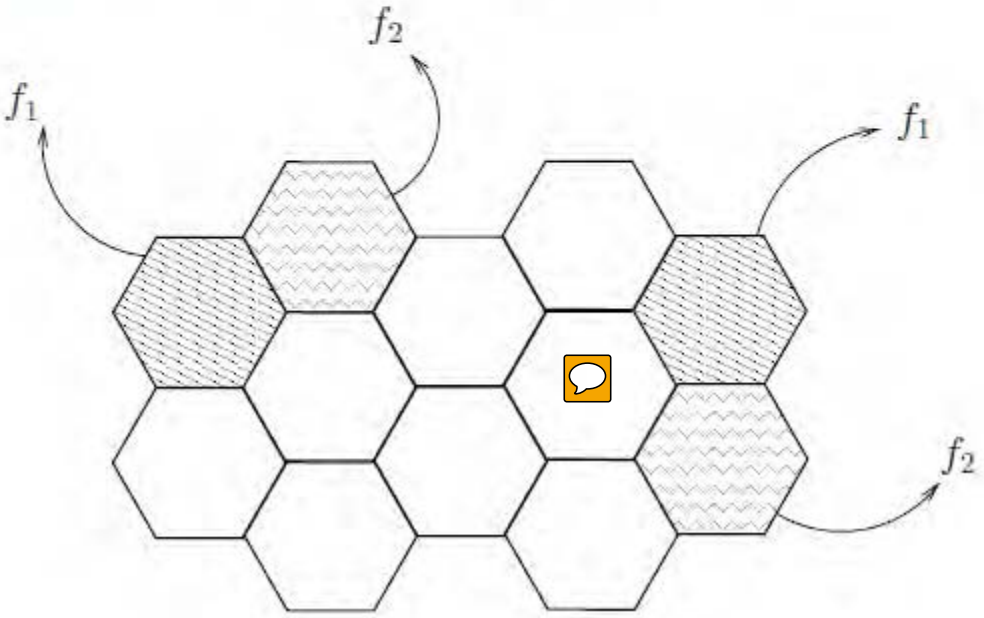
Outline

- **A preliminary overview**
- Propagation characteristics
- ISO-OSI Model
- Physical layer: modulation
- MAC layer:
  - Fixed resource assignment
  - Random access
    - Ethernet (CSMA/CD)
    - WiFi (CSMA/CA)
- Personal Area Networks
  - Bluetooth
  - Zigbee
- Cellular network dimensioning
- Cellular networks
  - From GSM (2G) to UMTS (3G)
  - LTE (4G)

History of Wireless Networks

- First examples by policemen and firemen: only half-duplex.
- IMTS (Improved Mobile Telephone System): first full-duplex system, but not really cellular.
- First cellular network by AT&T USA: space reuse concept.



Cellular Networks in USA

1983 AMPS (Advanced Mobile Phone System): analogical and with only a few channels.

1991 IS 54: first digital network with TDMA (Time Division Multiple Access), $\pi/4$-QPSK (Quaternary Phase Shift Keying) modulation, and carrier modulation at 1.9 GHz.

1995 IS 95: 2G mobile system with use of CDMA (Code Division Multiple Access).

2000 IS 2000: 3G mobile system with an improved CDMA. It is backward-compatible with IS 95.

2008 Qualcomm announced for 4G systems that UMB (Ultra Mobile Broadband) was ending development of the technology, favoring LTE (Long Term Evolution) instead.

Cellular Networks in Europe

1985 TACS (Total Access Communication System): European variant of AMPS with a similar analogical technology. In UK, the last TACS service was discontinued on 31 May 2001 (Vodafone). ETACS is however still in use in a handful of countries elsewhere in the world.

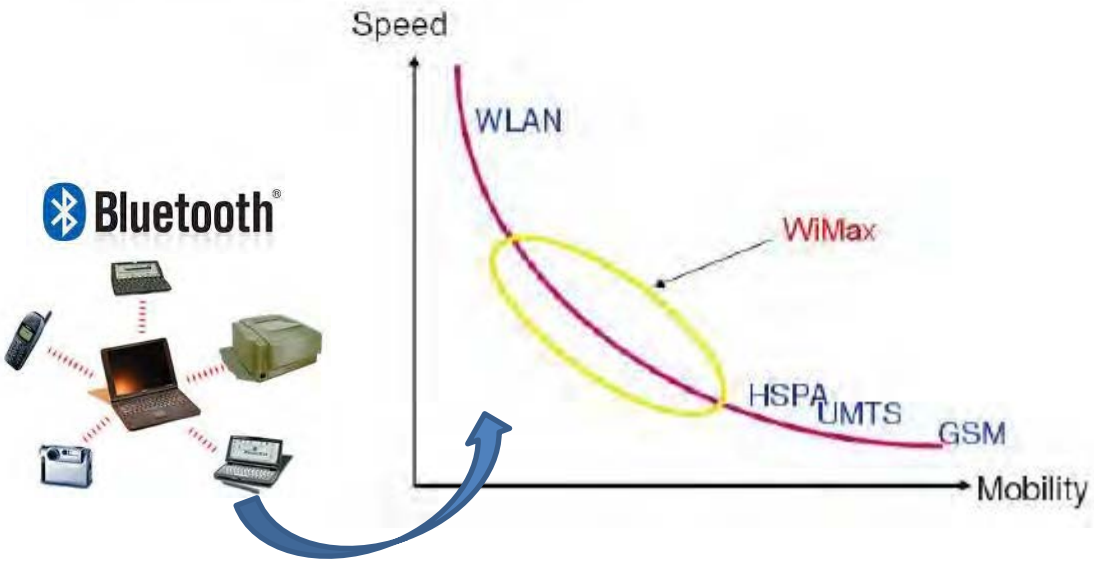
1991 GSM (Global System for Mobile Communications, originally from Groupe Special Mobile): first digital 2G technology with GMSK (Gaussian Minimum Shift Keying) modulation and TDMA medium access.

2000 UMTS (Universal Mobile Telecommunications System): 3G mobile system with use of CDMA and maximum theoretical data transfer rate of 21 Mbit/s (with HSDPA, High Speed Downlink Packet Access).

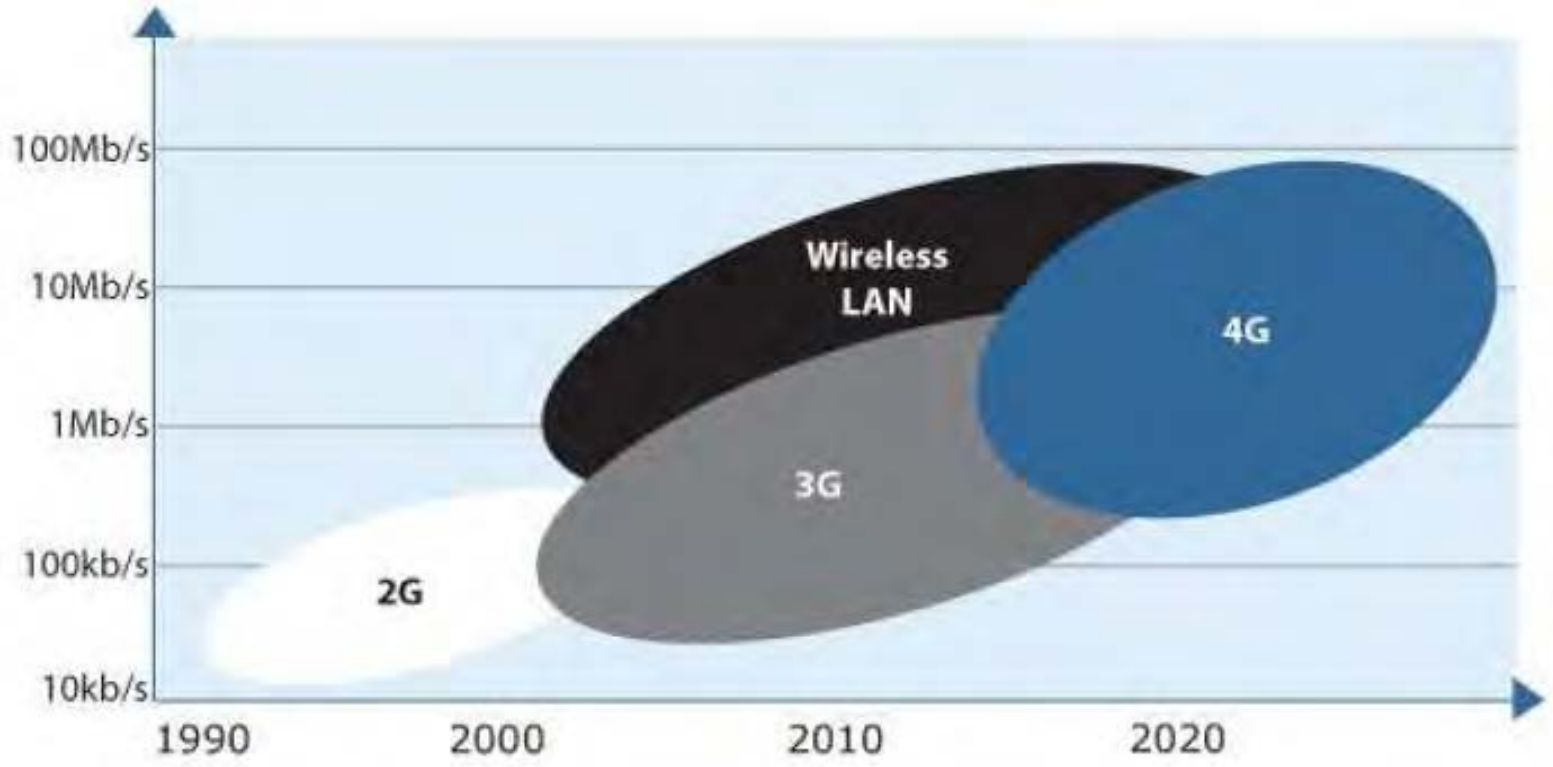
2006 The 3GPP LTE project plans to move UMTS to 4G (higher) speeds, using a next generation technology based upon Orthogonal Frequency-Division Multiplexing (OFDM).

Other Examples

- WiMAX (Worldwide Interoperability for Microwave Access): IEEE 802.16 standard for providing large bandwidth and high mobility (last mile connectivity).
- WiFi: wireless local area networks (WLANs) based on the IEEE 802.11 standards (802.11a/g/n).
- Ethernet: standardized as IEEE 802.3 for wired-based communications.



Transmission Capacity



Key Aspects of Infrastructure-Based Networks

- Many users want to exchange information by using a shared medium (e.g., the air)

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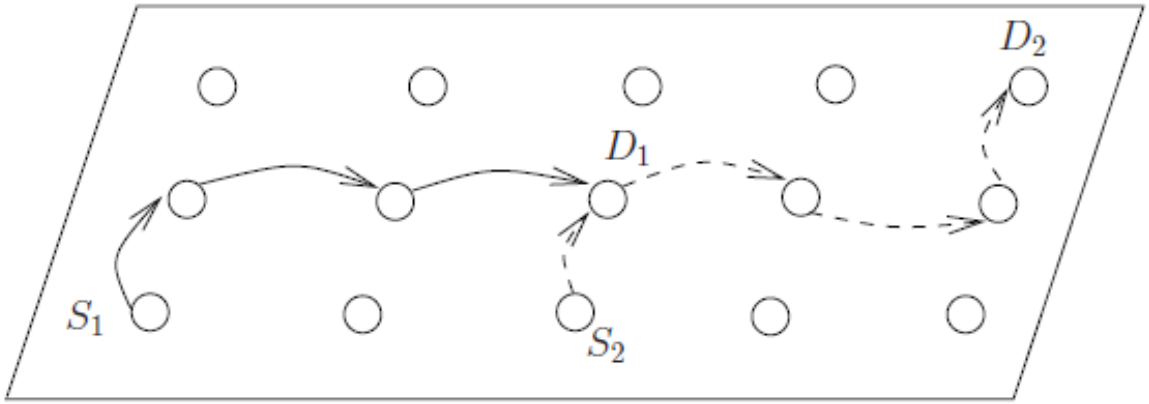
  Need of a MAC (Medium Access Control) protocol.

- Received power experiences (possibly high) statistical fluctuations due to fading and shadowing.

- The presence of neighbors leads to interference and, therefore, central authorities are needed.

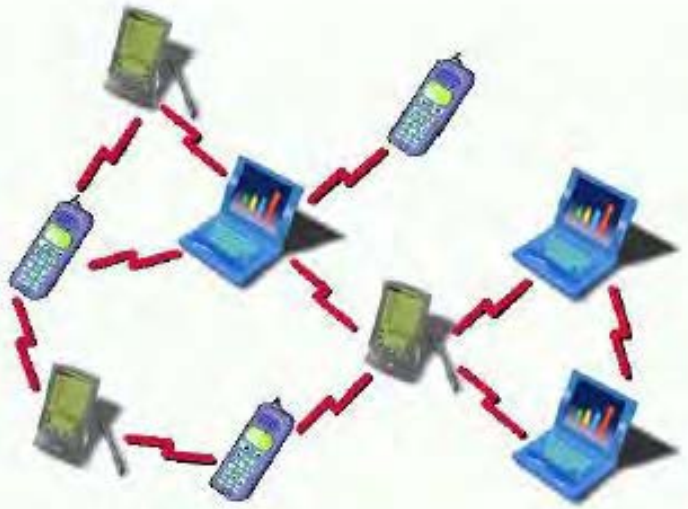
From Cellular Networks to Pervasive Computing

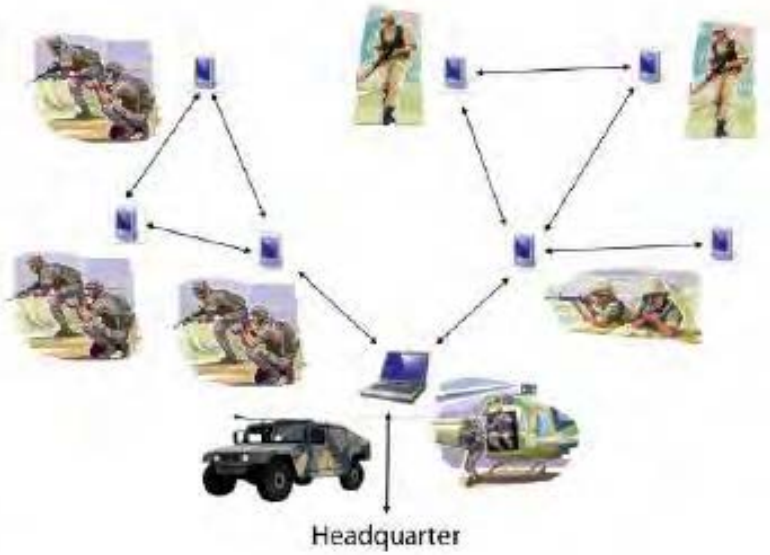
- The central authority should be cancelled: decentralized control of the network.
- Concept of networking on demand: paths between pairs of nodes are established iif they want to communicate.
- A lot of small and low-complexity devices are placed in a given area $\Longrightarrow$ need for distributed computing.
- Topology can change dynamically.



Mobile Ad hoc NETworks (MANETs)

Wireless Ad Hoc Networks: like WiFi, but without any central entity and with need of proper physical/MAC layer protocols.





Characteristics of MANETs

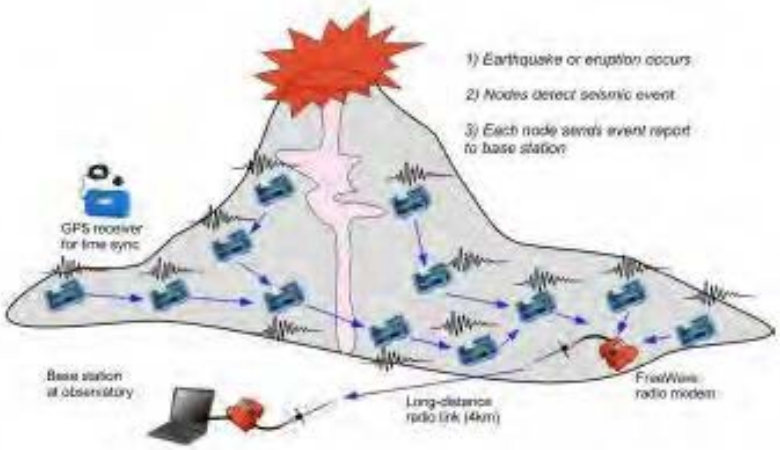
- Autonomous system of nodes.
- Lack of fixed infrastructure relays.
- Absence of centralized authority.
- Peer-to-peer connectivity and multi-hop forwarding to ensure network connectivity.
- Topology may change dynamically.
- Random multi-hop graph.
- Energy-constrained (battery) and bandwidth-constrained (variable capacity links).

Applications of MANETs

- Defense: on-the-fly communications for soldiers on the ground, fighter planes in the air, etc.
- Crisis management: natural disasters where the entire infrastructure may fail.
- Tele-medicine: paramedic assisting a victim at a remote location can access medical records, can get video conference assistance, etc.
- Tele-geoprocessing and virtual navigation: combines geographical information system (e.g., GPS and high capacity MSs), queries dependent of location information of users, and environmental monitoring using sensors.
- Education via Internet: educational opportunities on Internet to students and other interested individuals.

Wireless Sensor Networks (WSNs)

Spatially distributed autonomous sensors cooperatively monitor physical or environmental conditions, such as temperature, pressure, humidity, etc. $\Longrightarrow$ ZigBee standard.



Sensors

- Sensors are portable and self-sustained (power, communication, intelligence).
- Sensor nodes are capable of embedded (complex) data processing.
- Technology trends predict small memory footprint may not be a limitation in future.
- Sensor devices are equipped with multiple sensing, programmable computing, and communication capability.
- Sensors are capable of surviving harsh environments.

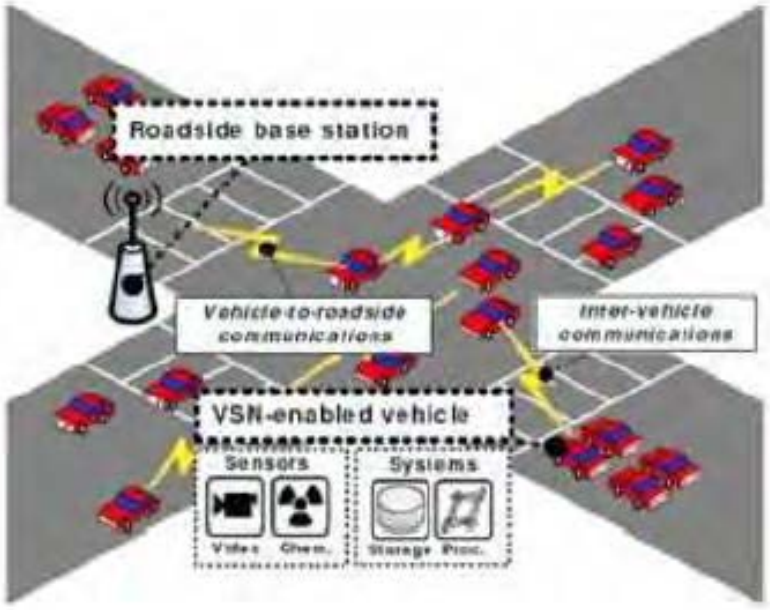
Sensor Networks

- Collection of tiny disposable and low power devices.
- The sensed attributes are converted into a form understandable by human users.
- The number of sensors can be large to cover as much area as desirable.
- Sensor networks are usually unattended and some degree of fault-tolerance needed.

Vehicular Ad hoc NETworks (VANETs)

Vehicles communicate with each other (V2V) as well as with roadside base stations (V2I) in order to contribute to safer and more efficient roads.

IEEE 802.11™



Radio Frequency IDentification (RFID)

As with barcodes, tags are applied to or incorporate into a product, animal, or person for identification and tracking using radio waves.