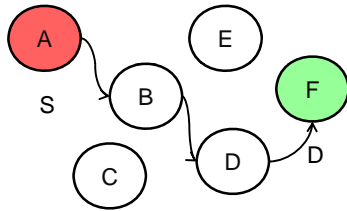


Wireless Ad Hoc & Sensor Networks



WS 2009/2010

Prof. Dr. Dieter Hogrefe/Prof. Dr. Xiaoming Fu
Dr. Omar Alfandi

1

Outline

- Terms of Lecture
- Lecture Overview
- History
- Definition
- Applications
- Repetition – Physical Layer
- Issues
- Summary

2

Terms of Lecture

- Weekly lecture (2 SWS, 4 Credits)
- Problem Sheets (self solution)
- Written Exam: 90 minutes at end of semester
- Target audience: INF BSc (5++ sem.); MSc (1++ sem.)
- No audio/video recording of lecture (physical presence required)

3

Terms of Lecture

- Learning Goals:
 - Understanding, application & critical evaluation of wireless Ad Hoc & Sensor network principles
 - Basics
 - Issues
 - Current solutions
 - Open research questions
- What we expect:
 - Be prepared for each lecture i.e. read announced chapter (text book) and lecture slides (published as soon as possible)
 - Autonomously solve problem sheets, feel free to ask questions (office hours, email)

4

Terms of Lecture

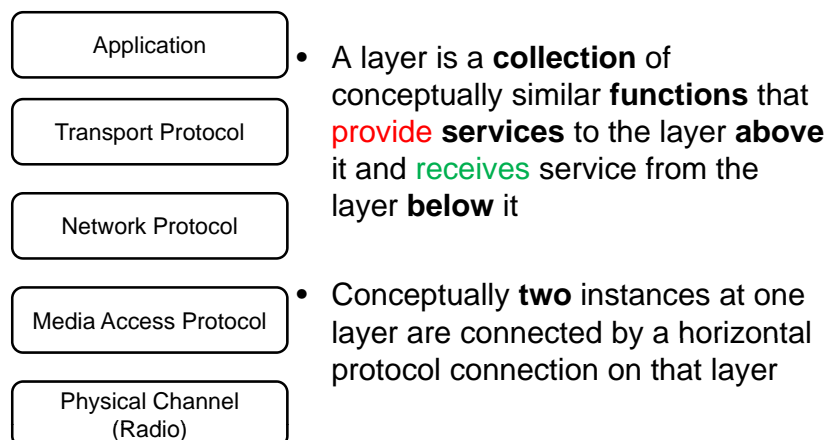
- Literature

- Ad Hoc Wireless Networks: Architectures and Protocols; C. Murthy & B. Manoj, Prentice Hall, 2004 ISBN: 013147023X
(First is the basic text book used for the lecture structure)
- Protocols and Architectures for Wireless Sensor Networks; H. Karl & A. Willig; 2005; Wiley & Sons; ISBN 0470095102
(Second is also used for Sensor Networks)
- Further Literature and papers, will be announced in lecture slides.

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Lecture Overview – OSI Reference Model



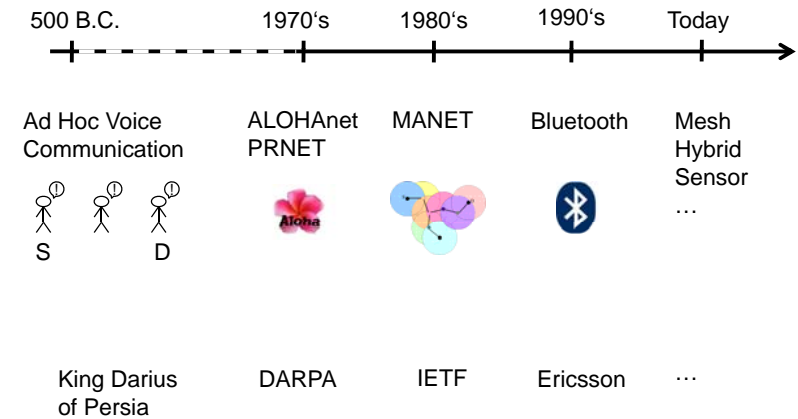
Lecture Overview

- Introduction [Ch.5]
- Medium Access Scheme (1 lecture) [Ch.6]
- Routing (1 lecture) [Ch.7]
- Energy Management [Ch.11]
- Transport Layer Protocols & QoS (1 lecture) [Ch.9,10]
- Security (3 lectures) [Ch.9 and other]
- Sensor Networks (3 lectures) [Ch.12]
- External Invited Talk (1 lecture, at the end)
- Final written **Exam** (last lecture date)

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History



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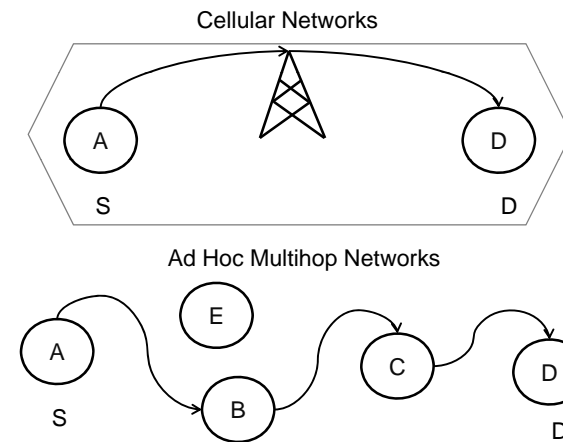
Definition – Ad Hoc Network

- **Ad hoc** is a **Latin phrase** which means "for this [purpose]"
- The **purpose** is to interconnect computational nodes for information exchange
- Interconnection is being realized decentralized, **without** pre-existing **infrastructure**, e.g. routers, access points
- Nodes participate in **routing** of packets, deciding **dynamically**, based on connectivity to neighbour nodes.

Definition – Sensor Network

- **Sensor** from the Latin word *sentire* which means “to feel” or “to perceive”
- A Sensor measures a **physical quantity** and converts it into a signal, destined for an observing instrument
- Sensors **use Ad Hoc** networking to communicate observed information

Definition – Cellular vs. Ad Hoc



Cellular vs Ad Hoc

Cellular Networks	Ad Hoc Wireless Networks
Fixed infrastructure based	Infrastructure less
Single-hop wireless links	Multi-hop wireless links
Centralized routing	Distributed routing
High reliability	Frequent path breaks due to mobility
Low complexity mobile hosts	Mobile hosts also routers
Geographical reuse of spectrum	Carrier sense bases reuse of spectrum
Widely deployed, currently 4G	Remaining issues, low commercial deployment, widespread in defense

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Applications

- Military Applications
- Transportation Communication
- Wireless Sensor Networks (Monitoring)
- Collaboration/Distributed Computing
- Emergency Operations
- Wireless Mesh Networks
- Hybrid Wireless Networks

17

Applications - Military

- **Why?** Establish communication among a **group** of soldiers/vehicles for **tactical operations**
- **Where?** Areas with **impossible** infrastructure set up
- Security is **crucial**, eavesdropping and other attacks can compromise information and personel **safety**.



18

Applications – Transportation (C2C)

- **Why?** Primary reduce number of lethal accidents.
Secondary enable new kinds of services.
- **How?** Enable Car to Car (C2C) and Car to Infrastructure (C2I) communication for road safety messages.



19

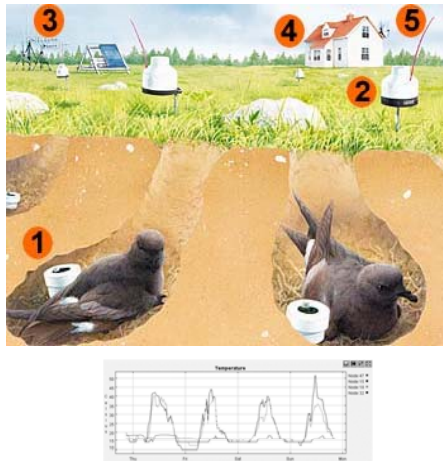
Applications – Sensor Networks

- **Why? Monitoring** of physical parameters and transmitting to a sensor sink
- **Where?** Health care, home security, military, environmental monitoring
- **Issues:** mobility, network size, deployment density, power constraints



20

Applications - Animal Monitoring



1. Biologists put sensors in underground nests of storm petrel
2. And on 10cm stilts
3. Devices record data about birds
4. Transmit to research station
5. And from there via satellite to lab

21

Applications – Collaboration

- **Why?** Required **instant** communication
- **Where?** Conference (file **exchange**), Lecture (notes **distribution**) using laptops/smart phones
- **Properties:** Lower security than military, energy constraints, **uni- and multicast**.



22

Applications – Emergency Operations

- **Why?** Required communication for **rescue, crowd control, commando operations** activities
- **Where?** Areas with **no/destroyed infrastructure** due to natural calamities, war, etc.
- **Properties:** self configurable, decentralized, capable of voice communication

23

Applications – Wireless Mesh Networks

- **Why?** Provision of **alternate** communication capability to mobile/fixed nodes, opposed to cellular networks.
- **Where?** Areas with **no/low cable** coverage or **cost** constraints or **quick** deployment needs.
- **Properties:** Simple expandability, high availability



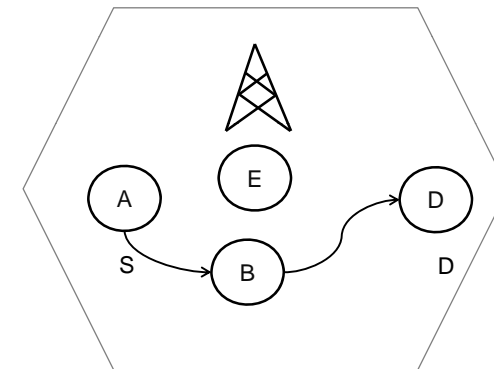
24

Applications – Hybrid Wireless Networks

- **What?** Multi-hop cellular networks
- **Why?** Exponential **growth** in subscriber base of cellular networks, over 4 bn in 2008.
- **Properties:** mobile nodes are involved in routing, High capacity/coverage, centric routing topology maintenance (BTS), Problem: **energy constrained** mobile nodes

Applications – Hybrid Wireless Networks

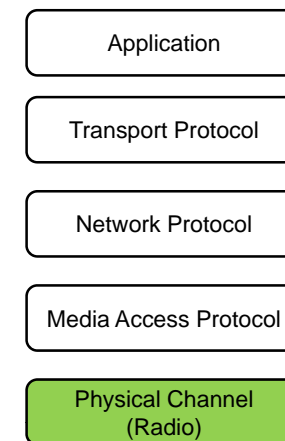
Cellular Multi-Hop Networks



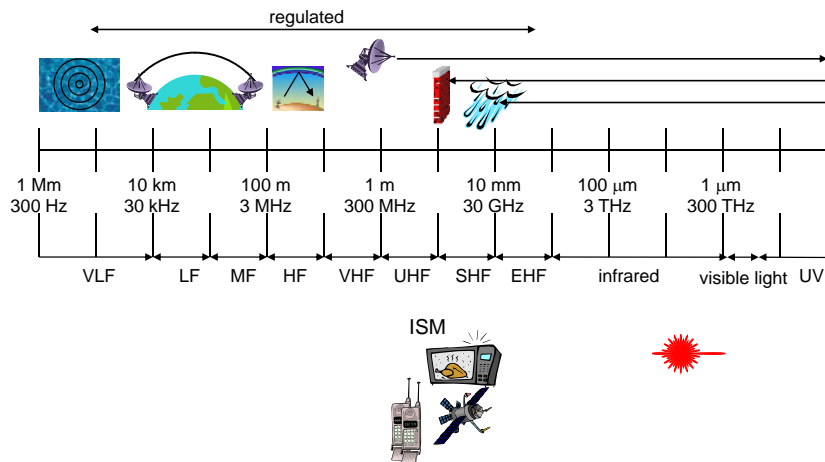
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Physical Layer - OSI Reference Model



Physical Layer - Spectrum

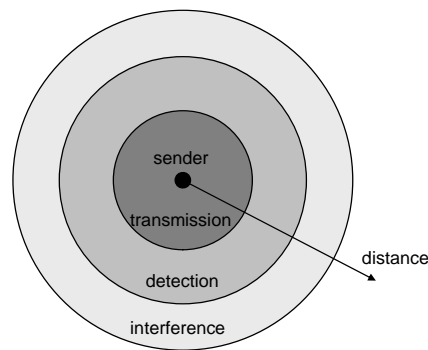


Physical Layer - Frequencies and Regulations

	Europe (CEPT/ETSI)	USA (FCC)	Japan
Mobile phones	GSM ≈ 800, 1700, 1800 Mhz	CDMA ≈ 800 MHz, CDMA, GSM ≈ 1800 MHz, 1900 MHz	PDC ≈ 800, 900, 1400 Mhz
Cordless telephones	DECT 1880-1900 MHz	PACS ≈ 1800, 1900 Mhz	PHS ≈ 1900 Mhz JCT ≈ 200 – 400 Mhz
Wireless LANs	IEEE 802.11 2400-2483 MHz	IEEE 802.11 2400-2483 MHz	IEEE 802.11 2471-2497 MHz

Physical Layer - Signal Propagation Ranges

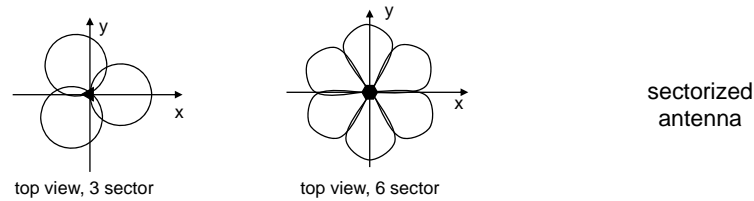
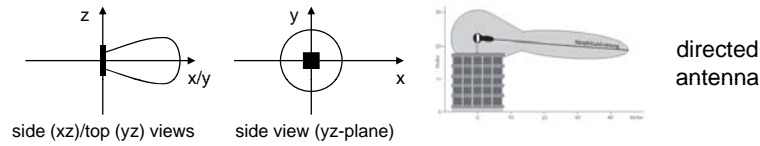
- Straight line propagation
- Transmission range
 - communication possible
 - low error rate
- Detection range
 - detection possible
 - no communication
- Interference range
 - no signal detection
 - Signal part of background noise



Physical Layer – Signal Propagation

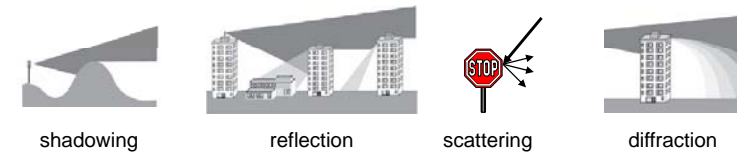
- Free space propagation
$$P_r = \frac{P_s G_s G_r}{\left(4 \frac{1}{4}\right)^2 d^2 L}$$
- P_s, P_r : Power of radio signal of sender resp. receiver
- G_s, G_r : Antenna gain of sender resp. receiver (how bad is antenna)
- d : Distance between sender and receiver
- L : System loss factor
- λ : Wavelength of signal in meters

Physical Layer - Antennas



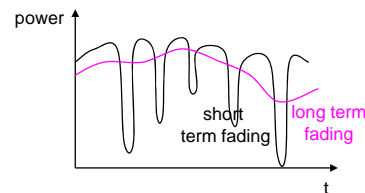
Physical Layer - Attenuation by Objects

- Shadowing (3-30 dB):
 - textile (3 dB)
 - concrete walls (13-20 dB)
 - floors (20-30 dB)
- reflection at large obstacles
- scattering at small obstacles
- diffraction at edges



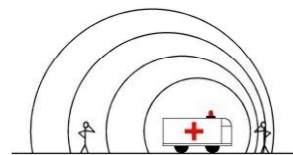
Physical Layer - Effects of Mobility

- Channel characteristics change over time and location
 - signal paths change
 - distance to sender changes
 - obstacles position changes

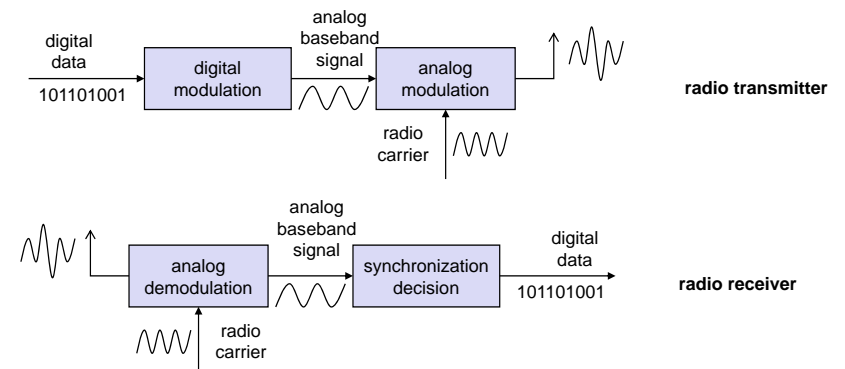


- Fading
 - short term
 - long term

- Doppler shift: Random frequency modulation

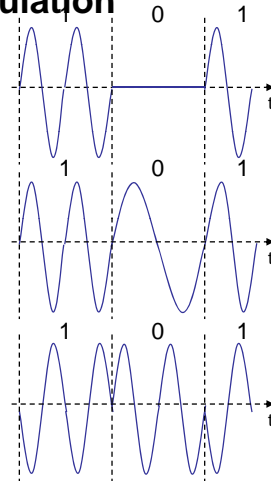


Physical Layer - Modulation and Demodulation



Physical Layer - Digital Modulation

- Modulation of digital signals
- Amplitude Shift Keying (ASK):
 - very simple
 - low bandwidth requirements
 - very susceptible to interference
- Frequency Shift Keying (FSK):
 - needs larger bandwidth
- Phase Shift Keying (PSK):
 - more complex
 - robust against interference



37

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38

Issues

- Medium Access Scheme
- Routing
- Multicasting
- Transport Layer Protocols
- Pricing Scheme
- Quality of Service Provisioning
- Self Organization
- Security
- Energy Management
- Scalability

39

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40

Summary

- Ad Hoc networks serve the purpose of connecting nodes instantly, without infrastructure
- Ancient use in natural societies with voice, drums, trumpets for high speed communication
- Sensors use ad hoc networks to communicate registered physical parameters to a monitoring sink
- Compared to cellular networks ad hoc nodes are more complex and deal with dynamic topology and resource constraints

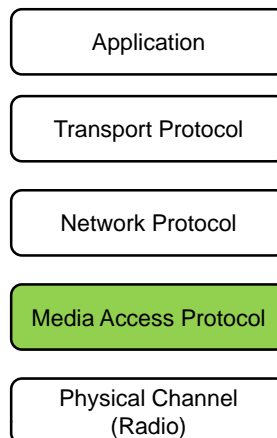
41

Summary

- A vast area of applications is possible for ad hoc networks
 - Military
 - Car2Car
 - Mesh
 - Sensors
 - ...
- Physical Layer has highly special characteristics
- Issues exist in all layers due to distribution and dynamics
- Outlook: Next lecture will tackle properties and issues of MAC layer and possible solutions

42

Summary – Next Session



43