Antennas and propagation for wireless systems

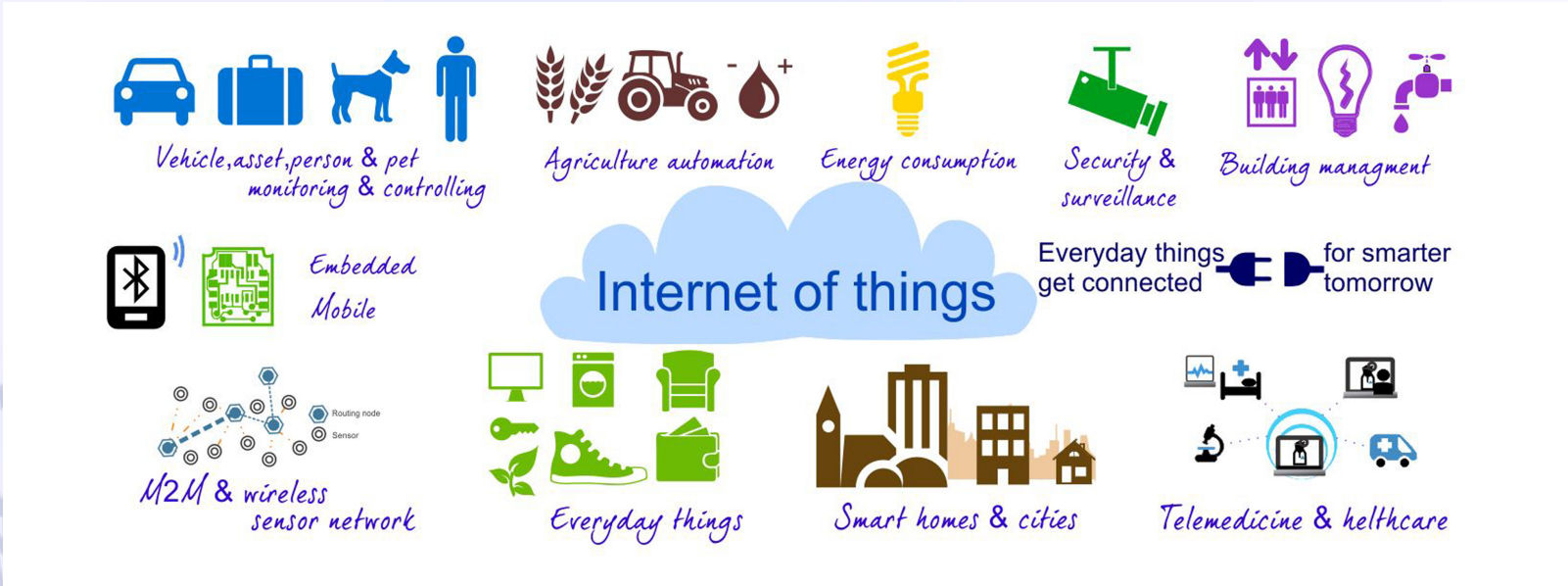
Electromagnetics
and
Remote Sensing Lab
(ERSLab)

Università degli Studi di Napoli Parthenope
Dipartimento di Ingegneria
Centro Direzionale, isola C4 - 80143 - Napoli, Italy

ferdinando.nunziata@uniparthenope.it

Outline

Internet of Things (IoT)



Click for video

Internet of Things (IoT)

The Internet of Things (IoT) is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

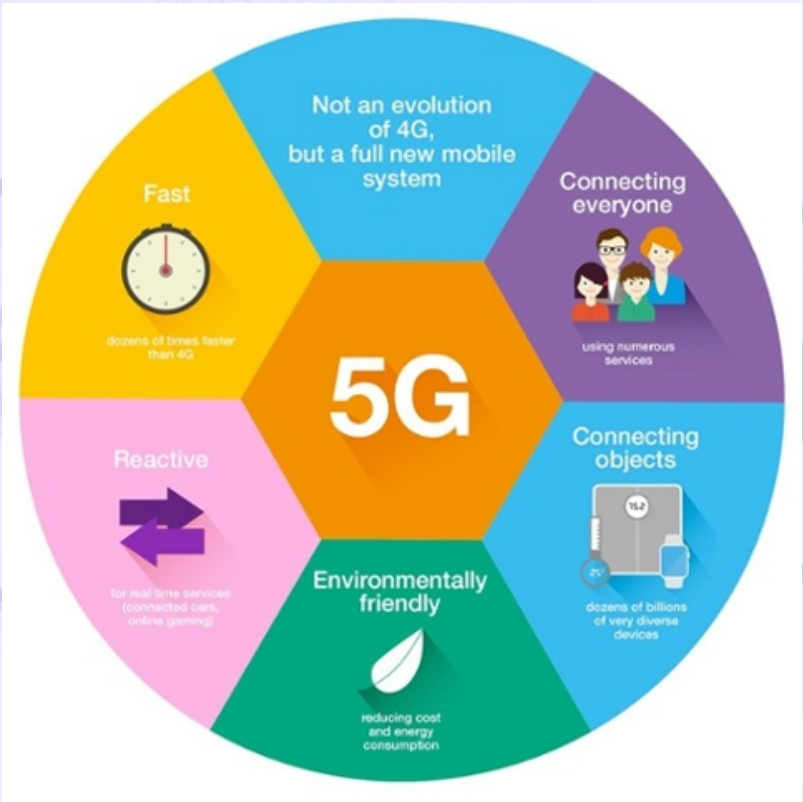
IoT is a promising integration system...

to nurture economy growth and facilitate future personal life, which can be applied in city-wide facilities and institutions. However, realizing such a magnificent vista of future intelligent life requires revolution on diverse advanced technologies such as:

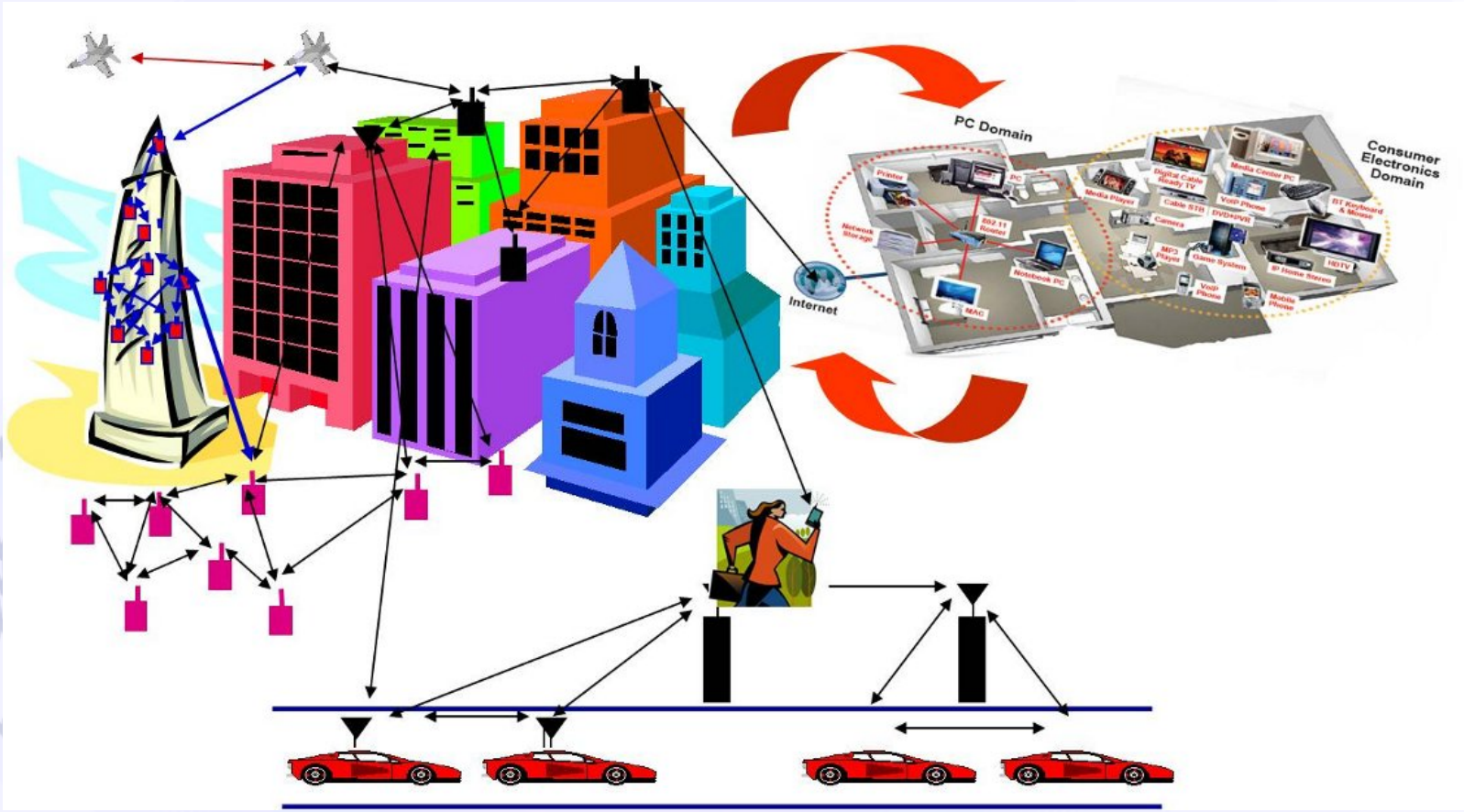
wireless communication.

Cellular wireless - 5G

5G's arrival at the end of this decade will mean faster service and highly reliable networks for IoT. 5G stands to encourage cities, hospitals, and industrial leaders to push the boundaries with new IoT applications.



Wireless communication system - overview

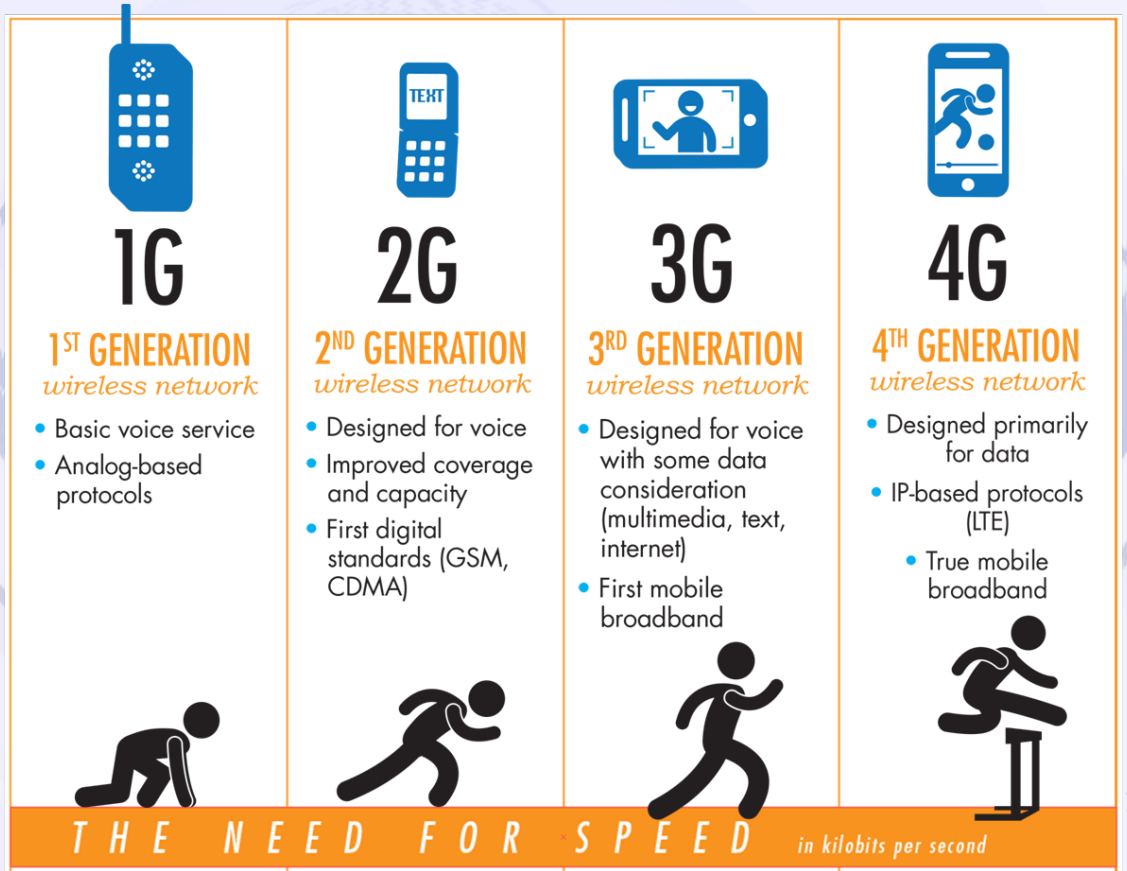


Wireless communication system - overview

- Wireless technology has enormous potential to change the way people and things communicate.
- Future wireless networks will allow people on the move to communicate with anyone, anywhere, and at any time using a range of high-performance multimedia services.
- Wireless video will support applications such as enhanced social networking, distance learning and remote medicine.
- Wireless sensor networks can also enable a new class of intelligent home electronics, smart and energy-efficient buildings and highways, and in-body networks for analysis and treatment of medical conditions.

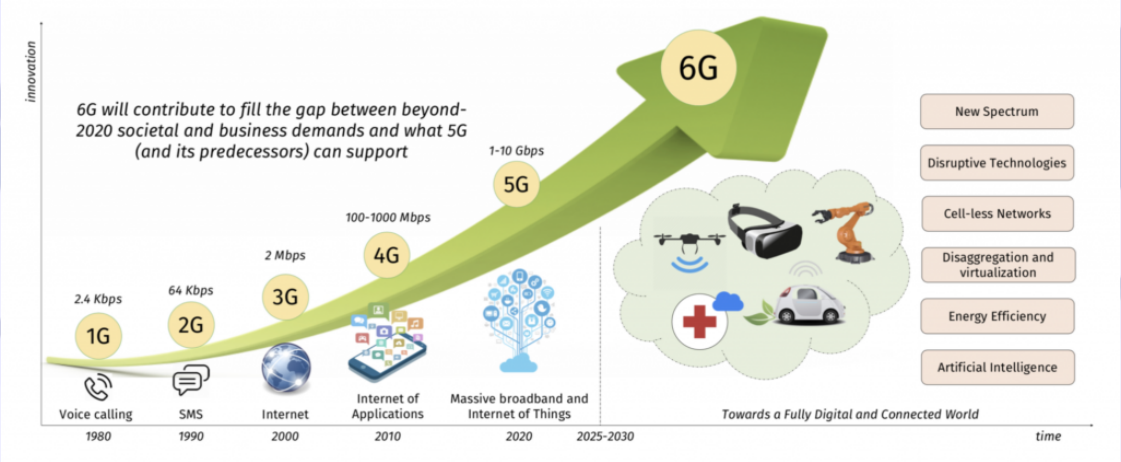
Cellular wireless

As the usage of phones increased and people became more mobile, new applications emerged for using the phones for data transfer, such as to download information from the Internet or to send video.



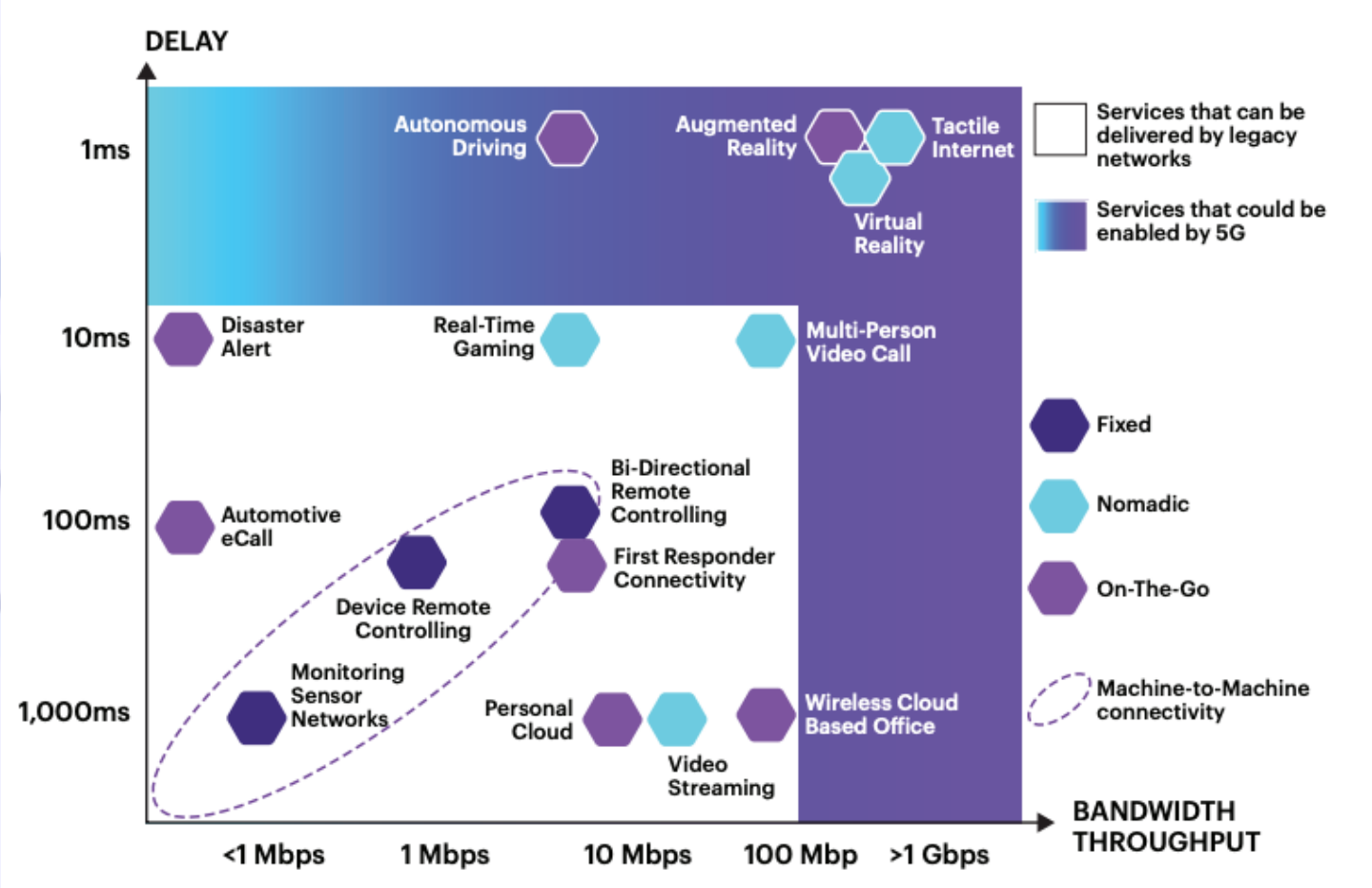
Cellular wireless

5G fouses on a low latency tactile access network, by providing new additional wireless nerve tracts, i.e., data pipes. Yet, nowadays societies will introduce increasingly more stringent requirements (in terms of ultra-high reliability, capacity, energy efficiency, and low latency). The sixth generation (6G) systems will contribute to fill this gap.



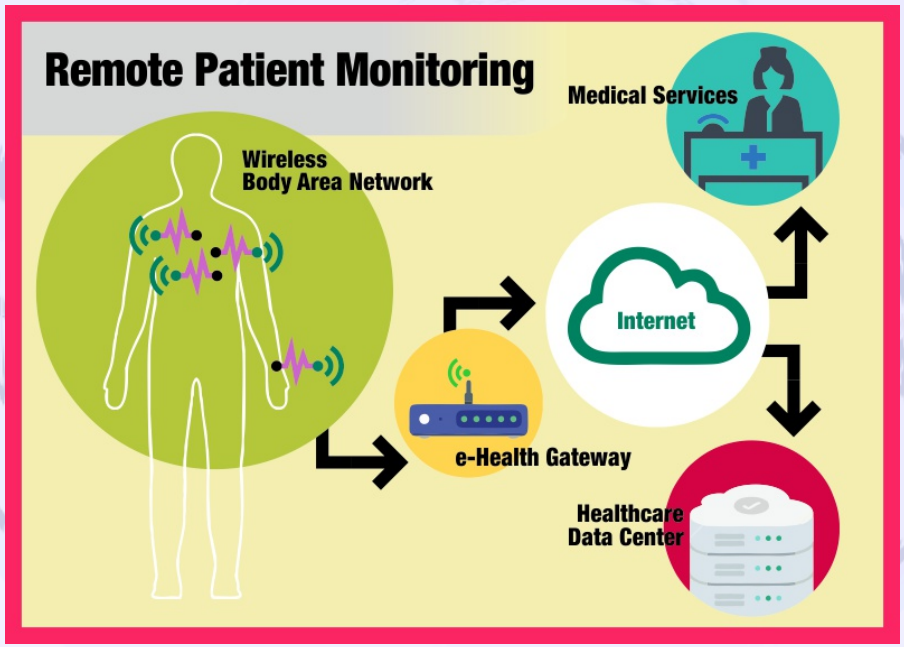
Tactile internet

The Tactile Internet is an internet network that combines ultra low latency with extremely high availability, reliability and security.



Remote medicine

Remote medical monitoring enables low cost in-situ monitoring of patients regardless of their location.



It requires that medical sensors (forming a body sensor network, BSN) are capable of detecting physiological data and transferring this data to physicians via wireless links.

m-eLearning

High-performance wireless networks are transforming e-learning into m-eLearning.

Wireless technologies are expanding Internet access on university campuses and have the potential to transform the instruction of marketing.

Drone technology - Wireless video for first person view

Drones can be piloted in two different ways, either line of sight by visually observing the drone, or by First Person View (FPV)

FPV live video using radio frequency technology is one of the main reasons why drones have become so popular.

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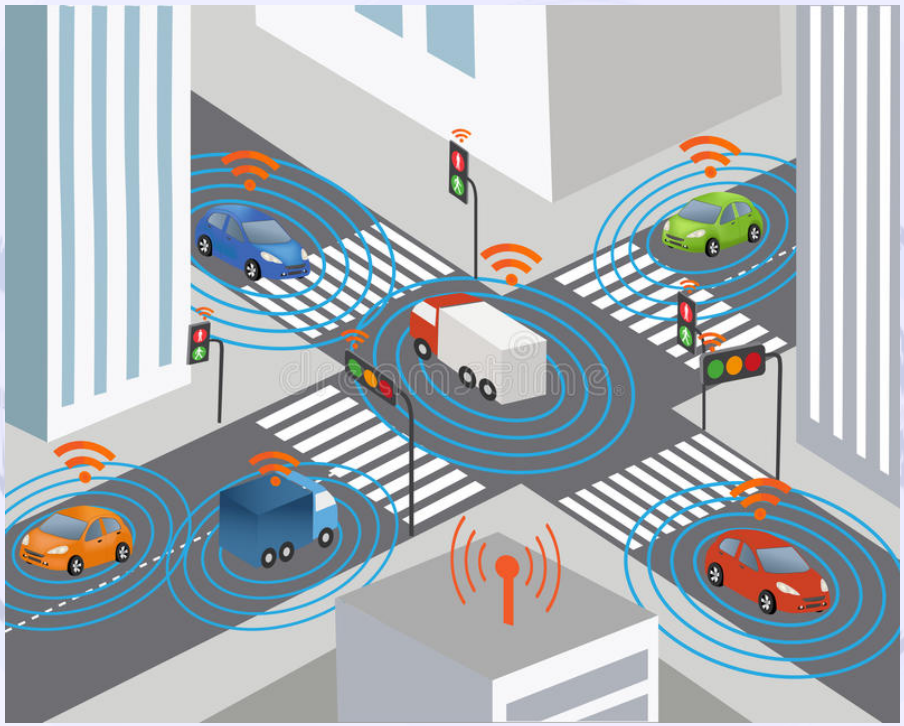
Smart cities



Communication that connects cars to devices on the road, such as traffic lights, sensors, or Internet gateways. Wireless network of vehicle. Smart Car

Future trends

Wireless communication system - overview

There are many technical challenges that must be met in order to make this vision a reality. These challenges include:

- Hardware.
- Communication link design.
- Wireless networking.
- Distributed sensing, communication, and control.
- Cross-layer design.

In addition, synergies between the hardware, link, and network designs must be exploited in order to meet the demanding performance requirements of these future systems.

Introduction

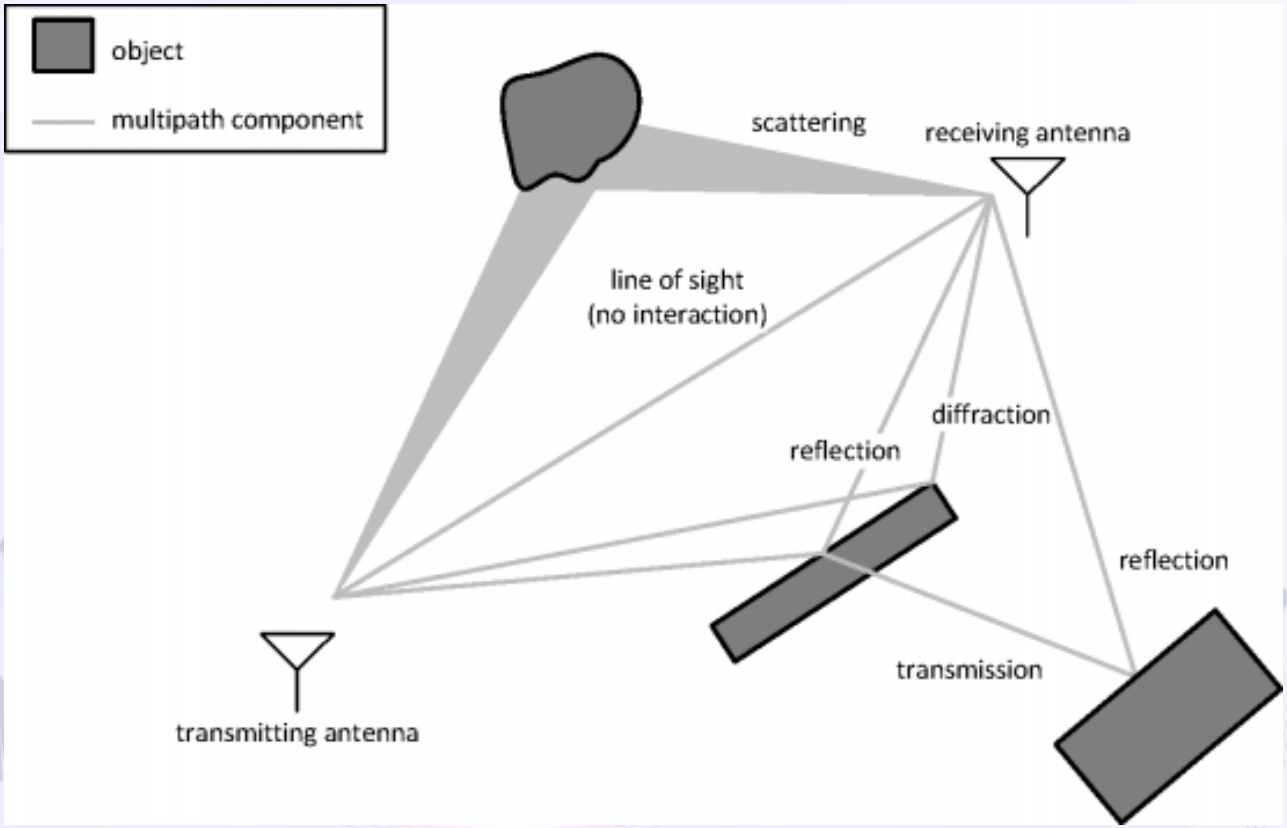
Wireless systems are significantly affected by variations imposed by the wireless channel. Hence it is mandatory to understand those variations in order to answer key questions:

- How fast data can be exchanged ?
- How many users can be served ?
- How big is the area covered ?
- . . .

Aim of the course

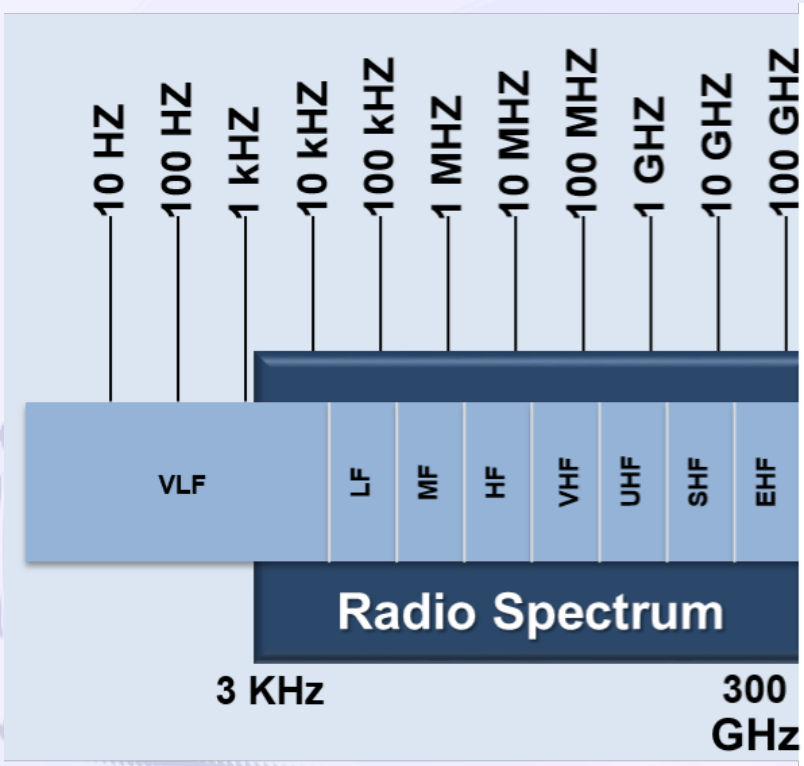
This course aims at providing students with the knowledge and understanding needed to answer questions like the above-mentioned for a large class of wireless systems.

Wireless communication system



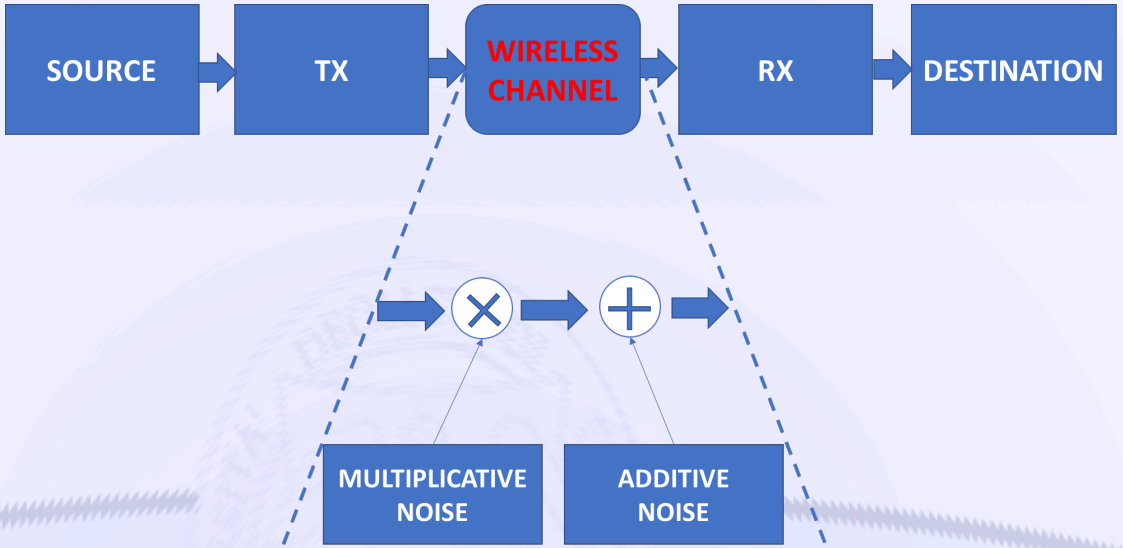
The wireless channel consists of transmitting and receiving antennas and the phenomena that affect the propagation of the em waves.

Wireless communication system



Electromagnetic waves in the range 3kHz to 300GHz are typically exploited.

Wireless channel



Two types of noise

Modeling the wireless channel consists of giving an understanding of the mechanisms that affect the propagation from the TX to the RX. This is done by modeling two sources of noise that affect wave propagation.

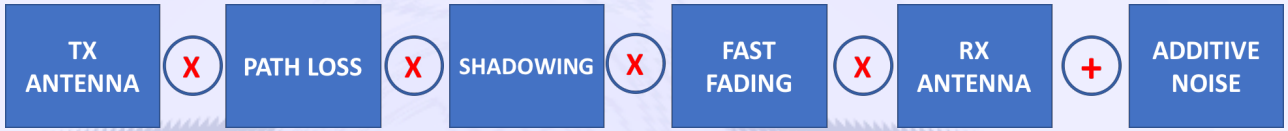
Wireless channel

Two types of noise

- Additive noise: It is independent of the signal strength.
  - It includes the noise generated by the receiver itself, atmospheric effects, cosmic radiation and other interferences.
- Multiplicative noise: It depends on the signal strength.
  - It arises from the various phenomena that affect em waves from TX to RX. Hence, it depends on the TX/RX antenna directional characteristics and reflection, absorption, scattering, diffraction and refraction mechanisms.
  - This multiplicative noise (aka fading) is further subdivided into: phat loss, shadowing (or slow fading) and fast fading (or multipath fading).

Wireless channel

The complete block-scheme that summarizes all the effects that arise from the wireless propagation channel is as follows:

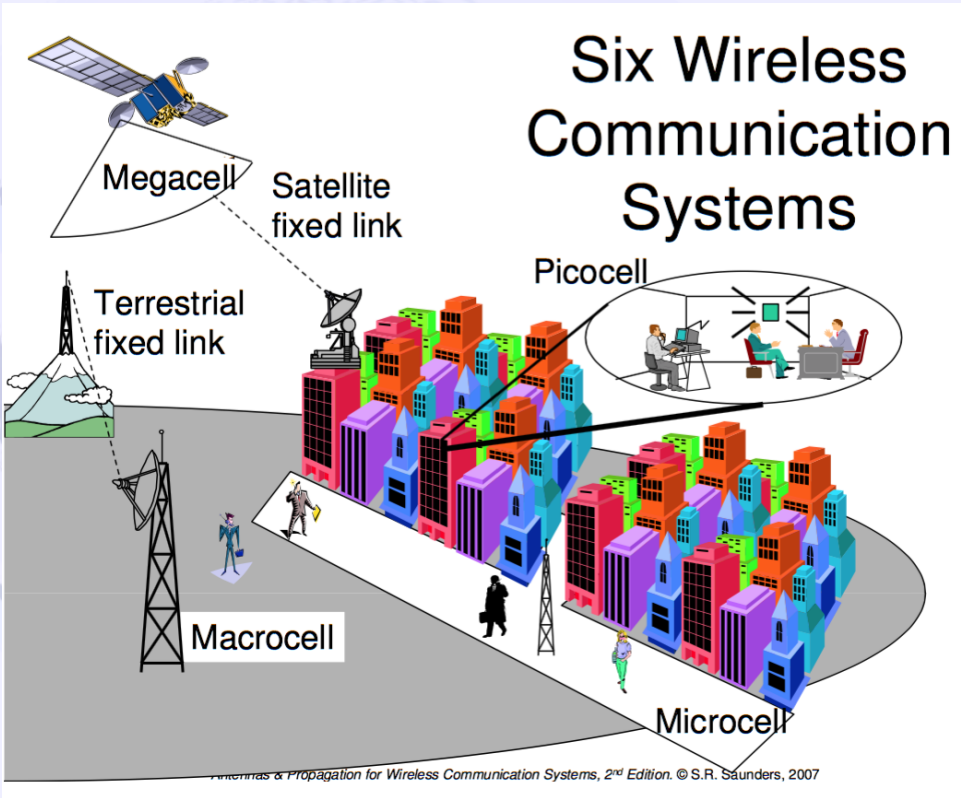


Noise

Unlike additive noise contributions, fading processes vary as the relative positions between TX and RX change and as any contributing obstacles between the propagation path are moved.

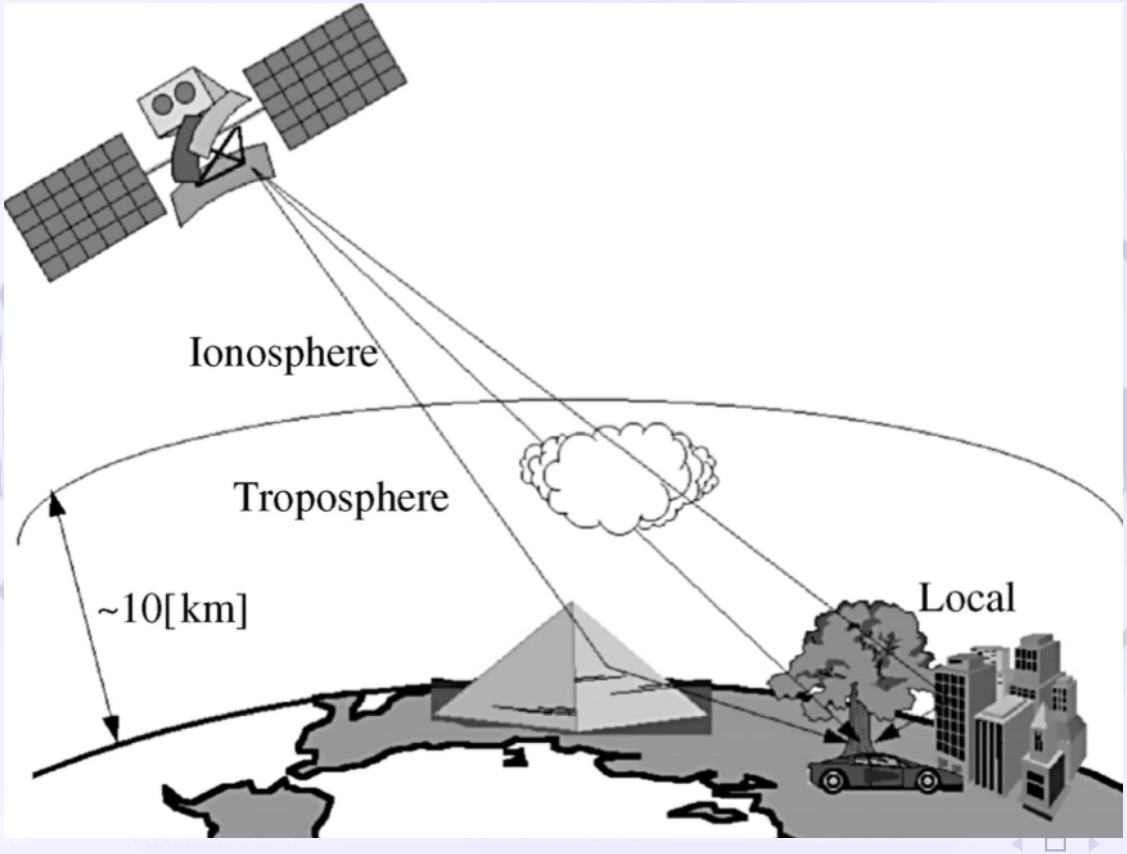
System types

To give a better understanding of the phenomena that affect the em wave while propagating from TX to RX it is useful to distinguish different system types according to antennas, area coverage, fixed/mobile RX, user density, etc.



Satellite fixed links

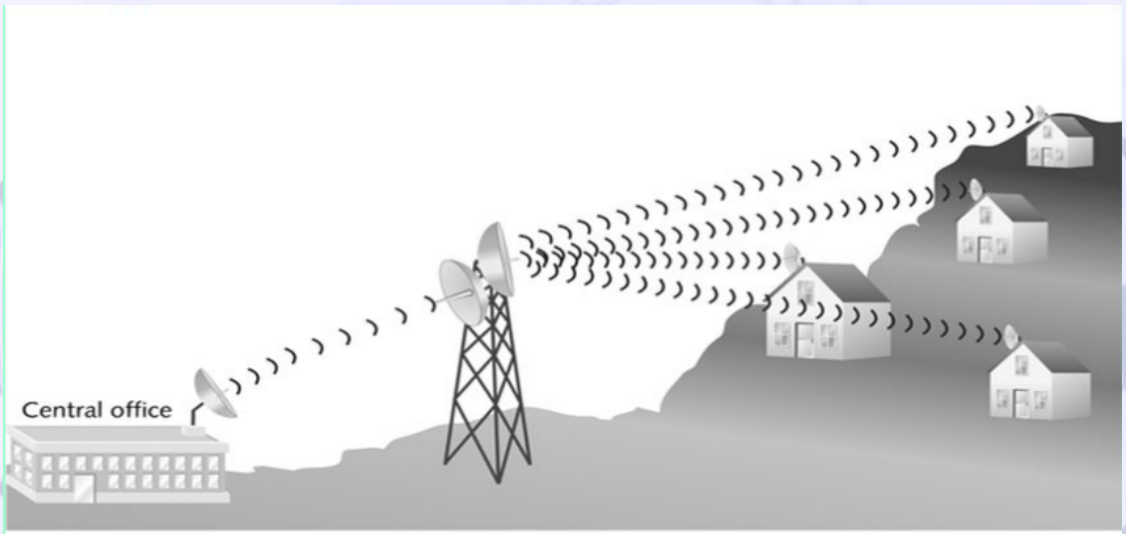
The link is between fixed earth systems equipped with dish antennas and geostationary earth-orbiting satellites.



- Effects related to atmosphere, rain, etc. must be accounted for.
- SHF and EHF bands.

Terrestrial fixed links

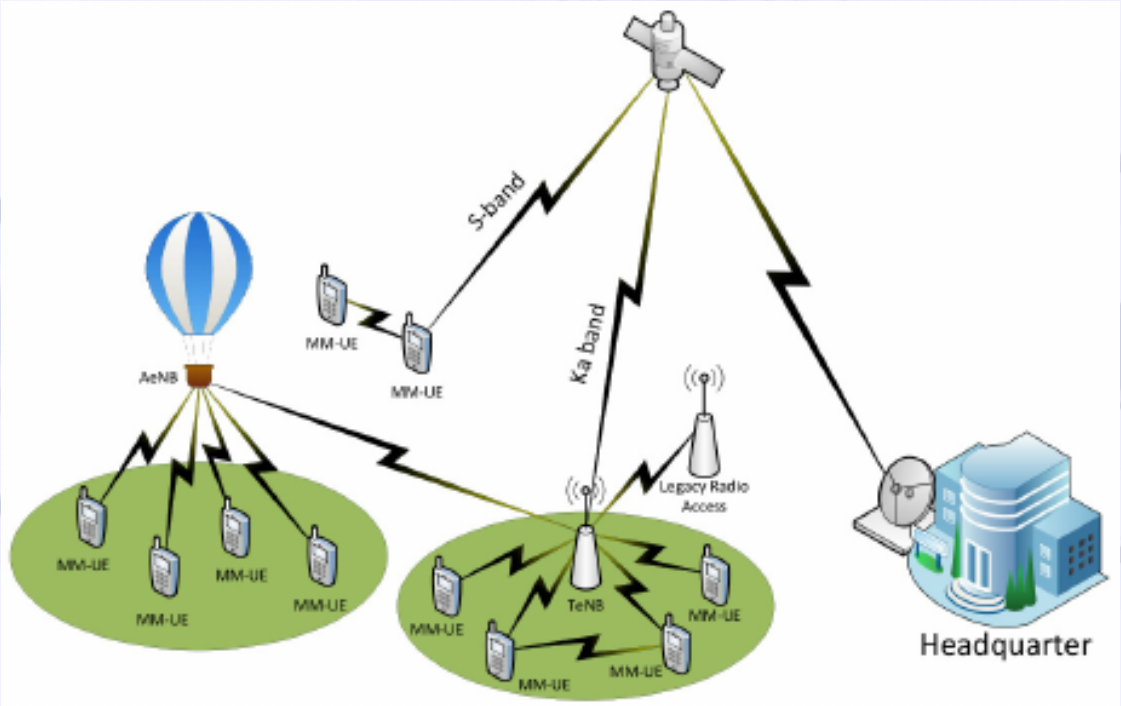
High capacity links between ground stations.



- Effects related rain, etc and obstructions (e.g., hills and trees) must be accounted for.
- From VHF to EHF band.

Megacells

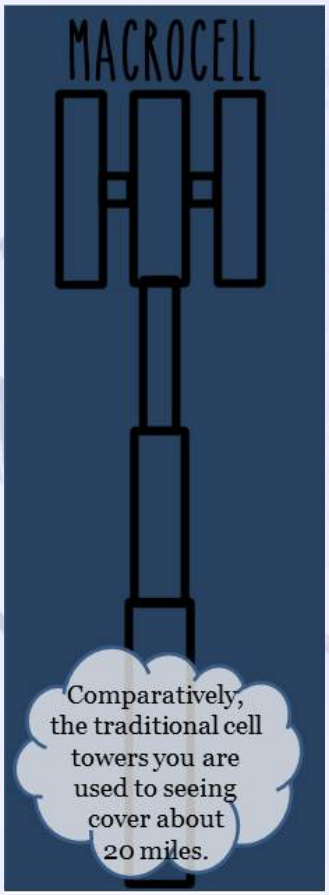
A large area coverage (with quite low mobile user density) is obtained using earth-orbiting satellites or stratospheric balloons.



- Effects related to atmosphere and interfering objects close to the users must be accounted for.
- L- and S-band.

Macrocells

A moderate area coverage (with medium mobile user density) is obtained using base station antenna height larger than the surrounding buildings.



- Effects related to atmosphere and interfering objects close to the users must be accounted for.
- VHF and UHF bands.

Microcells

High traffic density both outdoor and indoor and base station antennas lower than the surrounding buildings.

- The area coverage is determined by street layout.
- VHF and UHF bands.

Picocells

Very high traffic density or high data rate indoor applications.

- Both mobile and fixed users.
- The area coverage is determined by room layout.

Femtocells

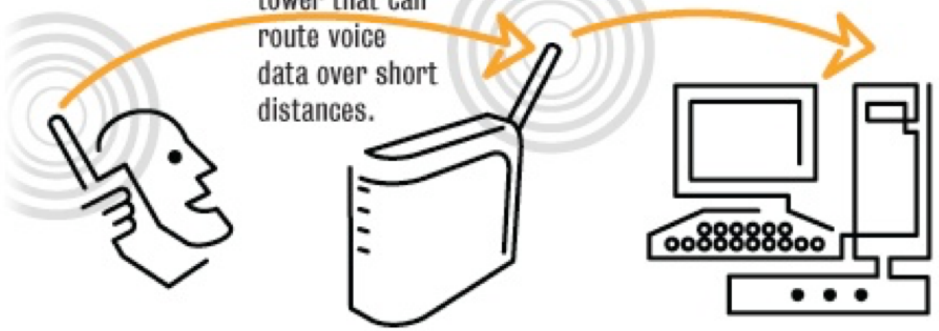
FEMTOCELL

Often self-installed, femto-cells are the smallest of small cells, capable of handling a few users at a time. These units are autonomous and can provide "5-bar" signal within a small area.

www.hetnetwireless.com

How femtocells work

1. Your cell phone rings and you answer it.
2. If the phone is in close proximity to your home's femtocell, it will automatically route its voice transmission through the femtocell rather than through the nearest cell phone tower. Essentially, the femtocell is a low-output cell tower that can route voice data over short distances.
3. The femtocell sends the voice data through your home cable or DSL modem, thus letting you save money on phone calls in your house by enabling you to send them over IP.



Info

- The course consists of 72h: 48h of traditional lectures and 24h of practice. The latter include both laboratory experiments, undertaken using the anechoic and reverberating chambers, and numerical simulations in Matlab environment.
- The examination consists of two parts that take place within the same day.
  Oral exam that aims at evaluating the student's ability to link and analyze the topics studied during the course; the minimal score to pass the test is 12/20;
  Group project where students (2-3 students per group) need to comment and discuss selected laboratory and numerical experiments.

Info (cont'd)

- Teacher's notes available on the course website (www.edi.uniparthenope.it).
- S. R. Saunders, Antennas and Propagation for Wireless Communication Systems, WileyÂ
- J. D. Parsons, Mobile Radio Propagation Channel, Wiley
- K. Siwiak, Radiowave Propagation and Antennas for Personal Communications, Artech House
- Online free-available tool to design a simple radio link (http://www.ve2dbe.com/rmonline.html)