

Wireless networks and mobile computing

Introduction - taxonomy

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Overview

- Read C01-Introduction.pdf from Schiller's course
- Mobile/wireless computing/communications
- History of wireless/mobile
- Layers

Mobile/wireless communication

- Two aspects of mobility:
 - *user mobility*: users communicate (wireless) “anytime, anywhere, with anyone”
 - *device portability*: devices can be connected anytime, anywhere to the network

- Wireless vs. mobile

Examples

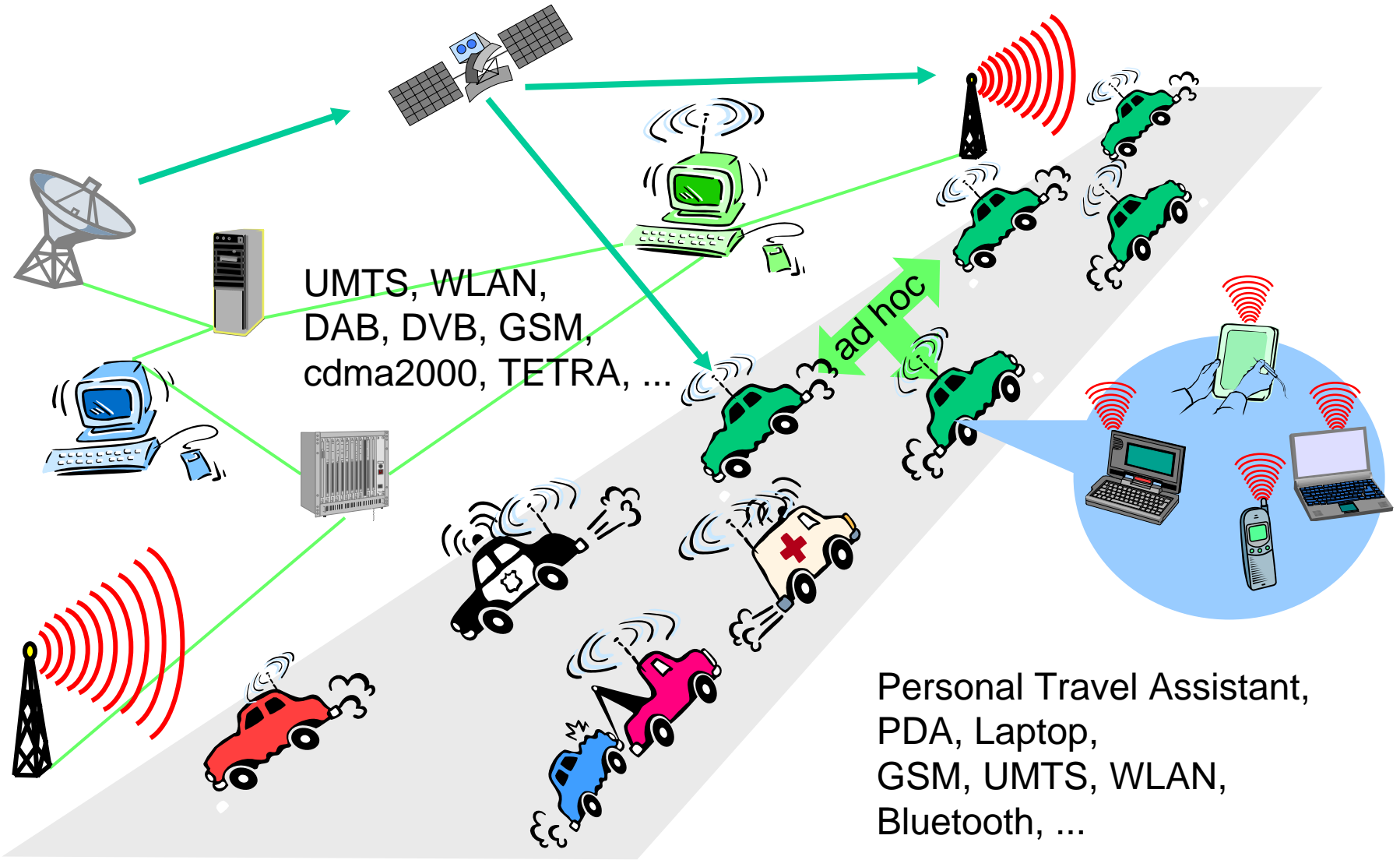
✗	✗	stationary computer
✗	✓	notebook in a hotel
✓	✗	wireless LANs
—	✓	Personal Digital Assistant (PDA)

- local area networks: standardization of IEEE 802.11...
- Internet: Mobile IP extension of the internet protocol IP
- wide area networks: e.g., internetworking of GSM and ISDN

Applications I

- Vehicles
 - transmission of news, road condition, weather, music
 - personal communication using GSM
 - position via GPS
 - local ad-hoc network with vehicles close-by to prevent accidents, guidance system, redundancy
 - vehicle data (e.g., from busses, high-speed trains) can be transmitted in advance for maintenance
- Emergencies
 - early transmission of patient data to the hospital
 - replacement of a fixed infrastructure in case of earthquakes, hurricanes, fire etc.
 - crisis, war, ...

Typical application: road traffic



Mobile and wireless services

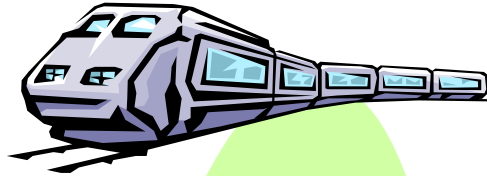
DSL/ WLAN
3 Mbit/s



GSM/GPRS 53 kbit/s
Bluetooth 500 kbit/s



UMTS, GSM
115 kbit/s



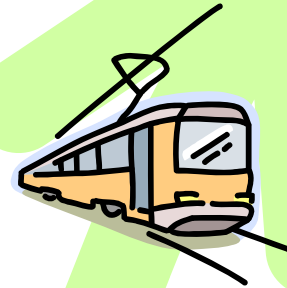
LAN
100 Mbit/s,
WLAN
54 Mbit/s



GSM/EDGE 384 kbit/s,
DSL/WLAN 3 Mbit/s



GSM 115 kbit/s,
WLAN 11 Mbit/s



UMTS
2 Mbit/s



UMTS, GSM
384 kbit/s

Applications II

- Travelling salesmen
 - access to customer files stored in a central location
 - consistent databases for all agents
 - mobile office
- Replacement of fixed networks
 - remote sensors, e.g., weather, earth activities
 - LANs in historic buildings
- Entertainment, education, ...
 - outdoor Internet access
 - intelligent travel guide, location dependent info
 - ad-hoc networks for multi user games



Mobile devices

Pager

- receive only
- tiny displays
- simple text messages

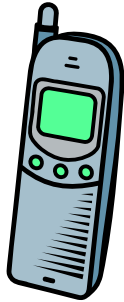
PDA

- graphical displays
- character recognition
- simplified WWW

Laptop/Notebook

- fully functional
- standard applications

Sensors,
embedded
controllers



Mobile phones

- voice, data
- simple graphical displays

Palmtop

- tiny keyboard
- simple versions of standard applications

www.scatterweb.net

performance



Effects of device portability

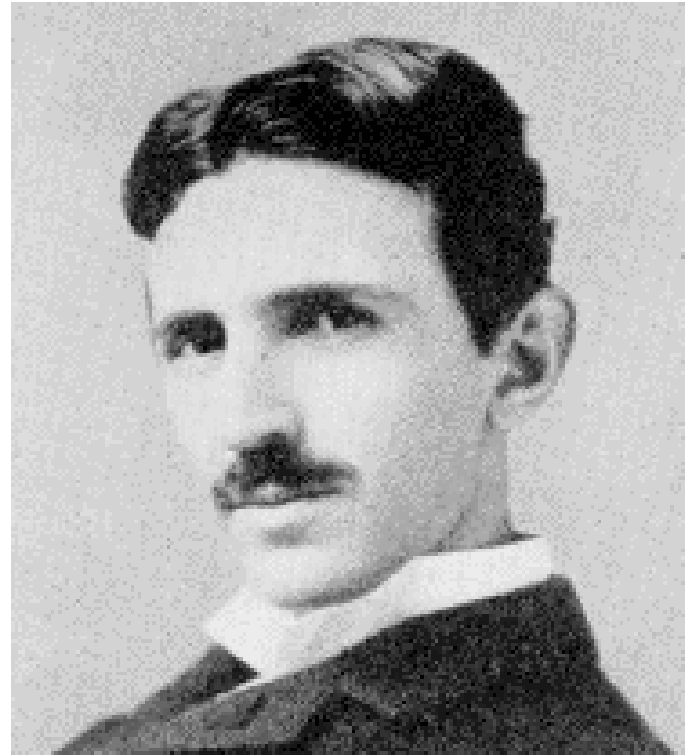
- Power consumption
 - limited computing power, low quality displays
 - Loss of data with higher probability
- Limited user interfaces
 - compromise between size of fingers and portability
 - character/voice recognition, abstract symbols
- Limited memory
 - limited value of mass memories with moving parts
 - flash-memory or ? as alternative

Wireless vs fixed networks

- Higher loss-rates due to interference
- Restrictive regulations of frequencies
- Low transmission rates
- Higher delays, higher jitter
- Lower security, simpler active attacking
- Always shared medium

History of wireless communications

Nikola Tesla
1856-1943



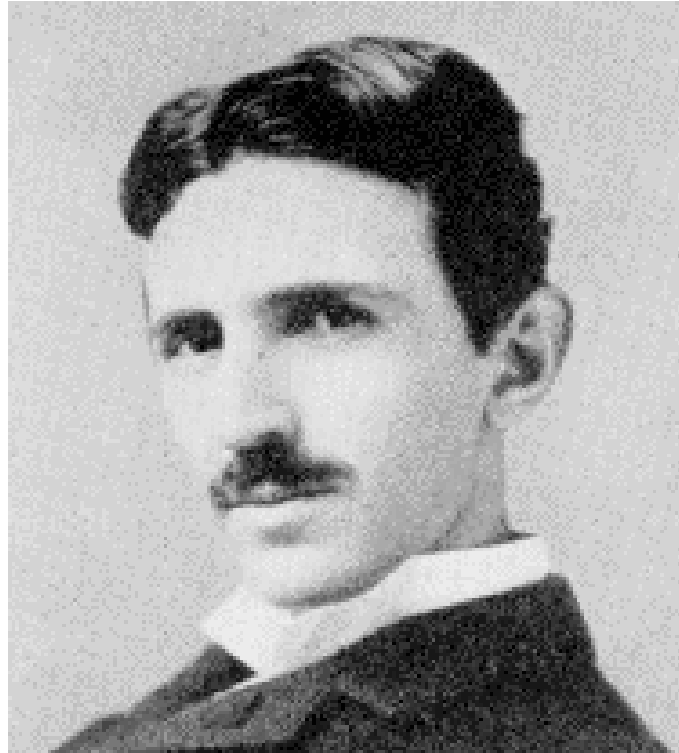
- **The Serbian-American inventor, electrical engineer, and scientist**
- www.teslasociety.com

Use of alternate current

- **Transformers** for long distance transfers
- Polyphase **motors** to use the current
- Built the world's first **hydroelectric plant** at Niagara Falls 1895



Nikola Tesla's inventions



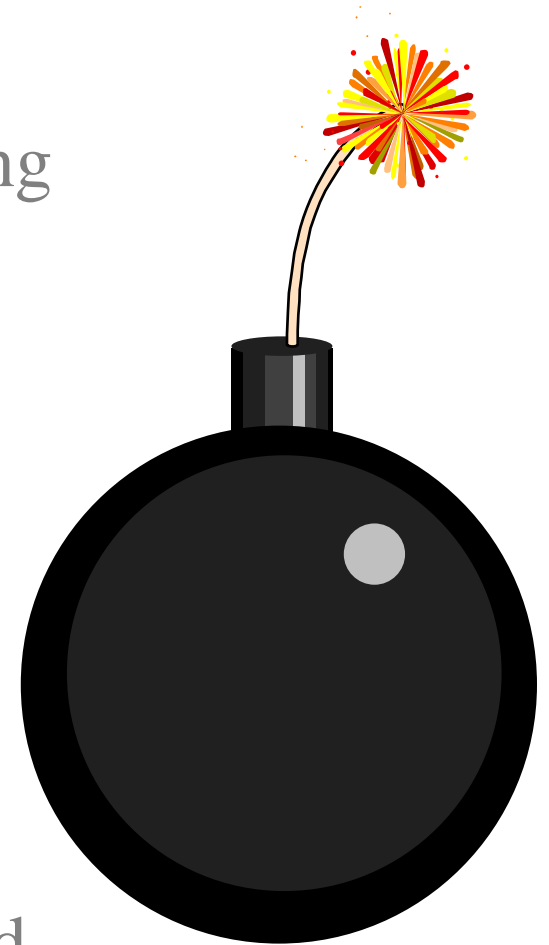
- **Radio/wireless transmission**
- US Supreme Court awarded patent to Tesla in 1945, taking it from **Marconi**

Lost inventions

- When Nikola Tesla announced working on the **free** transmission of solar to electric energy,
- His laboratory was **destroyed**.....
- And he lived in **poverty** ...

Among other achievements...

- Made a ship invisible
- Worked on time/space transfer
- After withdrawal, perhaps assassinated and his documentation is still classified by US government

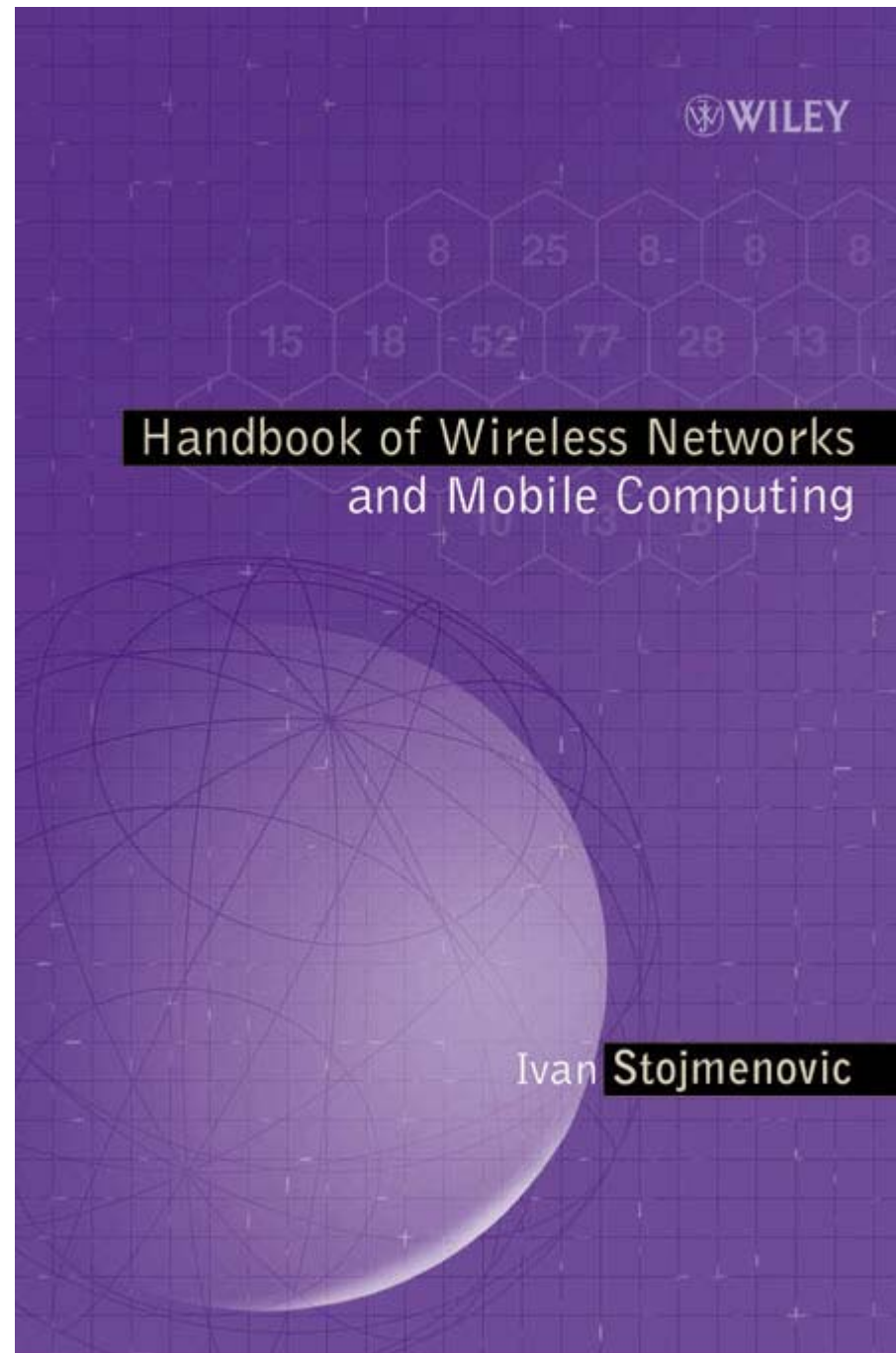


Wireless networks - taxonomy

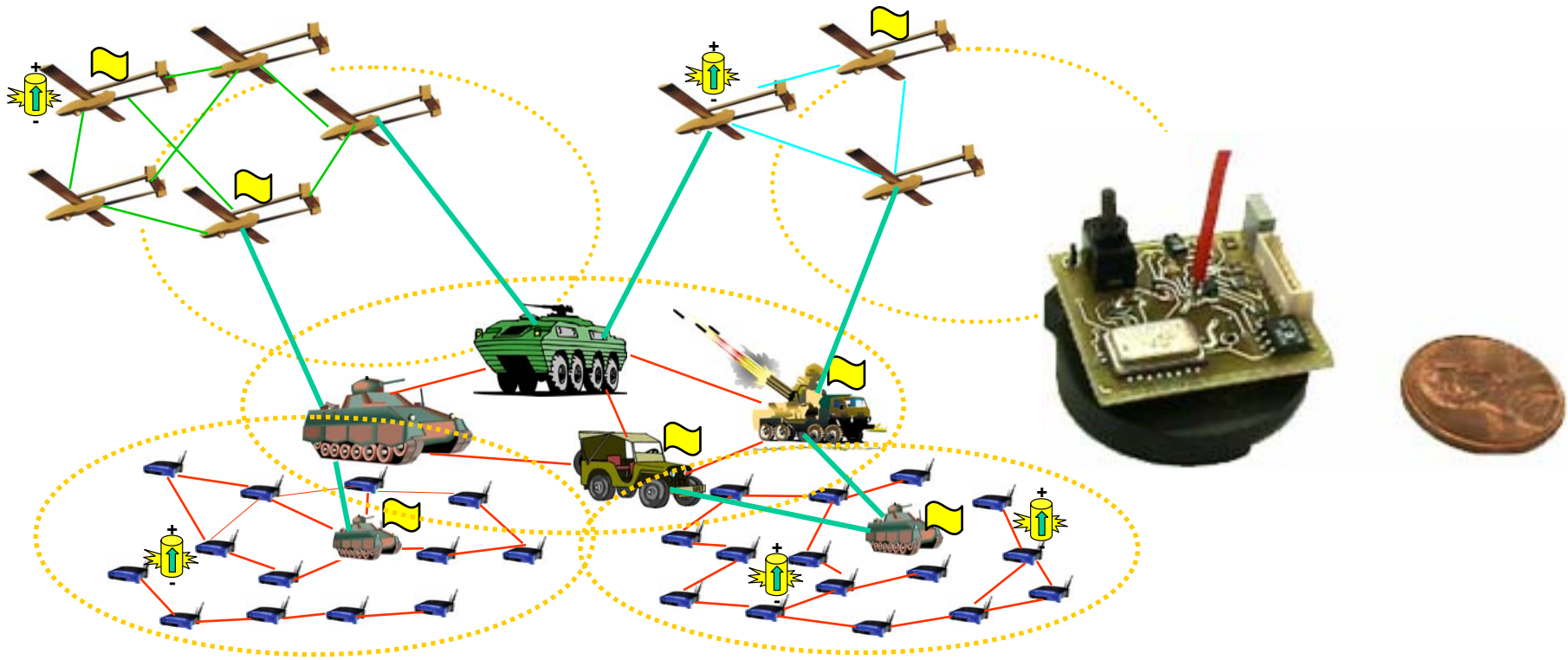
- *Single hop networks*
- Cellular networks
- Satellite networks
- Service discovery
- Home and office
- Bluetooth master-slave
- *Multi-hop networks*
- Sensor networks
- Mesh networks for wireless Internet access
- Ad hoc networks

Wireless networks & mobile computing

- Ad hoc networks
- Sensor networks
- Cellular networks
- RFID
- Data broadcast
- computer science components exist

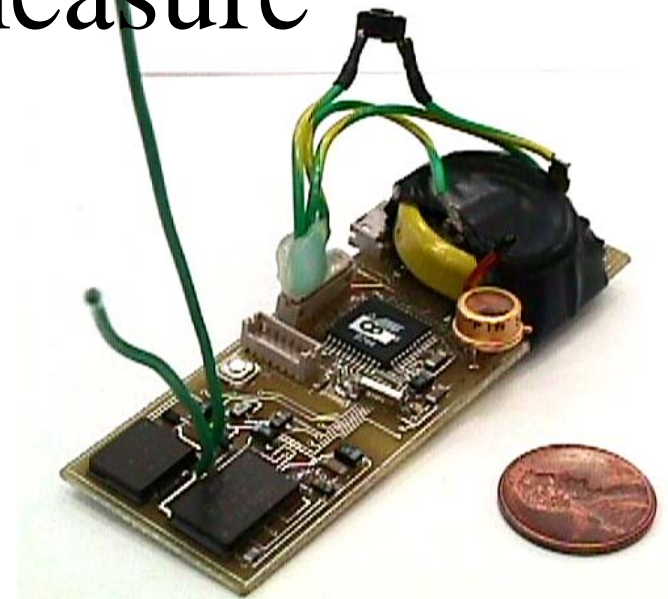


Ad Hoc and Sensor Networks

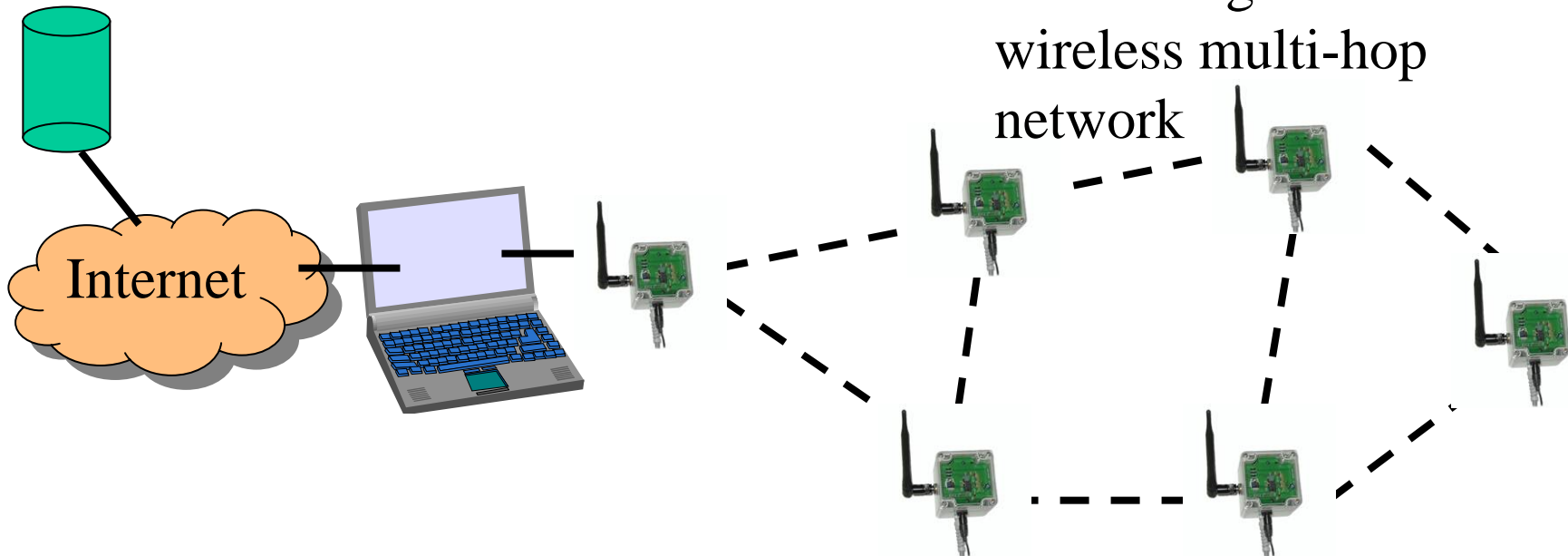


Sensors may measure

- Distance, Direction, Speed
- Humidity, Soil makeup
- Temperature, Chemicals
- Light, Vibrations, Motion
- Seismic data, Acoustic data
- strain, torque, load, pressure



- Self-configure into wireless multi-hop network

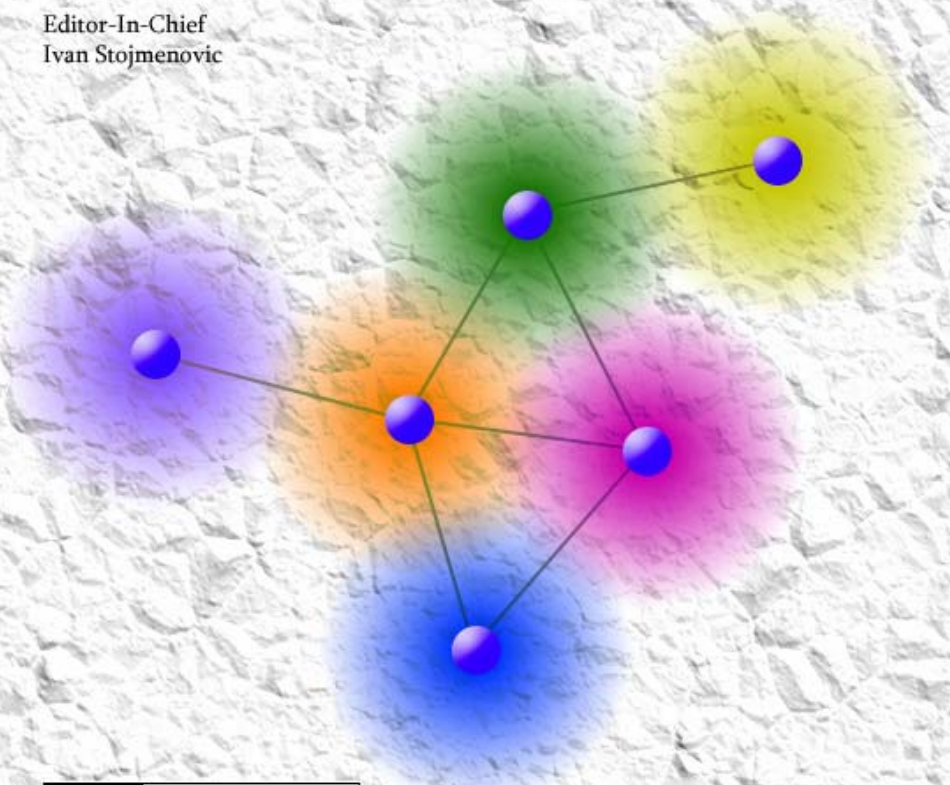


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HANDBOOK OF

SENSOR NETWORKS

ALGORITHMS AND ARCHITECTURES



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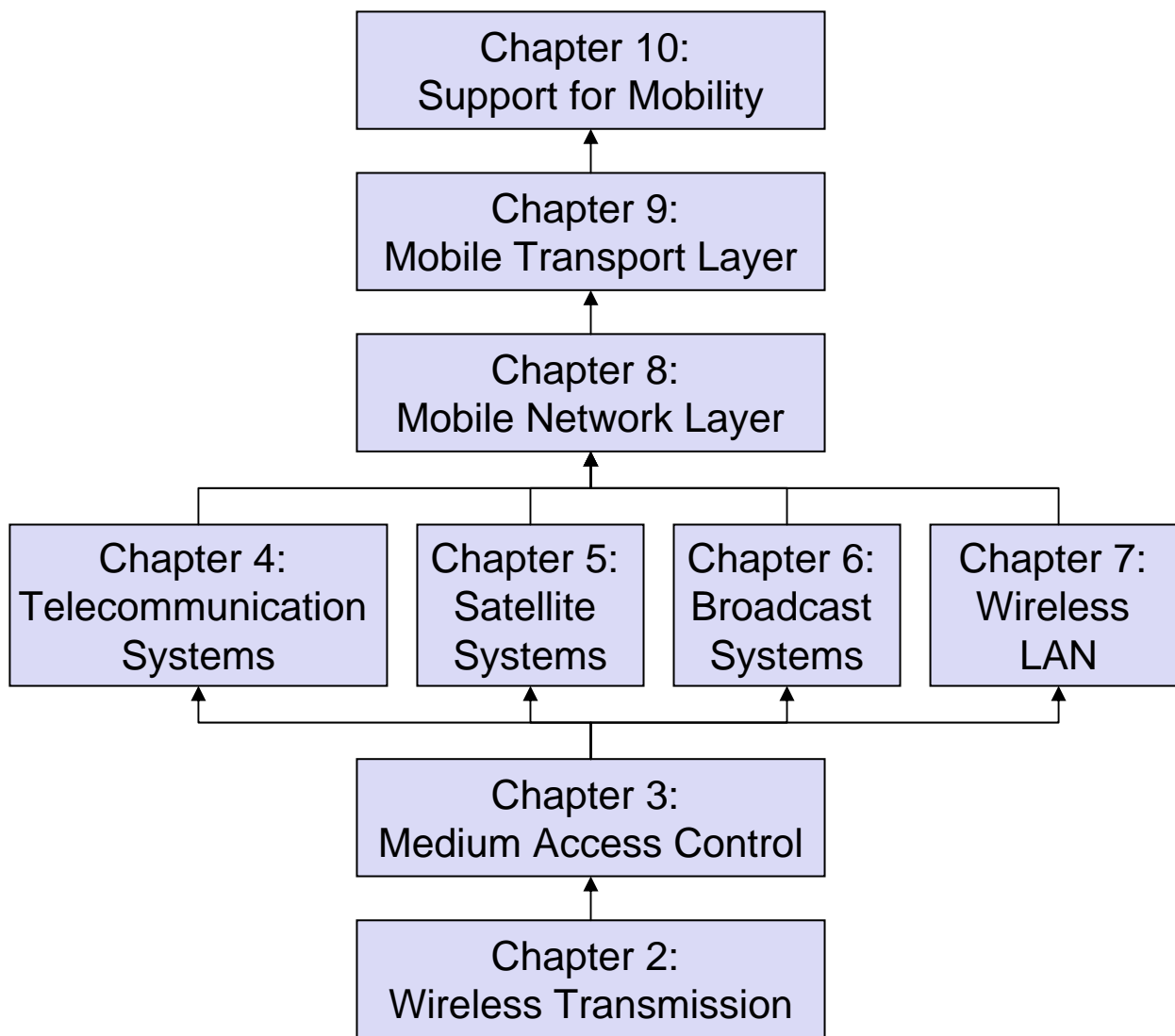
Wireless networks - layers

- Physical layer
- Medium access layer
- Network layer (multi-hop)
- Transport layer (TCP)
- Applications

mobile communication - layer model

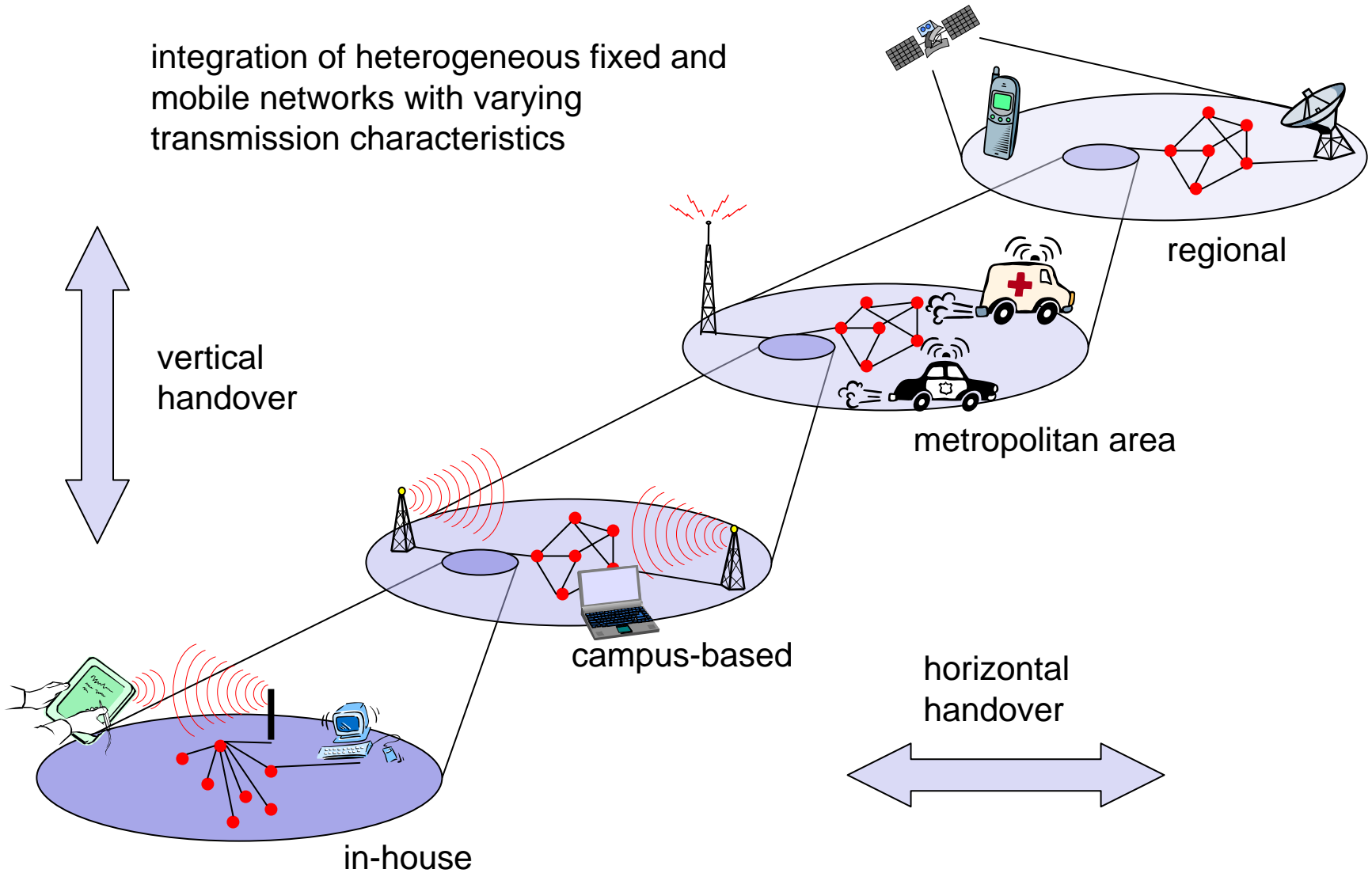
- Application layer
 - Multimedia, adaptive applications
 - service location
- Transport layer
 - congestion and flow control
 - quality of service
- Network layer
 - addressing, routing, device location
 - hand-over
- Data link layer
 - Authentication, Multiplexing, media access control
 - Encryption, modulation
- Physical layer
 - Interference, attenuation
 - frequency

Overview of the main chapters



Overlay Networks

integration of heterogeneous fixed and mobile networks with varying transmission characteristics



Physical layer

- Limited bandwidth, Limited power (if battery)
- Position information (GPS receiver ?)
- One-to-all commun. (omni-directional antennas)
- One-to-many communication (directional antennas with fixed or variable angular beam)
- One-to-one communication (narrow beam directional/smart antennas, separate frequency)
- Same frequency, different but fixed frequencies, frequency hopping (Bluetooth, ultra-wideband)
- Laptops, sensors, cellular phones, palmtops,...

Some physical layer problems

- **Power management** (battery operated)
- **Wireless error control** – choose error correcting codes suitable for wireless transfer
- **Wireless data compression** – compress data for faster wireless transfer
- **Channel modeling** – what is the interference model in cellular networks?
- **Smart antennas** (e.g. directional)
- **New technologies** (e.g. ultra-wideband frequency hopping)

Medium access control MAC

- IEEE 802.11
- Bluetooth for personal short range networks 10m
- Ultra-wideband MAC with position information ??
- Frequency allocation for cellular networks
- Neighbor discovery in ad hoc, sensor, Bluetooth
- Position discovery (GPS, indoor, relative, cell)
- Handoff in cellular networks
- Position based MAC
- Power adjusted MAC – fixed or variable transmission radii

MAC problems

- **Call admission:** which news calls to accept ?
- **Handoff management:** how to move ongoing call to new cell, which calls to move to new frequencies or other base station, which calls to terminate
- **Random access schemes:** ALOHA like protocols generate delay of broadcast at random
- **Data broadcast:** BS periodically broadcast desired data. Minimize average access delay.
- **CDMA** – code division multiple access: use different codes over the same channel, small interference

Network layer

- **Neighbor discovery in multi-hop**
- **Network organization:** choosing transmission radii for desired connectivity
- **Data communication:**
- Routing, broadcasting, geocasting, multicasting, QoS routing
- **Service access** in multi-hop = routing
- **Connection rerouting** in cellular = routing
- Paging and registration tradeoff = **location management** in cellular networks, cellular IP, mobile IP

Transport layer

- In wired networks, errors are mainly due to congestion
- In wireless networks, *error rate is increased* due to MAC problems, *disconnection* is possible due to mobility or power failure
- Wireless TCP different from TCP
- Choose best routes and choose best transmission rates to avoid congestion
- QoS issues
- Differentiated service: voice, data, multimedia

Applications

- Mobile, pervasive, ubiquitous, nomadic computing
- Computing anytime anywhere
- Distributed computing, CORBA
- Cellular and satellite networks
- Ad hoc networks: rescue, battlefield, conference
- Sensor networks: monitoring environment to detect object movement or presence of chemicals, fire, temperature reports
- Mesh networks;: rooftop networks for multi-hop wireless Internet access