

# Quali Prospettive per il Futuro?

## Wireless Networks and Pervasive Technologies

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Italian National Research Council (CNR)

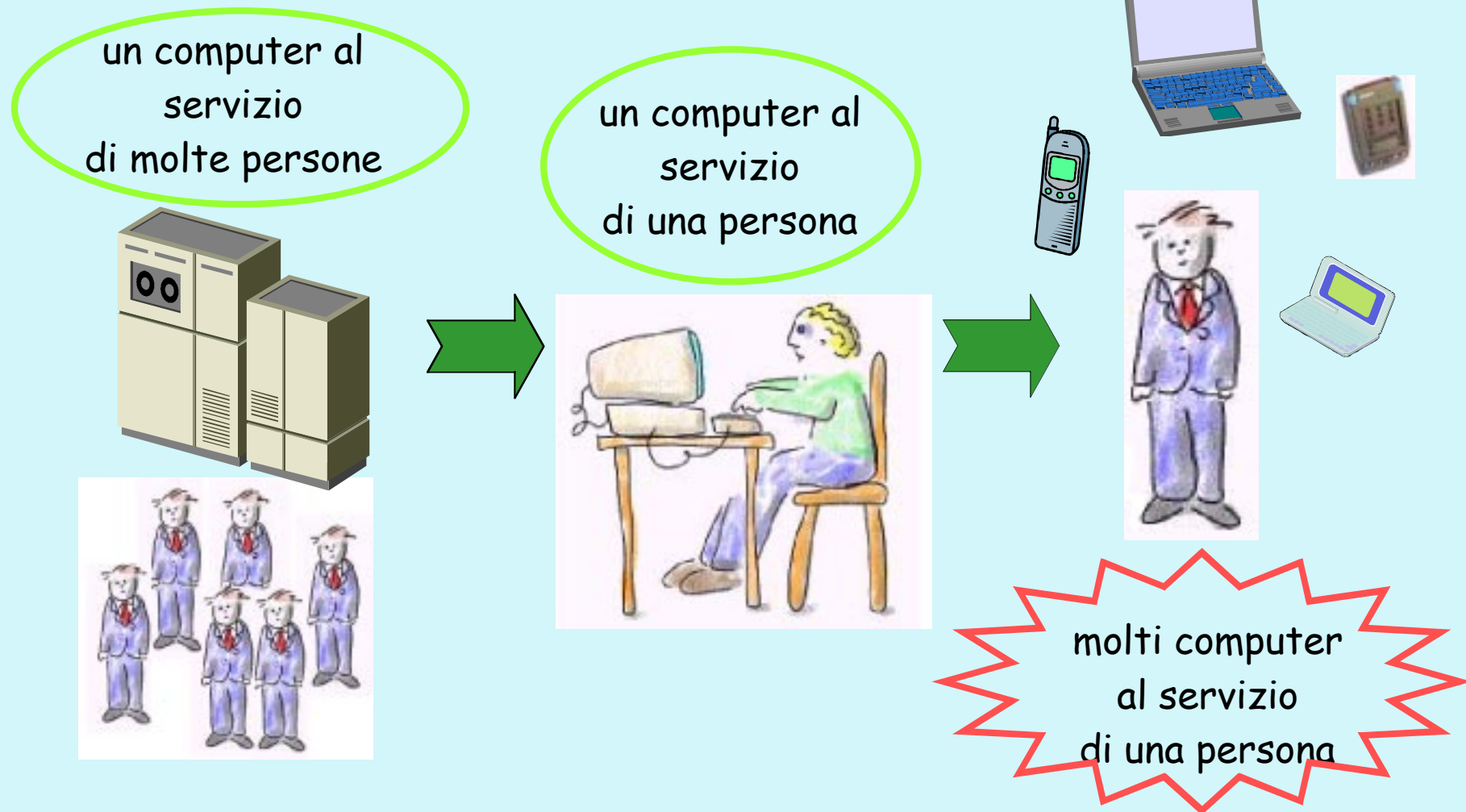
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## Technology Forecasts (?)

- *“Heavier-than air flying machines are not possible”*  
*Lord Kelvin, 1895*
- *“I think there is a world market for maybe five computers”*  
*IBM Chairman Thomas Watson, 1943*
- *“640,000 bytes of memory ought to be enough for anybody”*  
*Bill Gates, 1981*
- *“The Internet will catastrophically collapse in 1996”*  
*Robert Metcalfe*

# Pervasive/Ubiquitous Computing



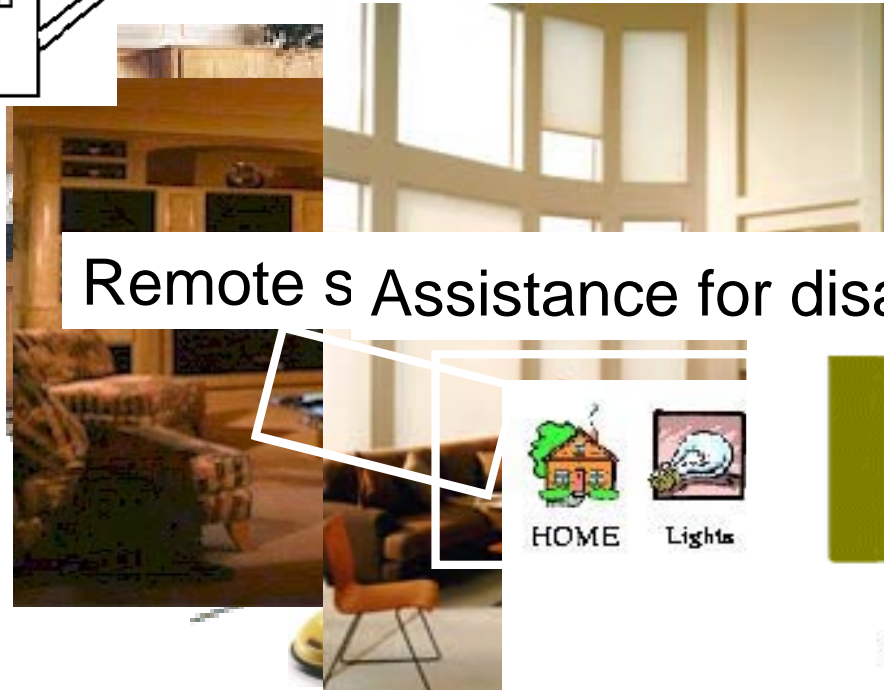
# Pervasive/Ubiquitous Computing

Environment saturated with computing and communication capabilities to make *intelligent decisions* in an *automated, context-aware* manner

- Technology transparently weaved into the fabric of our daily lives  
→ *technology that disappears*. (Weiser 1990)
- Portable devices around users networked with body LANs, PANs (*personal area networks*) and *wireless sensors* for reliable commun.
- Environment that *takes care of itself or users* → intelligent assistants provide *proactive interaction* with information Web.

**Examples:** Smart home, office, mall, hotel, hospital, park, airport

# Smart home



Automated blinds

Control appliances

Remote Assistance for disabilities

vacuum



Lighting Status and Control  
About this Page

REFRESH

LivingRoom ON OFF 10%Dim

Last Refresh: 10-10-2000 - 15:07:15

Living Room: OFF  
Living Room Computer: OFF  
Master Bedroom East: ON  
Master Bedroom West: ON  
Computer Room: ON

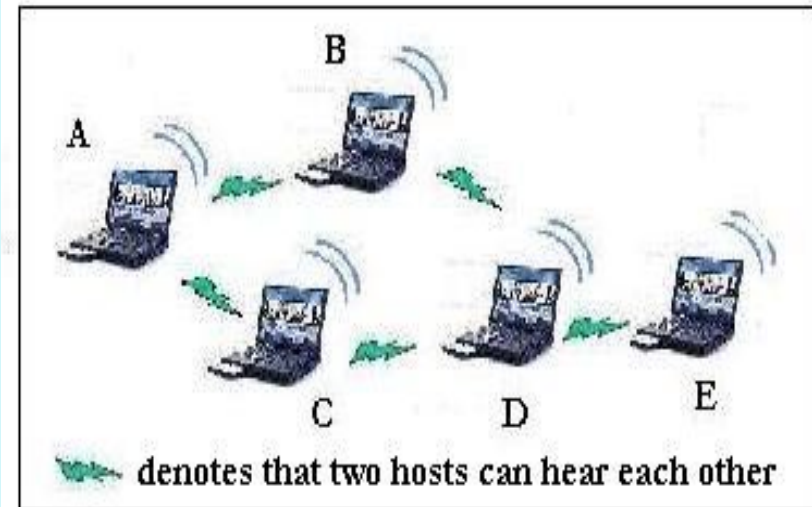
Driveway: ON  
Front Porch: OFF

# Pervasive/Ubiquitous Networking

## Sommario

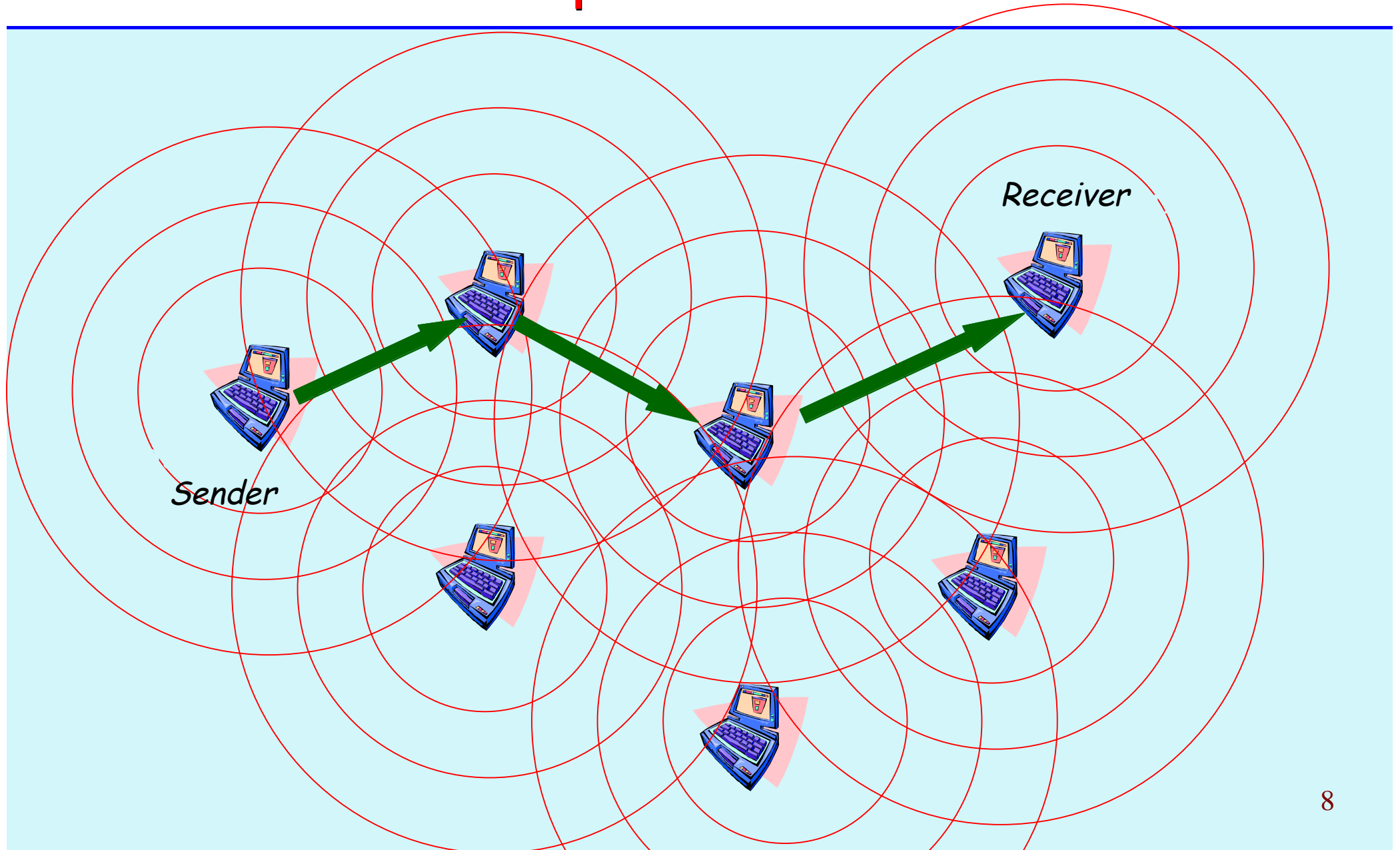
- Nuovi paradigmi di networking
  - Mobile Ad hoc NETwork (MANET)
- Nuove classi di reti
  - Body Area Network (BAN)
  - Personal Area Network (PAN)
  - Sensor Networks
- 4G Networks

# Ad Hoc Networking



- ✖ Mobile nodes, wireless links
- ✖ Infrastructure-less: *by the nodes,...*
- ✖ Minimal administration: *self organization*

# Multi hop Ad Hoc Networks





# Multi hop Ad Hoc Networks

## Caratteristiche

Nessuna infrastruttura

Nessun punto di centralizzazione

Cooperazione tra nodi

Routing

Forwarding

## Utilità

- Comunicazioni fra uomini e mezzi militari
- Comunicazioni in caso di disastri
- Comunità di utenti



# Multi hop Ad Hoc Networks

What's *unique* about a *MANET* ?

- ✖ Moving nodes → *ever changing topology*

- ✖ Wireless links

  - ✖ → *various and volatile link quality*

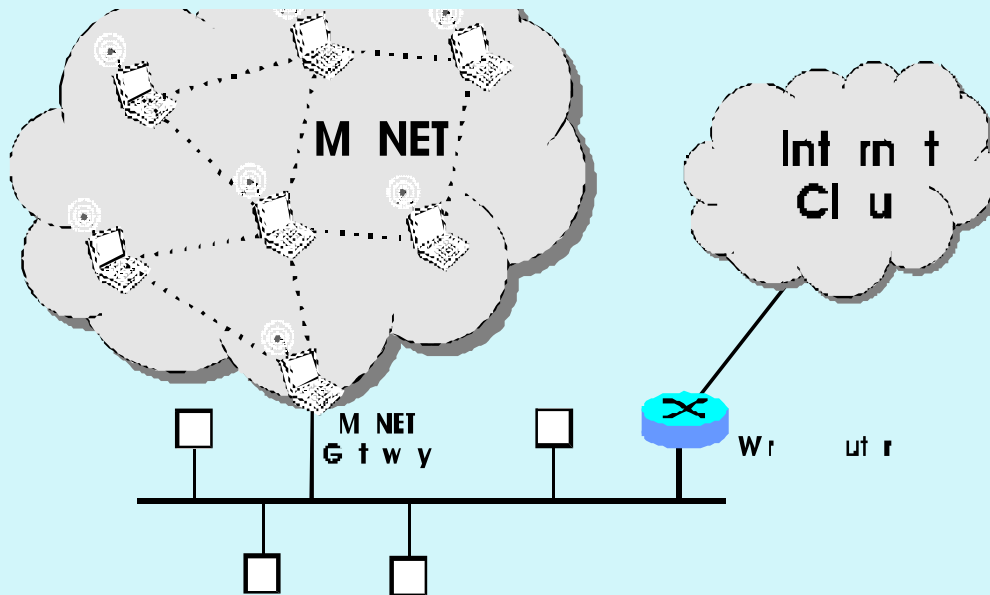
- ✖ Pervasive (cheap) devices

- ✖ → *Power constraints*

- ✖ Security & Cooperation

  - *Confidentiality, Selfishness, other attacks*

# MANET e Internet



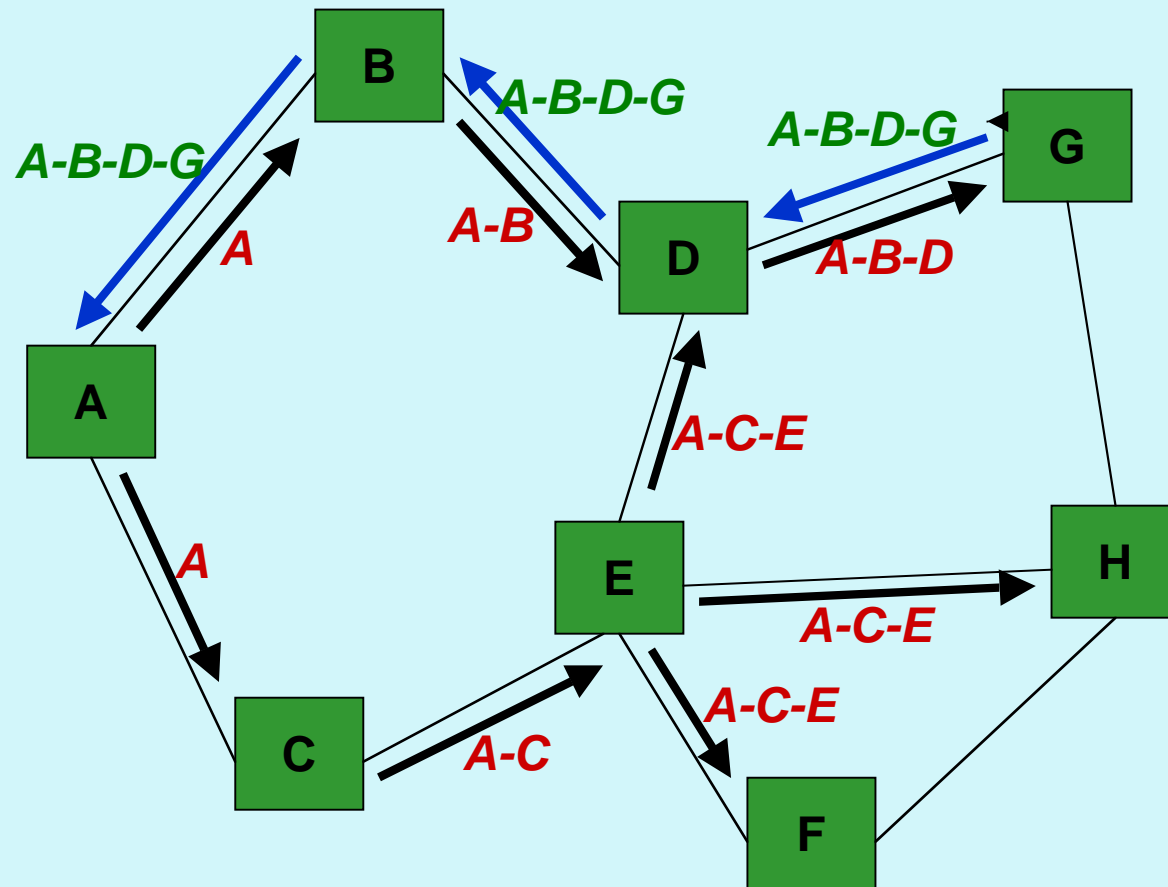
MANET scales:

- small-scale (i.e., 2-20 nodes)
- moderate-scale (i.e., 20-100 nodes)
- large-scale (i.e., 100+ nodes)
- very large-scale (i.e., 1000+ nodes)

- Small-medium scale ad hoc islands
- Ad hoc islands interconnected to the Internet

# IETF MANET Working Group

## Routing Algorithm Research



## *RREQ FORMAT*

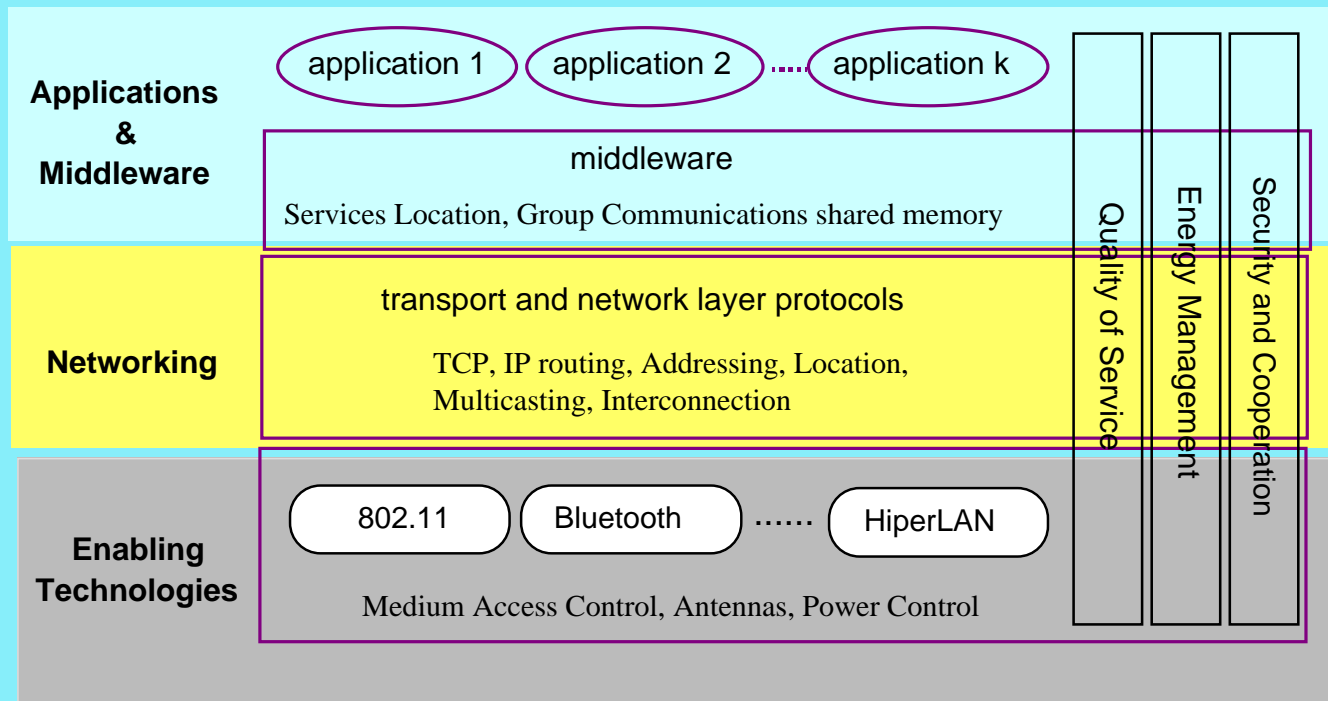
Initiator ID
Initiator seq#
Target ID
Partial route

*A-B-C*  
Route Request (RREQ)

*A-B-C*  
Route Reply (RREP)

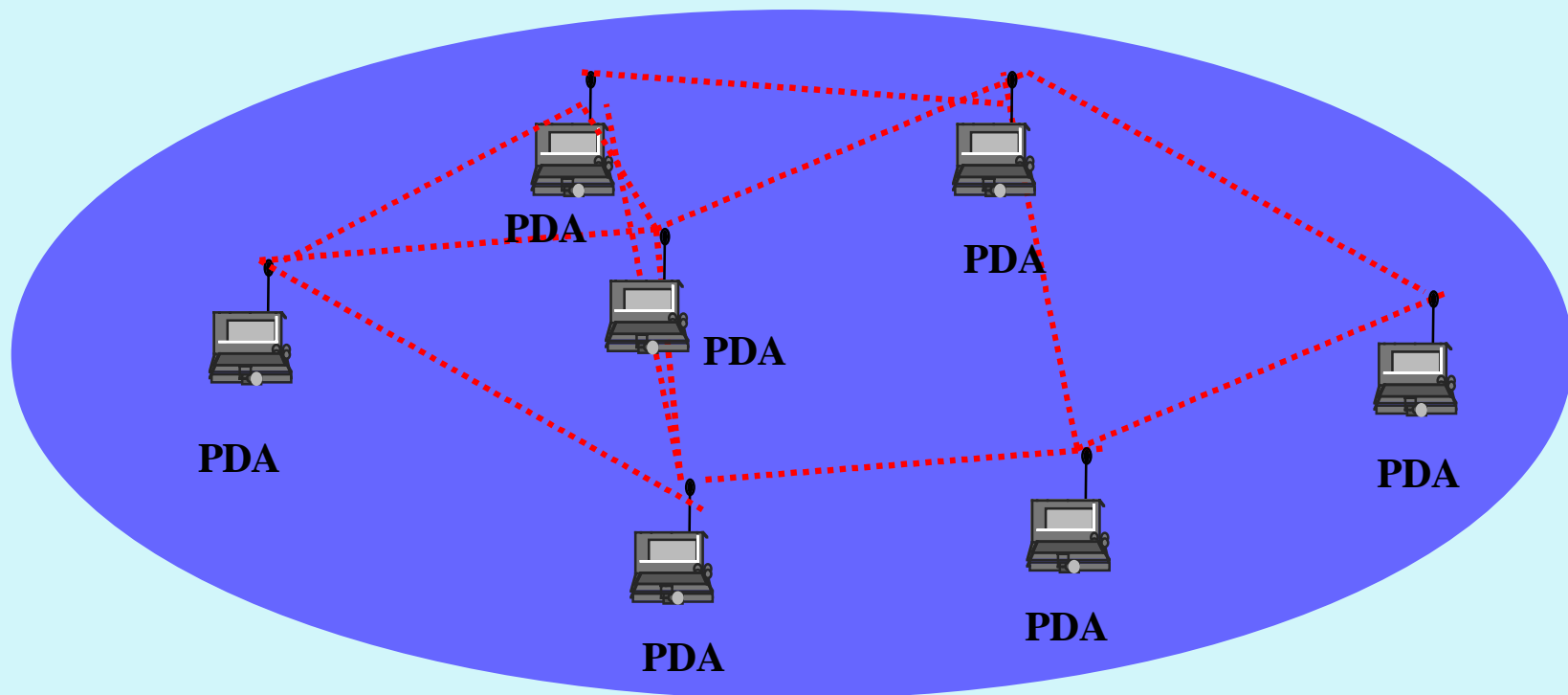
*Route Discovery is issued with exponential back-off intervals.*

# Research on Multi hop Ad Hoc Networks



# The MobileMAN Project

The project aims to define and develop a self-organizing, and totally wireless network that we call Mobile Metropolitan Ad hoc Network (MobileMAN).



MobileMAN IST-2001-38113  
Project funded by the Future and Emerging Technologies arm of the IST Programme  
FET-Open scheme



# The MobileMAN Project info

Partic. Role*	Partic. no.	Participant name	Participant short name	Country	Date enter project**	Date exit project**
C	1	Consiglio Nazionale delle Ricerche	CNR	I	Start of project	End of project
P	2	University of Cambridge	UCAM-CLAB	UK	Start of project	End of project
P	3	Institut Eurecom	EURECOM	F	Start of project	End of project
P	4	Helsinki University	HUT	FIN	Start of project	End of project
P	5	NETikos	NETikos	I	Start of project	End of project
P	6	Scuola Universitaria Professionale della Svizzera Italiana	SUPSI	CH	Start of project	End of project

- ❑ Operative commencement date : October 1st, 2002
- ❑ Duration 36 months
- ❑ Total effort: 317.7 man months
- ❑ Eligible Cost: 2,453,502 EURO

# The MobileMAN Project info

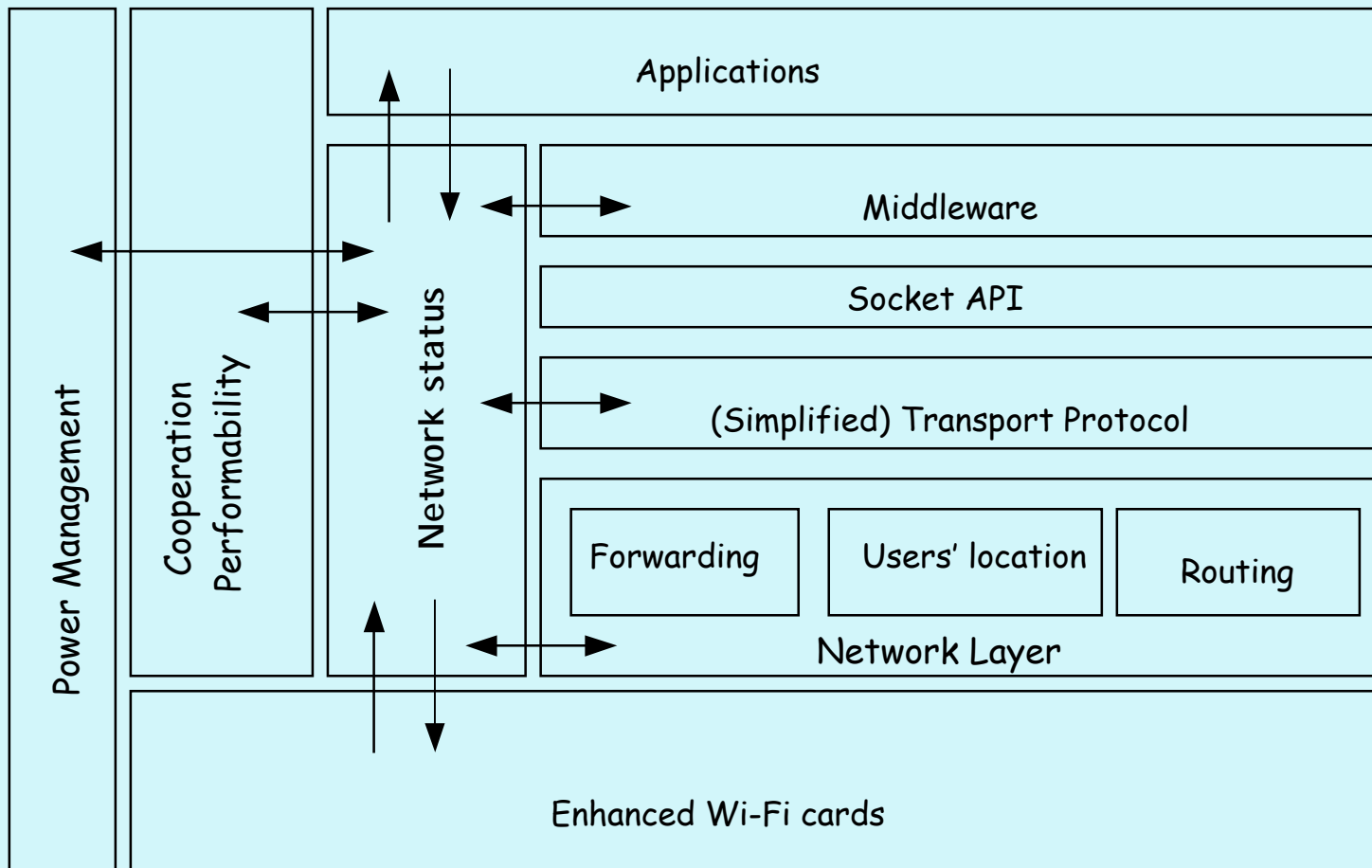
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# MobileMAN I Year

## Cross Layer Architecture and Protocols



# MobileMAN II & III Years

## II Year: Implementations/Testbeds

- Whenever possible, hardware/software implementation of the MobileMAN solutions
- The integration of the developed solutions in a testbed.

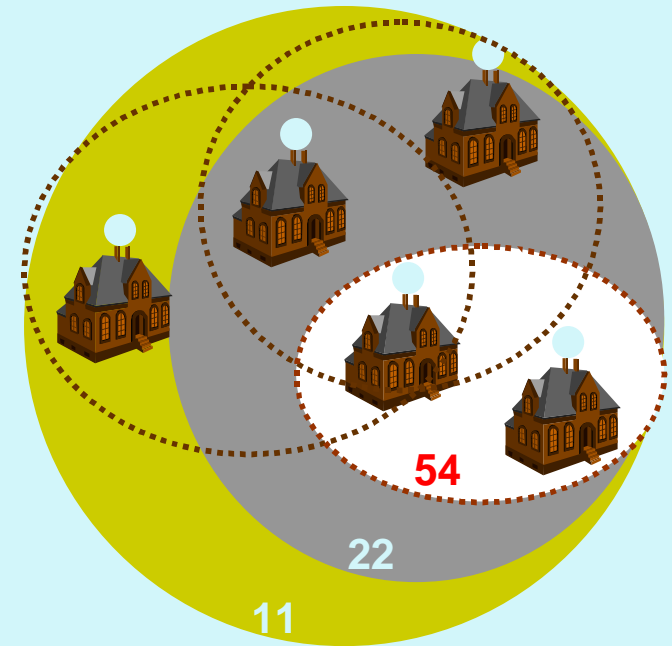
## III Year: Experimentation

- Use of real testbeds to validate the developed solutions

Attività congiunta IIT-CNR and Dipartimento Ingegneria dell'Informazione

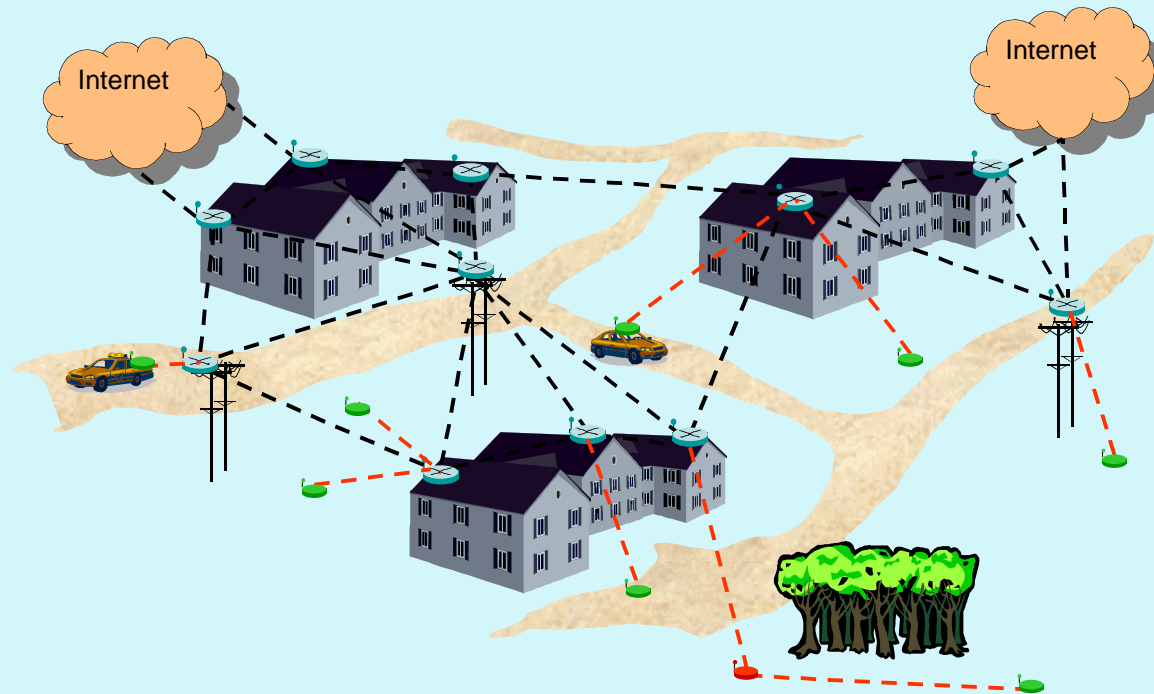
# Multi-hop WLANs

- Emergence of high-speed and variable rate WLANs
  - 1,2,...,11, ...,22, ...,54, 108 Mbps
  - Larger bit-rate => smaller coverage area
- Multi-hop architecture for fixed wireless networks
  - Start with a large cell; as nodes increase split into (higher rate) smaller cells



Multi-hop wireless path to wireline gateway

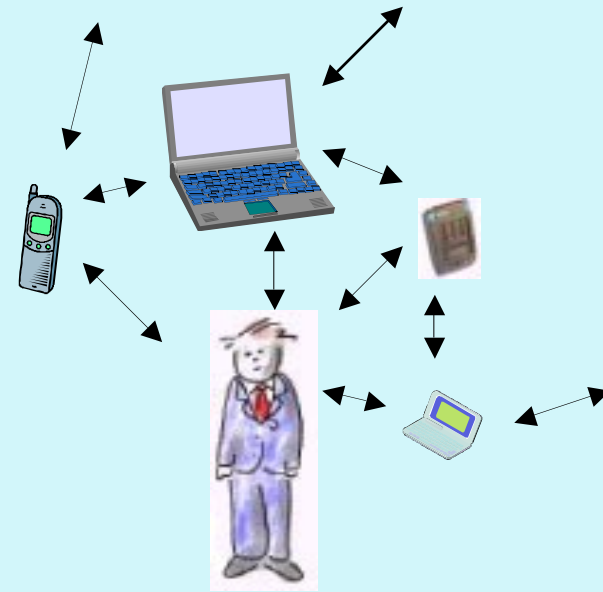
# Multi-hop WLANs



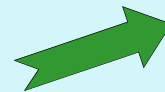
Hybrid Infrastructure: Access Points + Ad Hoc

# Nuove Classi di Reti

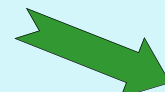
Il concetto di **Ubiquitous Communications** si basa sull'esistenza di reti di calcolatori che consentono all'utente una immersione globale nell'ambiente che lo circonda



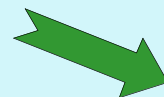
Si delineano nuove classi di reti  
in grado di seguire l'utente nei suoi  
spostamenti e capaci di percepire  
il contesto nel quale sono inserite



**Body Area Networks**



**Personal Area Networks**



**Sensor Networks**

# Body Area Network (BAN)

Rete in grado di interconnettere i vari dispositivi elettronici che si possono trovare sulla persona

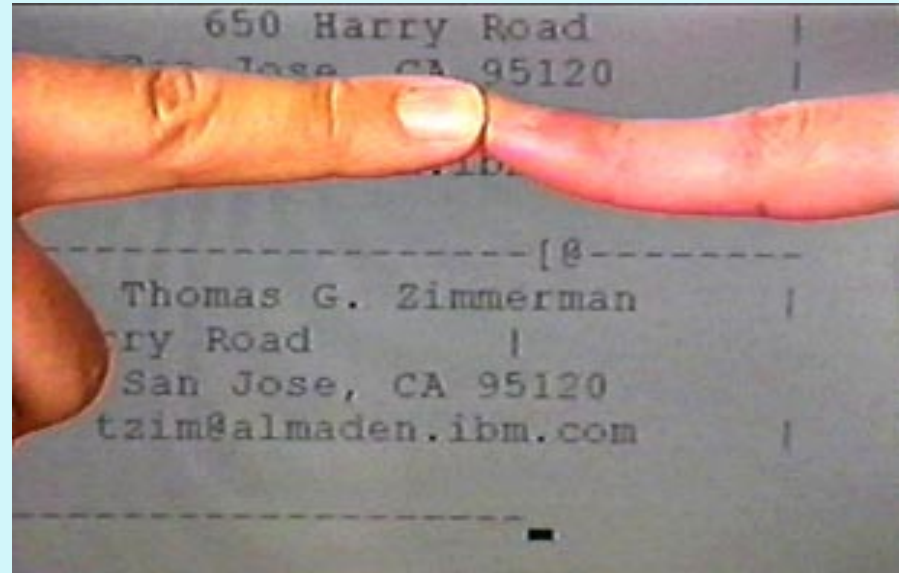
- collega dispositivi eterogenei
  - Personal Digital Assistant
  - lettore MP3
  - display, auricolari, ecc...
- supporta vari tipi di dati
- supporta collegamenti eterogenei
  - wired, wireless
- facile da usare e configurare
- protezione dei dati della persona



**BODY AREA NETWORK**

# Body Area Network (BAN)

- un piccolo dispositivo crea una impercettibile corrente che attraversa tutto il corpo
- la modulazione del campo elettrico permette il trasporto di dati
- 100 Kbps

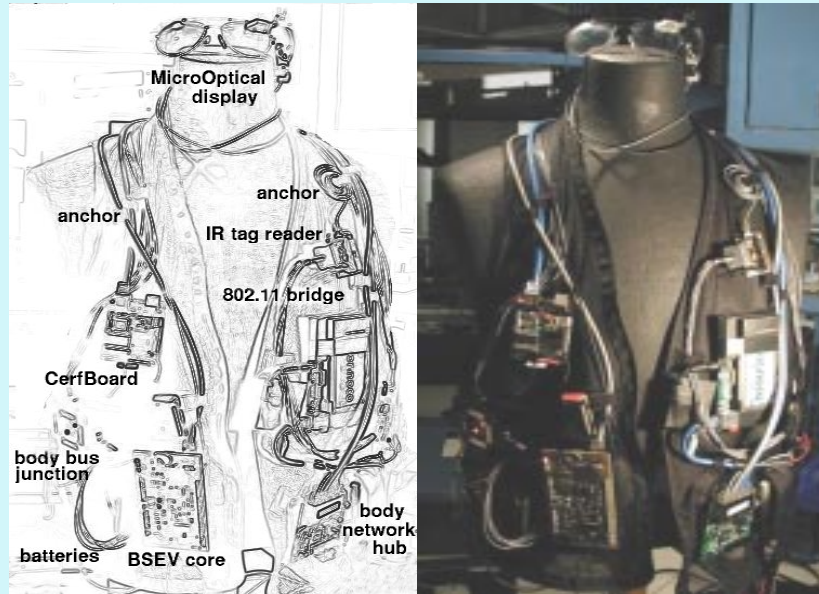


Il corpo umano come mezzo  
fisico di trasmissione dati !

## Possibili applicazioni:

- scambio di dati tra due persone mediante una stretta di mano
- un dispositivo può riconoscere l'utente
- un medico può identificare il paziente e la relativa cartella clinica

# Body Area Network (BAN)



## MITHRIL

una rete Ethernet che avvolge il corpo dell'utente

microfono, videocamera, sensore ad infrarossi, visore ottico e microtastiera

Le reti wireless rappresentano la soluzione più flessibile per interconnessione di wearable devices !

## LEVIS ICD+

Primo esempio commerciale di BAN.

Cellulare, lettore MP3, auricolare e microfono integrati in una giacca e controllabili da un singolo dispositivo





# Personal Area Network (PAN)

Rete **wireless** a corto raggio per connessioni con il mondo esterno in modalità **ad hoc** e riconfigurabili

- composta da dispositivi eterogenei
  - cellulari, notebook
  - stampanti, elettrodomestici
  - videocamere, sensori, ecc...
- offre diversità di servizi
- natura dinamica
- assicura la connessione con l'esterno
- sicurezza dei dati



**PERSONAL AREA NETWORK**

# Personal Area Network (PAN)

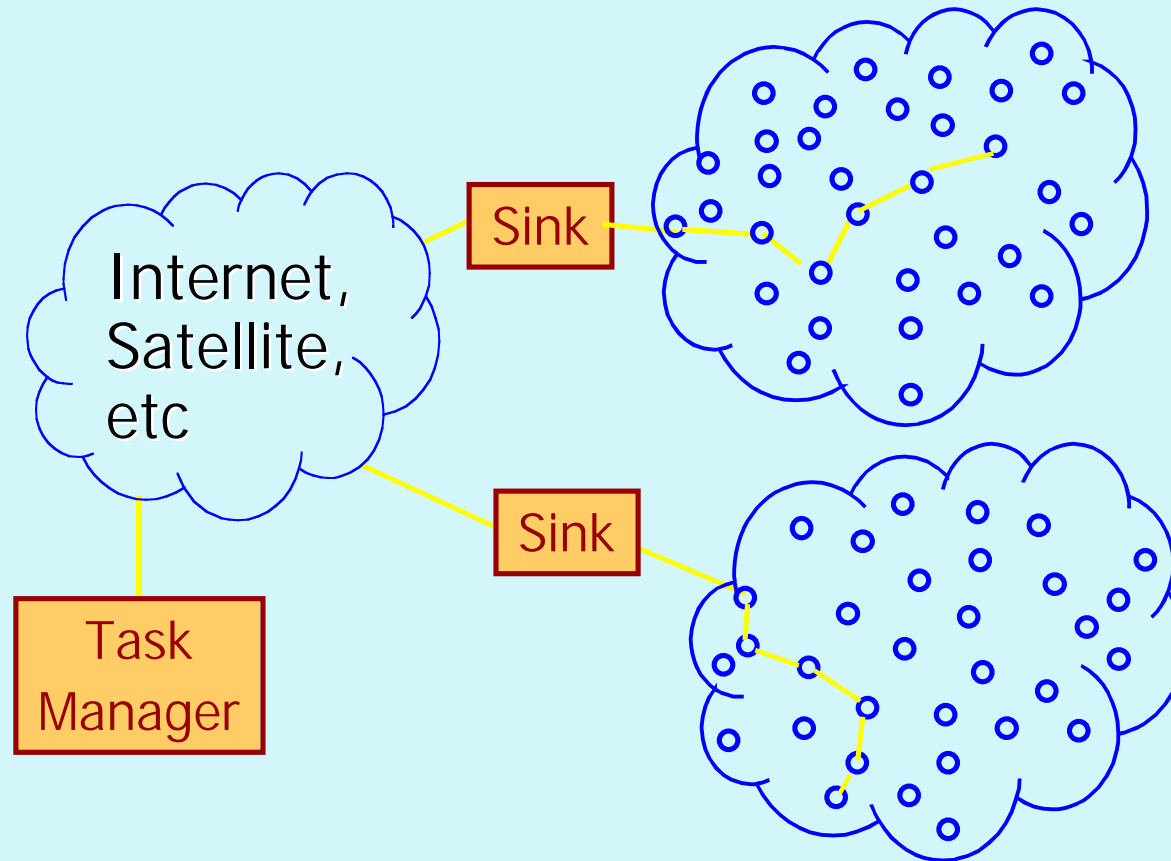
## TECHMOBILE IBM

Esempio di PAN realizzata all'interno di un'automobile.



- **TSpaces**: sistema software che consente ai dispositivi inseriti nell'auto di riconoscersi, scambiarsi informazioni e controllarsi. Permette comunicazioni asincrone.
- **BlueEyes**: sistema in grado di percepire lo stato fisico dell'utente.
- **ViaVoice**: sistema di riconoscimento vocale.
- **BlueDrekar**: sistema che permette il controllo in remoto dell'auto.

# Sensor Networks

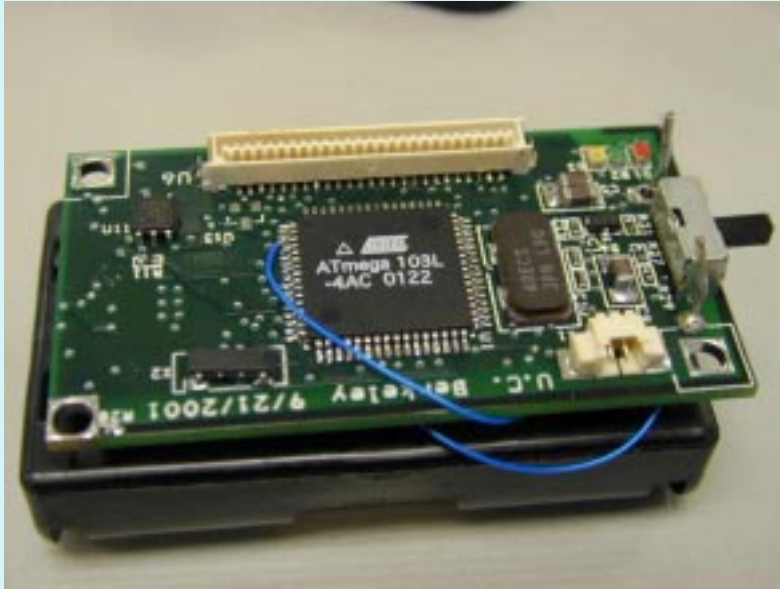


- Several thousands of nodes
- A sensor node is a battery-powered, wireless computer
- nodes are physically small (a few cubic centimeters) and use extremely low power

# Sensor Networks Applications

- Military, Environmental, Health, Home, Space Exploration, Chemical Processing, Disaster Relief....
- SENSOR TYPES: Seismic, Low sampling rate magnetic, Thermal, Visual, Infrared, Acoustic, Radar...
- SENSOR TASKS: Temperature, Humidity, Vehicular Movement, Lightning Condition, Pressure, Soil Makeup, Noise Levels, Presence or Absence of Certain Types of Objects, Mechanical Stress Levels on Attached Objects, Current Characteristics Speed, Direction, Size) of an Object ....

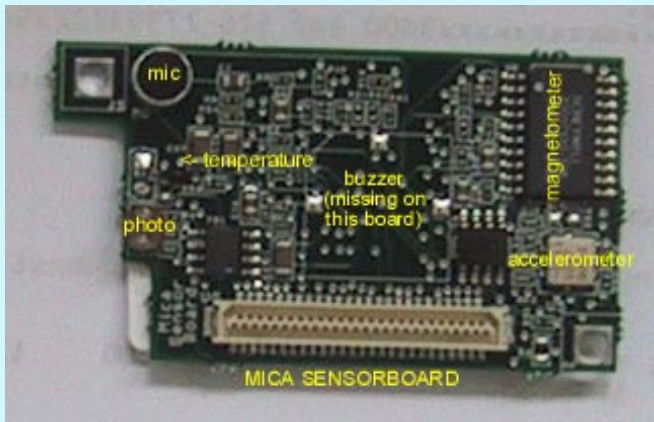
# Sensor Node: Mica Motes



- ATmega103L (4 MHz)
  - 128k programmable memory
  - 4k data memory
- TR1000 915MHz radio
  - 50kbps
- 2-AA for power + regulator

## MICA SENSORBOARD:

- Photo
- Temperature
- Microphone (4kHz)
- Buzzer (4kHz)
- Accelerometer
- Magnetometer



Sperimentazioni sulla piattaforma Mica Motes sono attualmente in corso nell'ambito di una attività di ricerca congiunta tra Ingegneria Informatica (Prof. G. Anastasi) e CNR-IIT

# IEEE Standards per BAN, PAN e Sensor Networks

The development of standards for short distance wireless networks is currently ongoing in the framework of the IEEE 802.15 working group for Wireless Personal Area Networks.

Currently, four Task Groups (TGs) are active inside the IEEE 802.15 working group:

- The TG 1 that, in 2002, approved a Wireless Personal Area Network standard based on the Bluetooth v1.1 Specifications.
- The TG 2 that is developing recommendations to guarantee the coexistence between 802.11 and 802.15 devices.
- The TG 3 that has just produced a draft standard for high-rate (20Mbit/s or greater) WPANs. TG3 also contains an Alternative PHY Task Group (TG3a) that is working to define a higher speed physical layer enhancement to 802.15.3.
- The TG 4 is investigating a low data rate, low cost, and low power solution for WPANs operating in an unlicensed frequency band. Potential applications are sensors, interactive toys, smart badges, remote controls, and home automation.

# IEEE 802.15.1: a Bluetooth based Network

## Accessori per PC

- Connessione di mouse e tastiera
- Connessione di stampanti
- Connessione di modem e PDA

## Cordless headset

- Usato con il telefono (composizione del numero)
- Usato con il PC (ascoltare musica, comandi vocali)



# IEEE 802.15.1: a Bluetooth based Network

- Mobilità dei dispositivi in ambiente home ed office
- Connessione wireless di telecamere, proiettori, sistemi stereo, ecc.
- Sincronizzazione di PDA, cellulari e PC

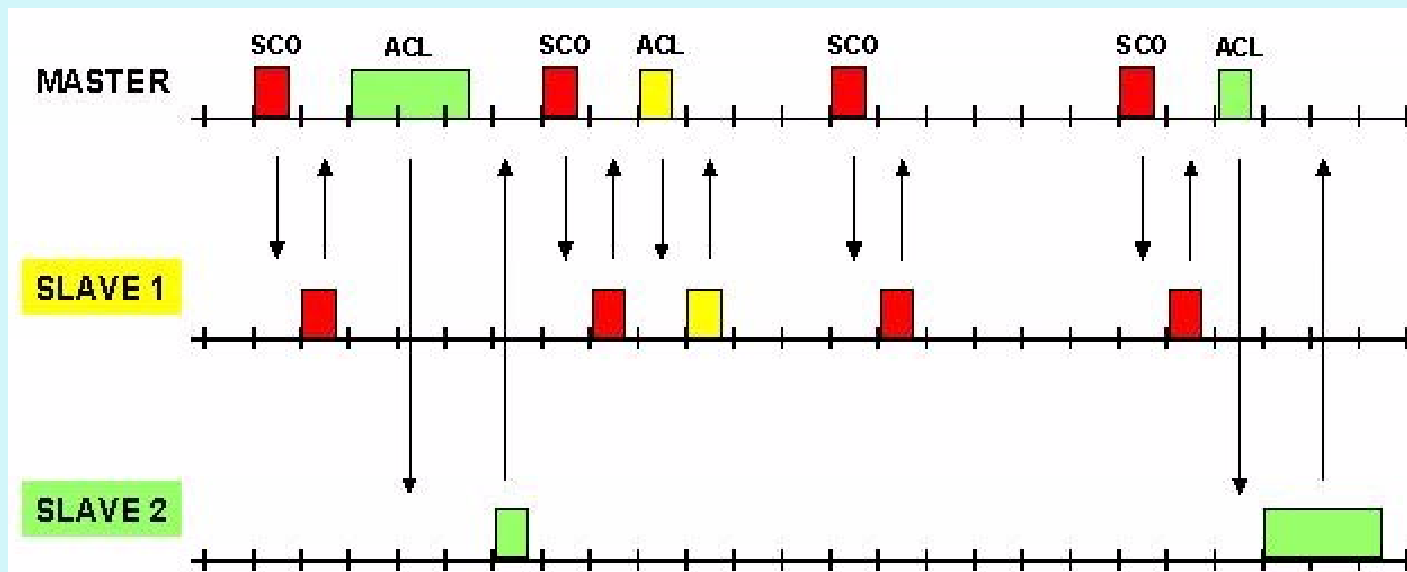
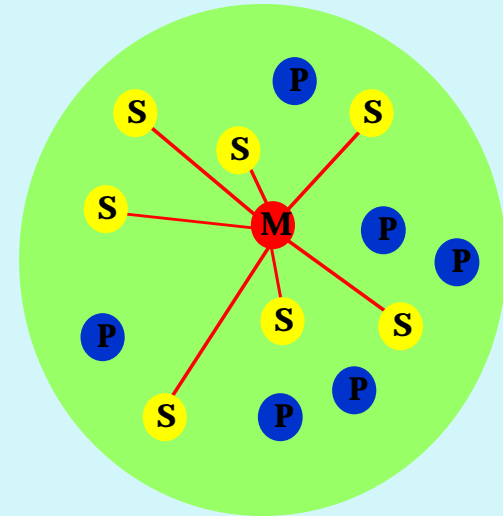




# Bluetooth Technology

## Piconet

- Is the building block for Bluetooth networks
- Gross Capacity 1 Mbps
- A Piconet contains one master and up to 7 slaves
- The slaves are synchronized on the master clock
- **Polling system** : a slave can transmit only after the master polling



# IEEE 802.15.3: a High Rate WPAN

- Video and audio distribution:
  - High speed DV transfer from a digital camcorder to a TV screen
  - HD MPEG2 between video players/gateways and multiple HD displays
  - Home theater
  - PC to LCD projector
  - Interactive video gaming
- High speed data transfer:
  - MP3 players
  - Personal home storage
  - Printers & scanners
  - Digital still cameras to/from kiosk

# IEEE 802.15.3: High Rate WPAN

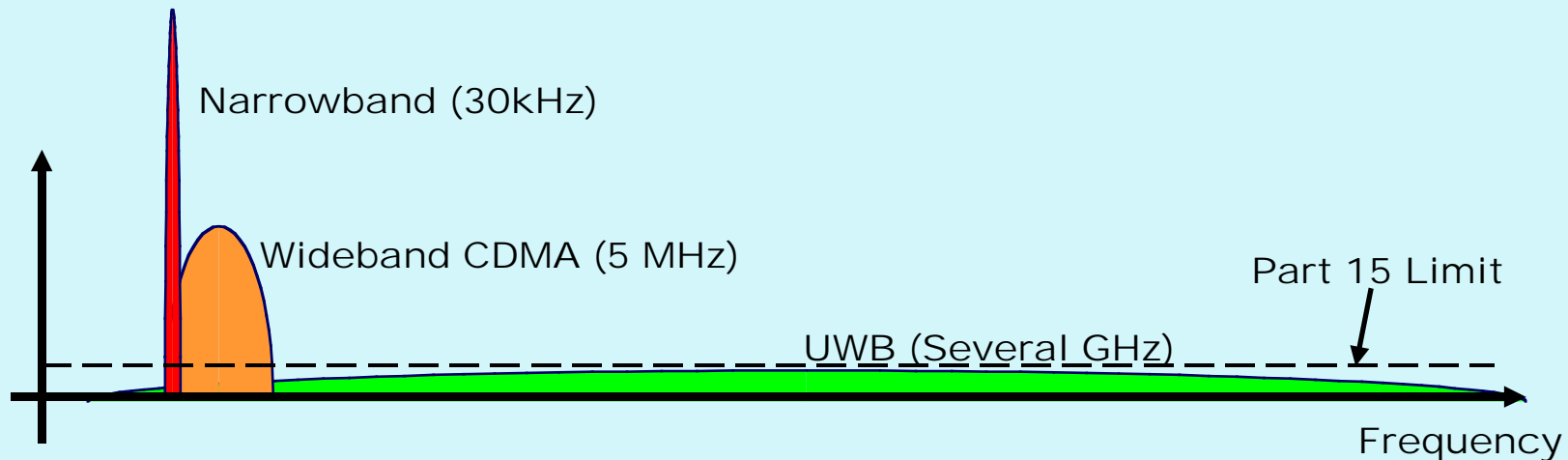
- High Rate WPAN:
  - 2.4 GHz
  - Short Range (at least 10m, up to 70m possible)
  - High Data rates
  - 5 selectable data rates: 11, 22, 33, 44, 55 Mb/s
- Dynamic Topology:
  - Mobile devices often join and leave piconet
  - Short time to connect (<1s)
- Ad-hoc network with Multimedia QoS provisions

# Alternate IEEE 802.15.3: TG 3a

## 802.15.3a Goal

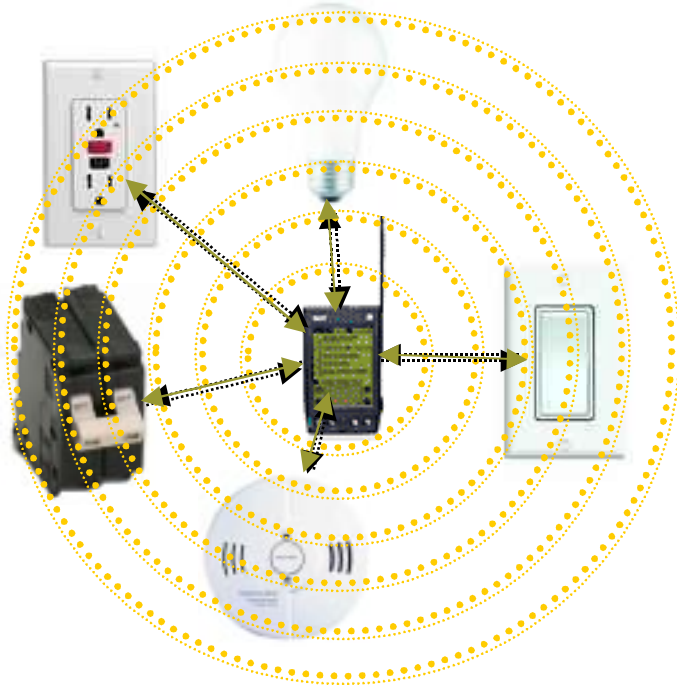
> 110Mbps @ 10 m, > 400 Mbps @ 5 m

UWB is a potential candidate for these VHR WPAN applications



- UWB is a form of extremely wide spread spectrum where energy is spread over gigahertz of spectrum
- UWB signals can be designed to look like imperceptible random noise to conventional radios

# IEEE 802.15.4: Applications' space



- Home Networking
- Automotive Networks
- Interactive Toys
- Remote Metering

Energia è una risorsa critica !

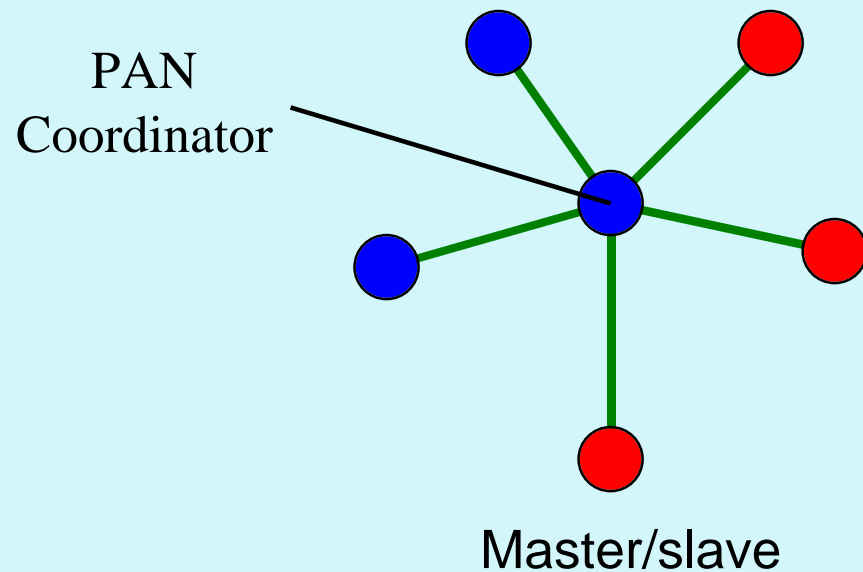


## Obiettivi 802.15.4

- Data rate: 250 kb/s, 40 kb/s and 20 kb/s
- Tempo di vita delle batterie estremamente lungo (mesi/anni con una batteria AAA)

# IEEE 802.15.4: Topologie

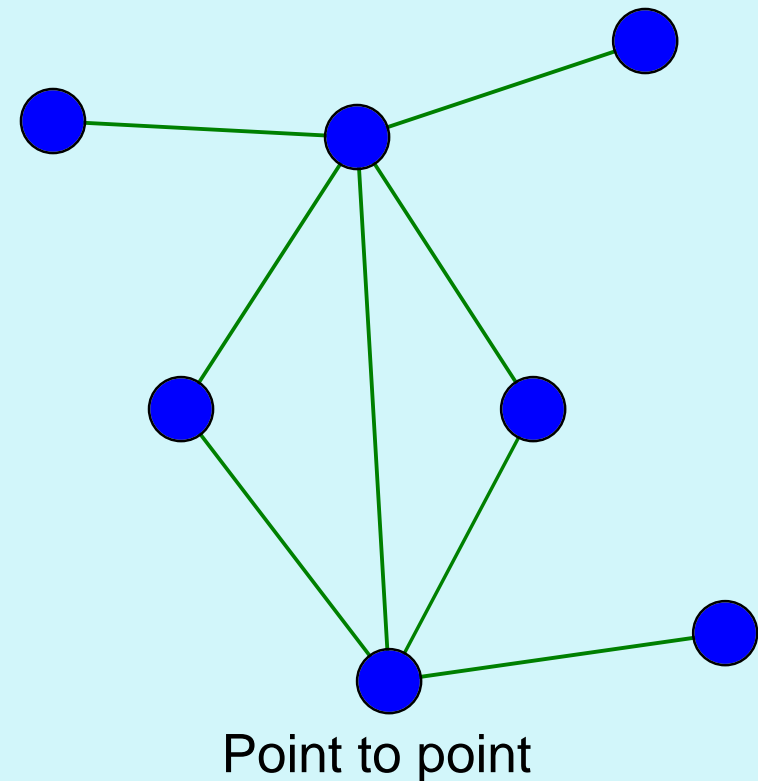
## Star Topology



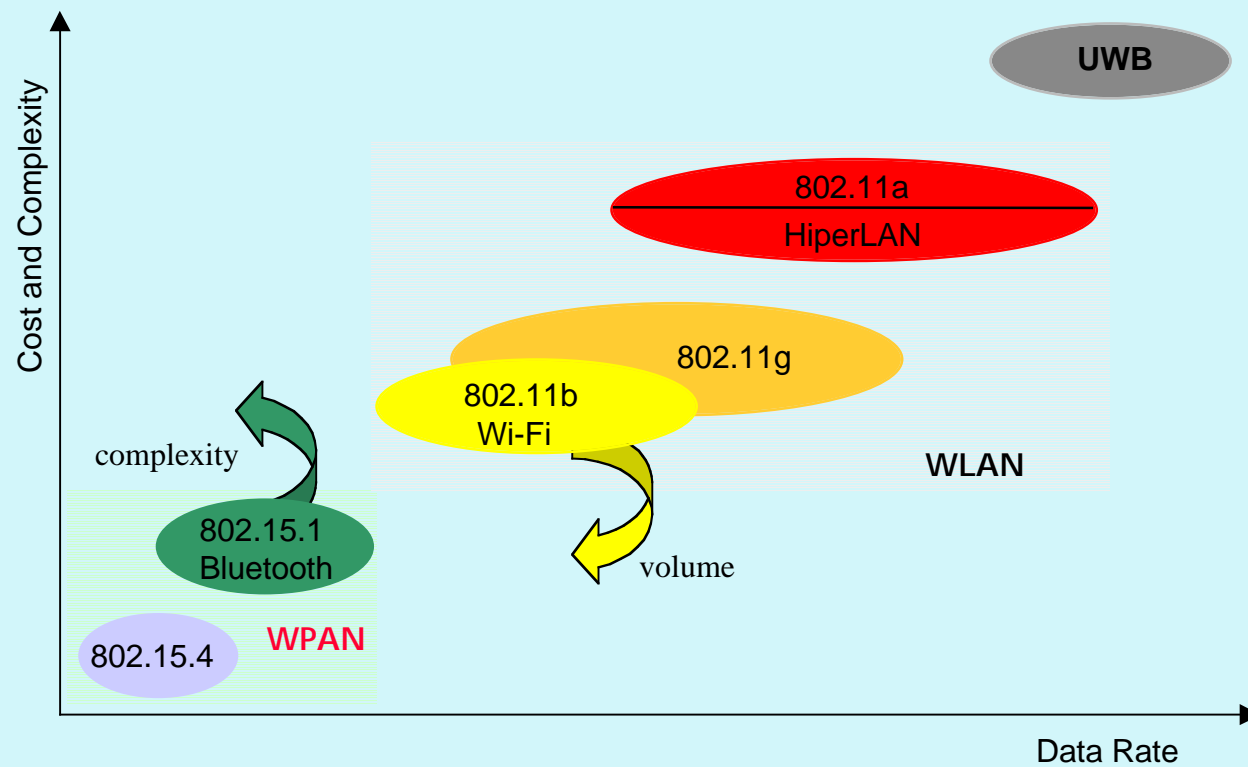
- Full function device
- Reduced function device

— Communications flow

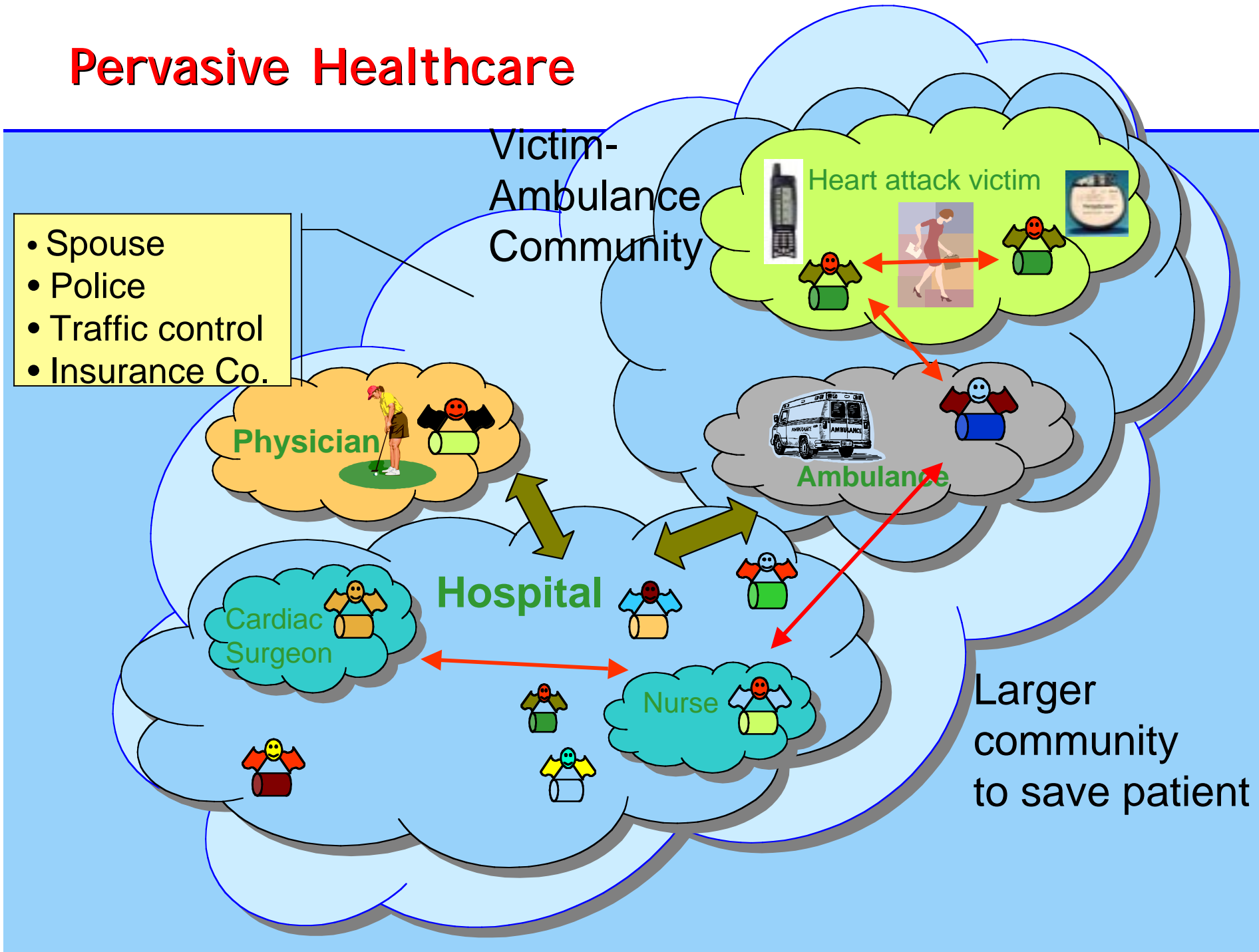
## Peer-Peer Topology



# Tecnologie per Smart Environments

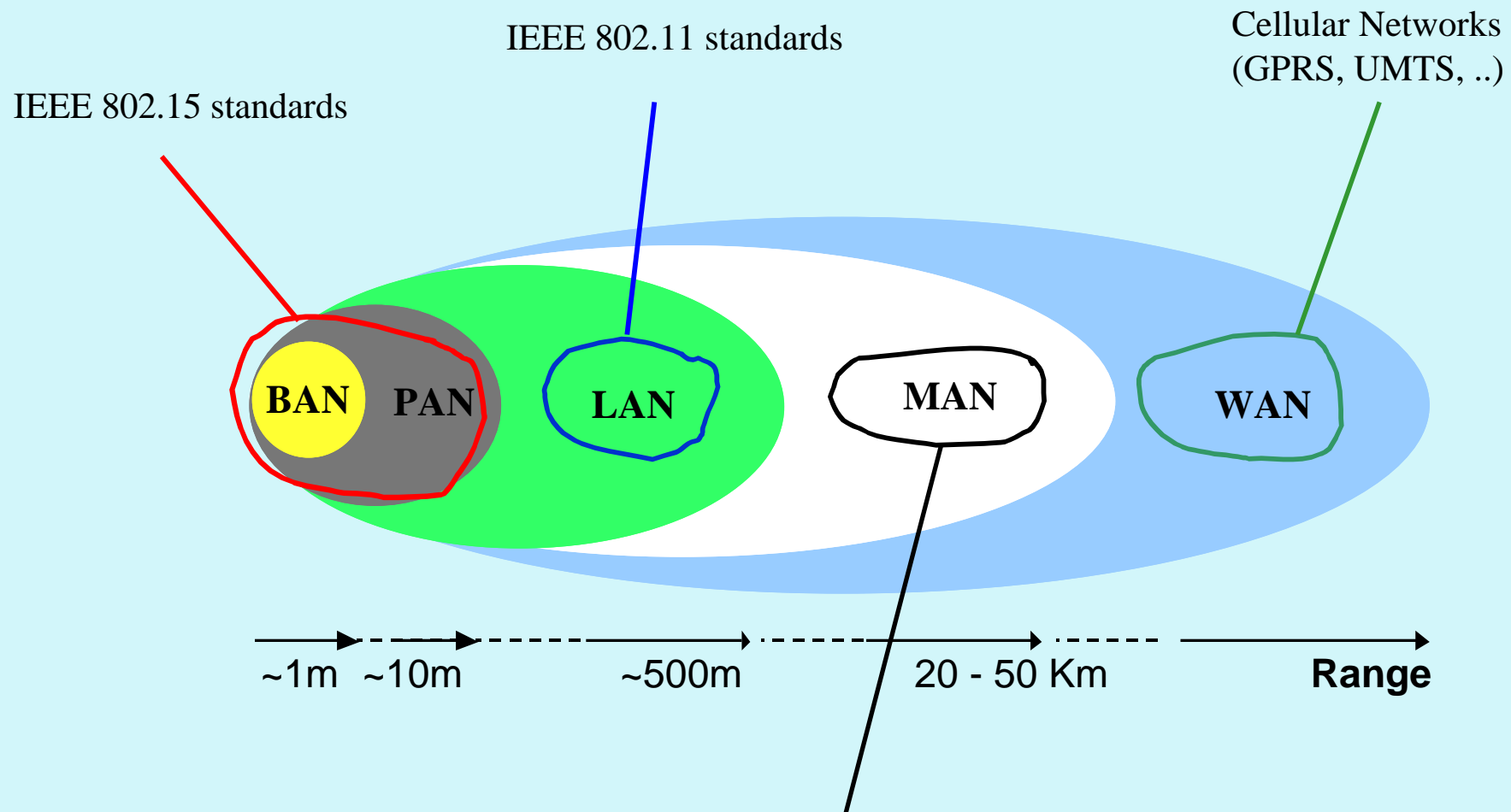


# Pervasive Healthcare



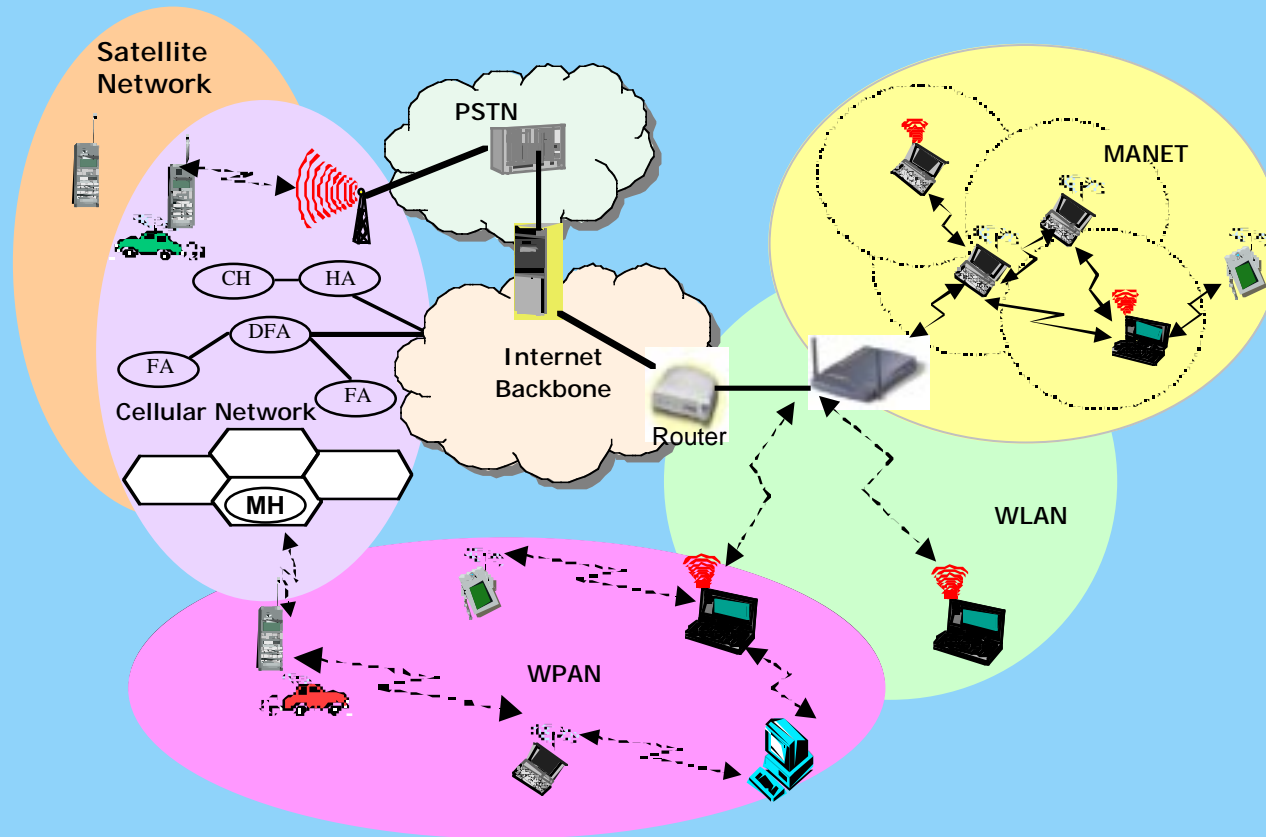


# Pervasive Communications



the IEEE 802.16 standards for broadband WMAN. This body is concerned with fixed broadband wireless access systems, also known as “last mile” access networks.

# 4G Networks



Thank You !