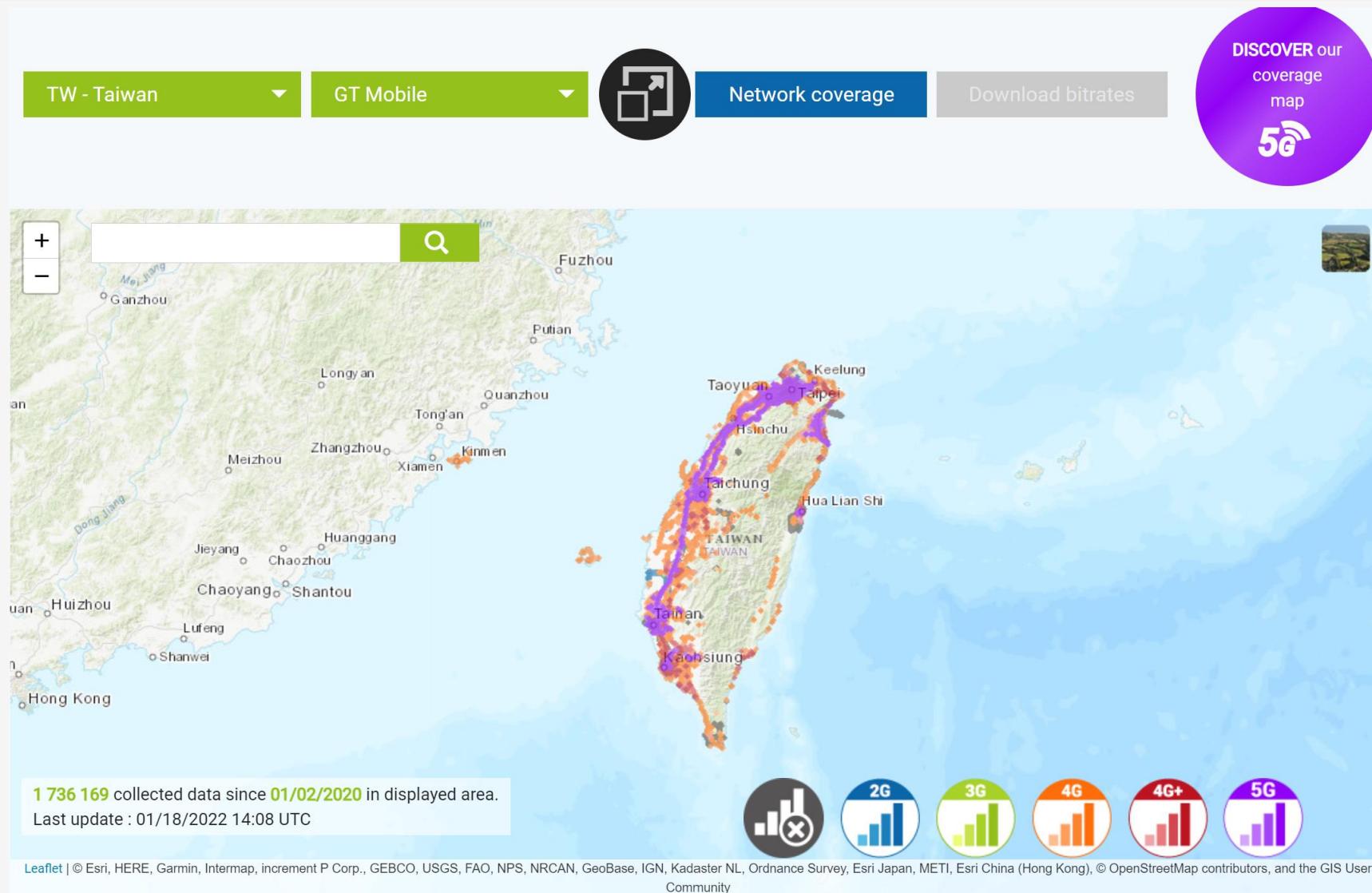
Taiwan Mobile 3G / 4G / 5G coverage map, Taiwan



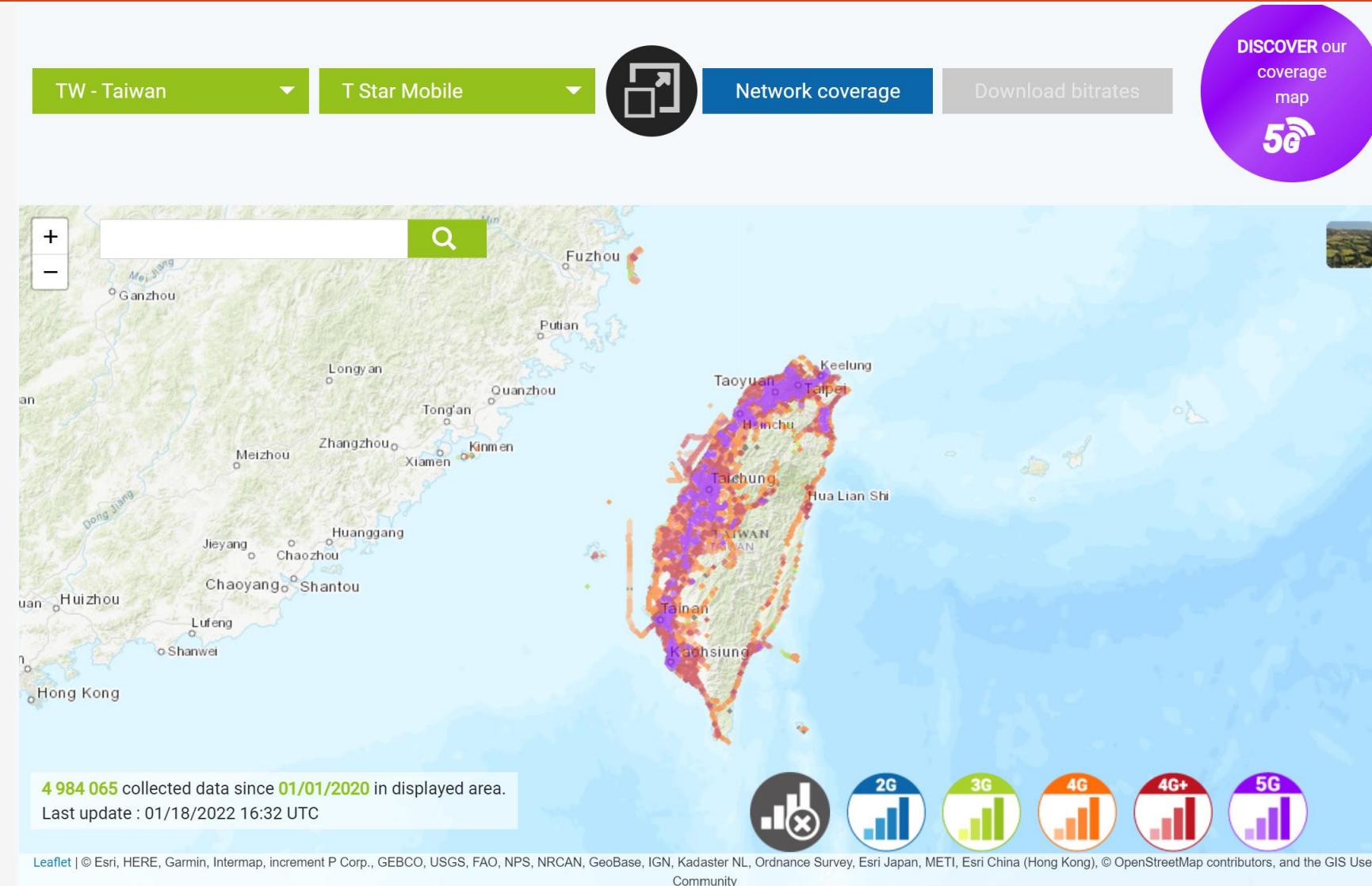
Taiwan Mobile 3G / 4G / 5G coverage map, Taiwan



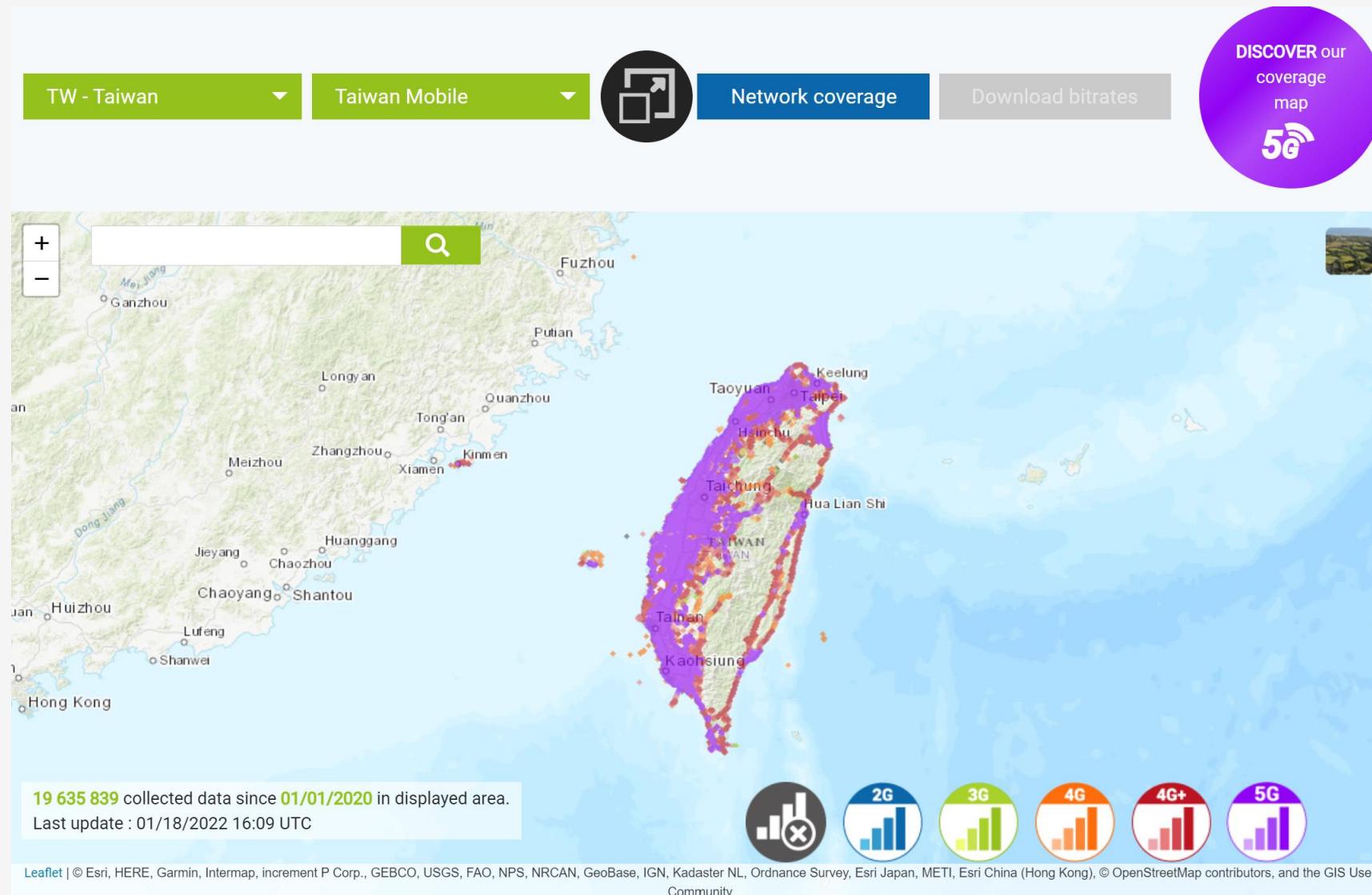
Taiwan Mobile 3G / 4G / 5G coverage map, Taiwan



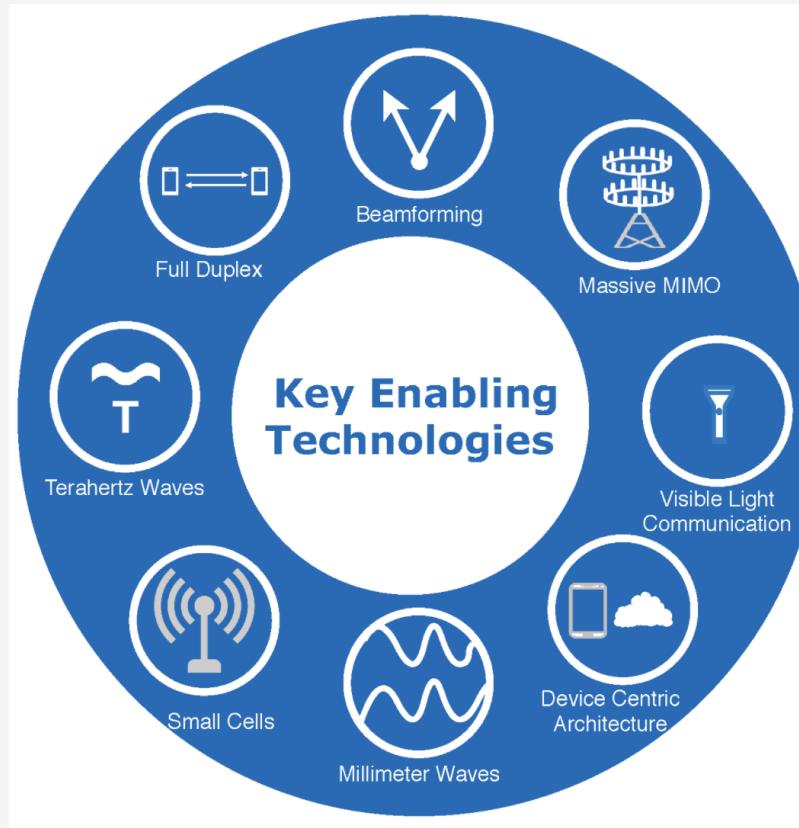
Taiwan Mobile 3G / 4G / 5G coverage map, Taiwan



Taiwan Mobile 3G / 4G / 5G coverage map, Taiwan

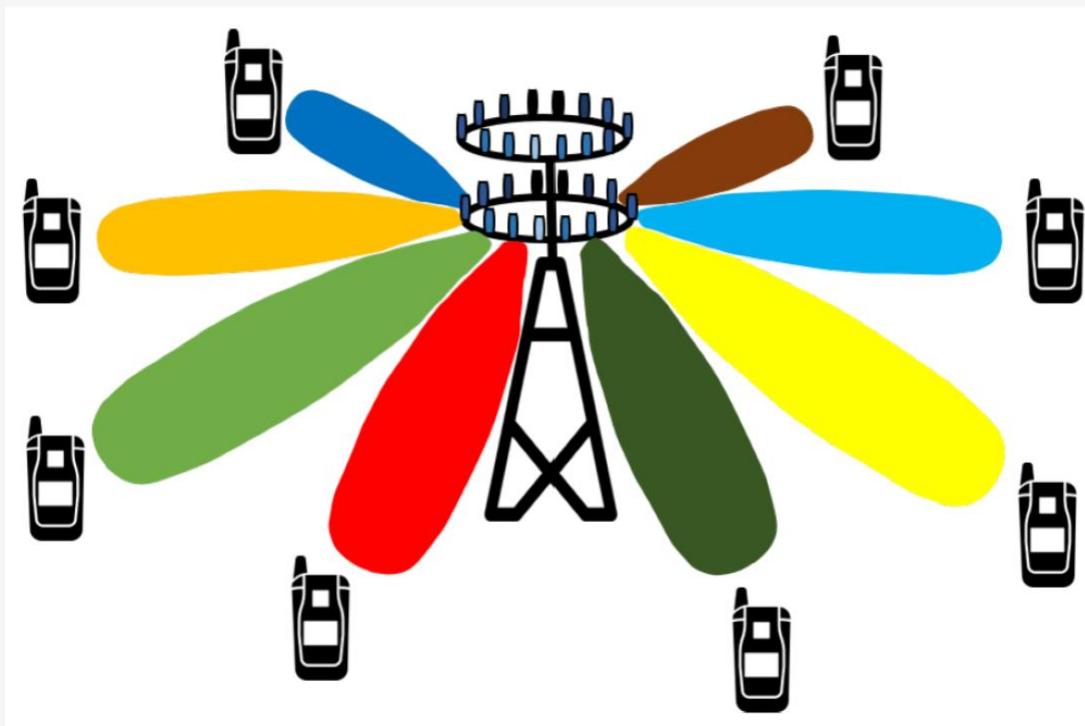


Key Enabling Technologies for 5G and Beyond Networks



The 8 Key enabling technologies for 5G and beyond networks

Key Enabling Technologies for 5G and Beyond Networks – Massive MIMO

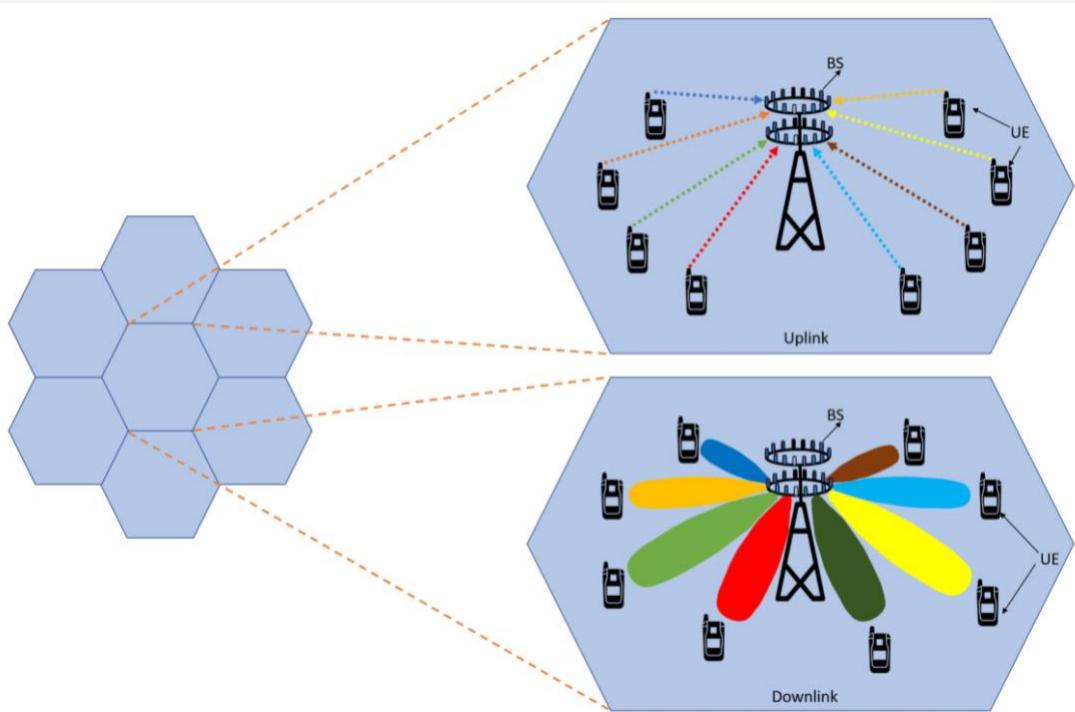


Massive Multiple Input–Multiple Output (MIMO)
beamforming

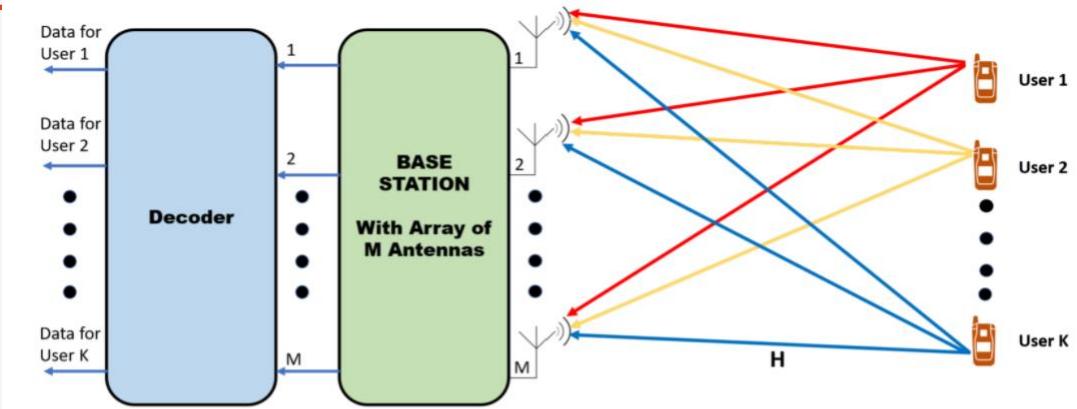


An assembled 100-antenna massive MIMO test bed

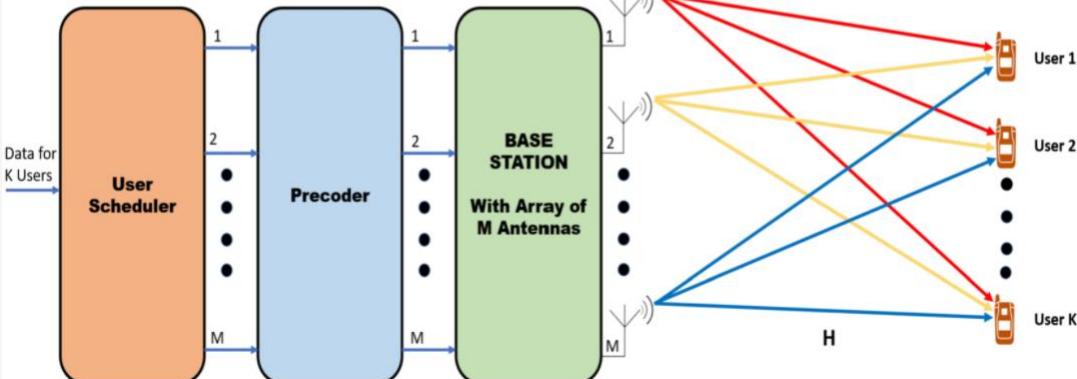
Key Enabling Technologies for 5G and Beyond Networks – Massive MIMO



Massive MIMO uplink and downlink.



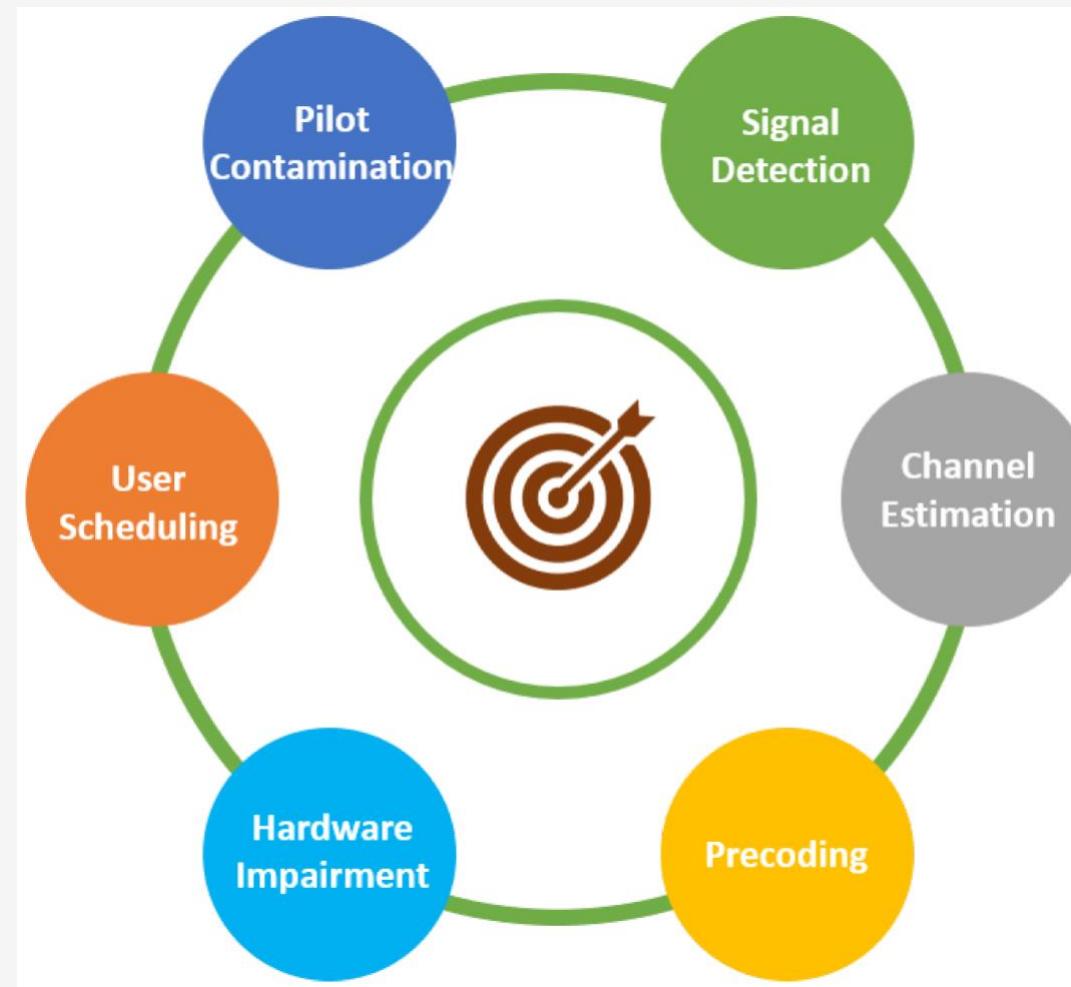
(a)



(b)

Massive MIMO uplink and downlink operation. (a) Uplink
(b) Downlink

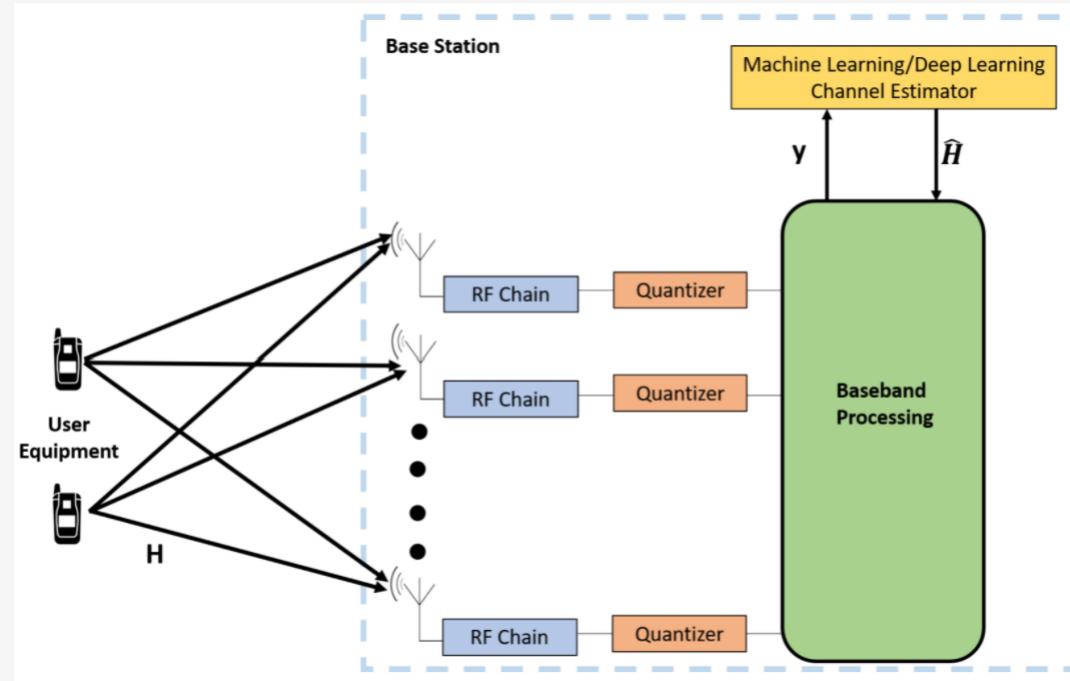
Key Enabling Technologies for 5G and Beyond Networks – Massive MIMO



Challenges in massive MIMO deployment

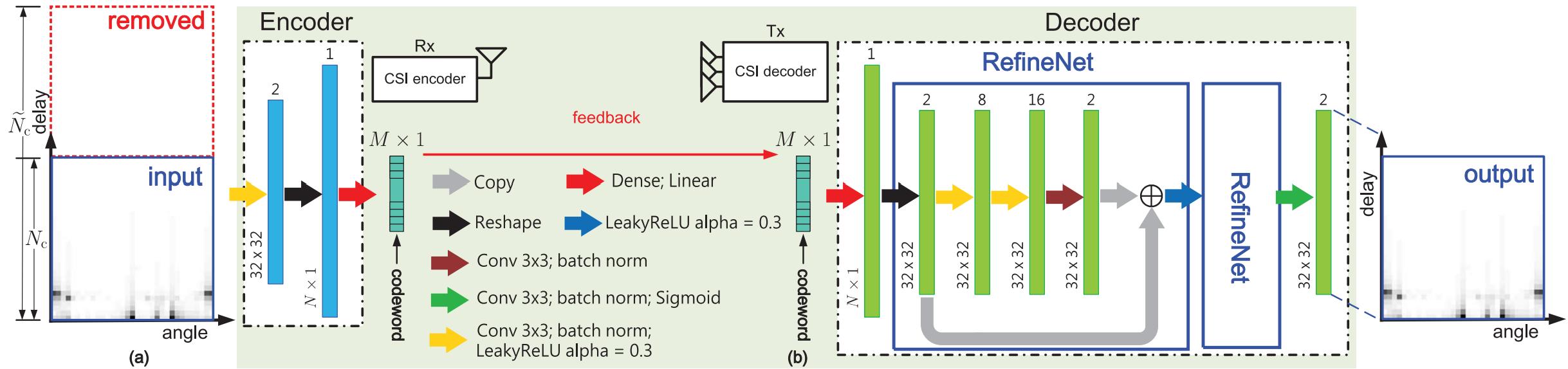
Machine Learning and Deep Learning for Massive MIMO Systems

The machine learning and deep learning algorithms are useful during massive MIMO beamforming, channel estimation, signal detection, load balancing, and optimization of available spectrum



Massive MIMO channel estimation using machine learning and deep learning

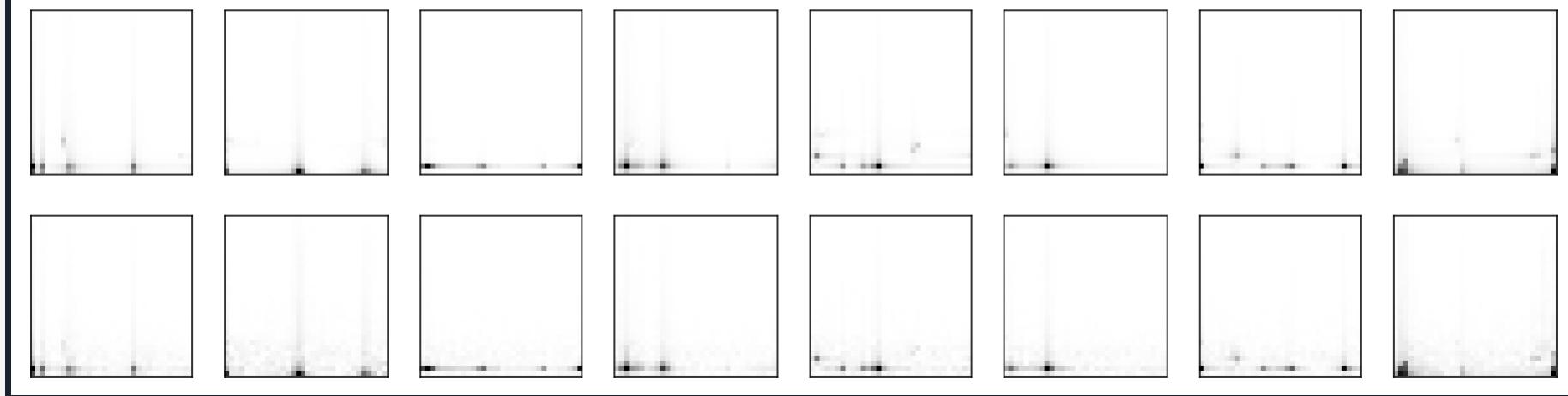
Machine Learning and Deep Learning for Massive MIMO Systems



Deep Learning for Massive MIMO CSI Feedback

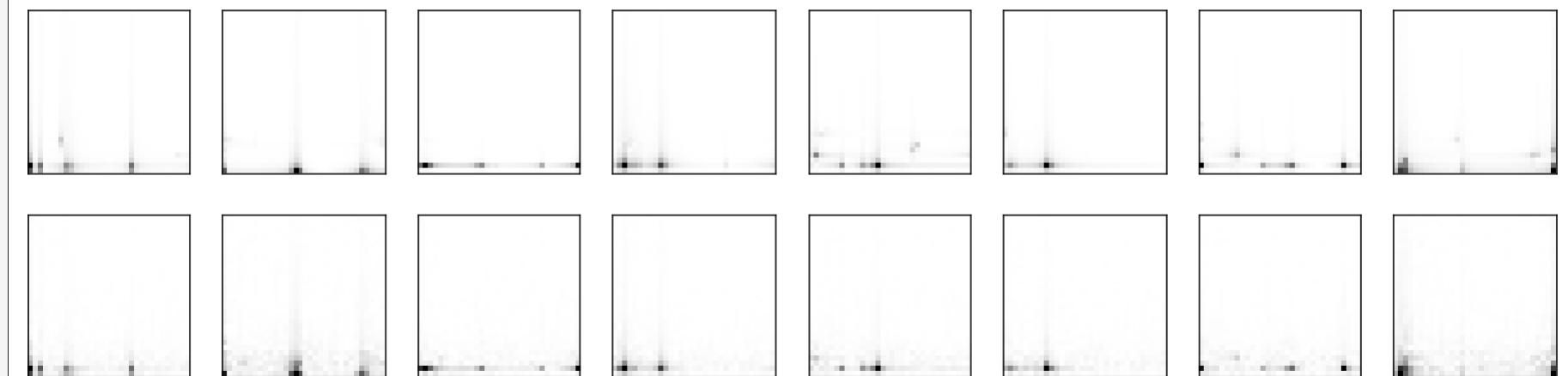
Machine Learning and Deep Learning for Massive MIMO Systems

```
n2 = n2.astype('float64')
In indoor environment
When dimension is 512
NMSE is -11.824607205763272
Correlation is 0.9644325807192492
```



Machine Learning and Deep Learning for Massive MIMO Systems

```
In indoor environment  
When dimension is 512  
NMSE is -9.136482538854588  
Correlation is 0.9393068585859459
```



See you next week

