Ad Hoc Networks

Introduction

Organization

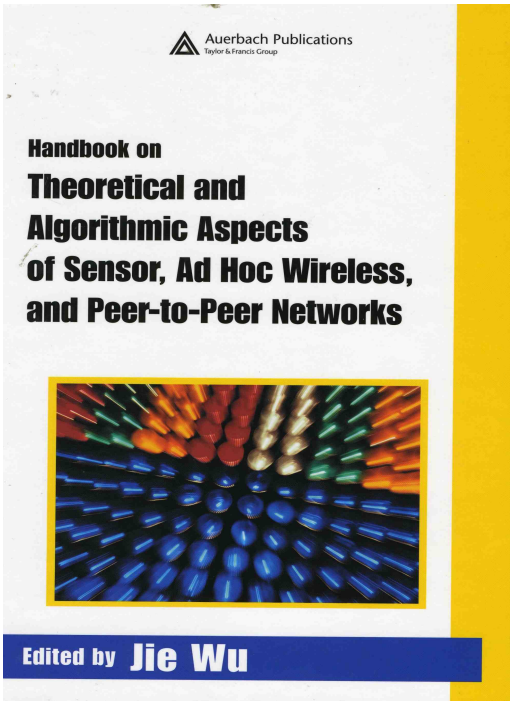
- Lecture: Wednesday 16:15 –17:45, room 7.102
- http://people.inf.elte.hu/lukovszki/Courses/1617MSC_EN/
- Practice: Wednesday 17:45 – 19:15, room 7.102

Topics

- Introduction
- Physical backgrounds
- Medium Access Control
- Flows and network capacity
- Topology control
- Position based routing
- Distributed location services
- Energy, dilation, congestion trade-offs
- Mobility models
- Network coding

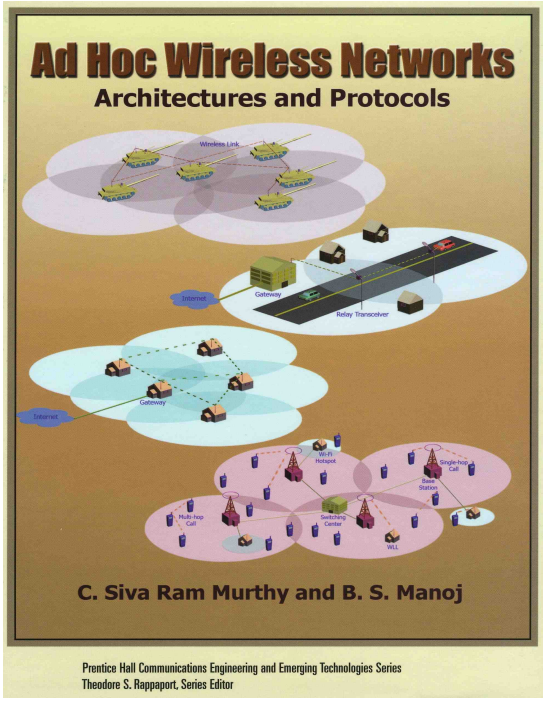
Literature 1

- Editor: Jie Wu
  - *Handbook on Theoretical and Algorithmic Aspects of Sensor, Ad Hoc Networks and Peer-to-Per Networks*
  - Auerbach, 2005
- Collection of works written by experts



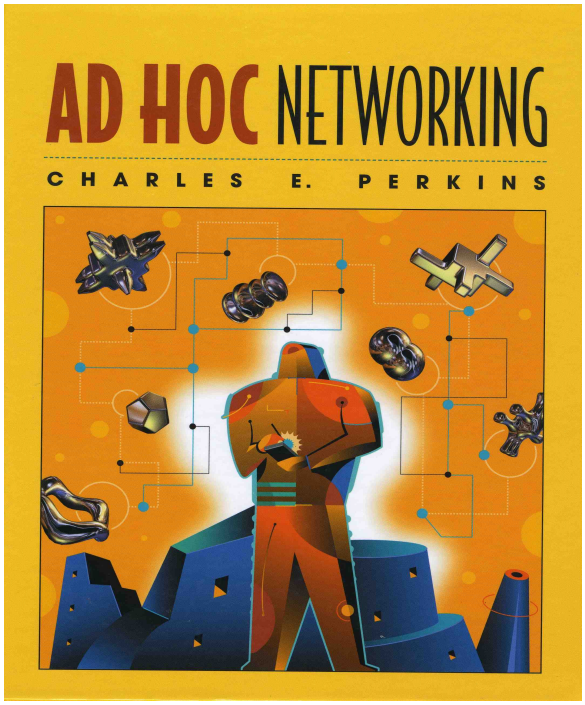
Literature 2

- Murthy and Manoj
  - *Ad Hoc Wireless Networks, Architectures and Protocols*
  - Pearson/Prentice Hall, 2004
- Covers many aspects of wireless communication
  - 802.3, 802.11, HiperLAN, GSM, ATM, WATM, MobileIP, MANET, MAC for Wireless, Routing and Multicast Routing in MANETs, Transport layer, QoS, Energy Management, Sensor Networks, Hybrid Networks



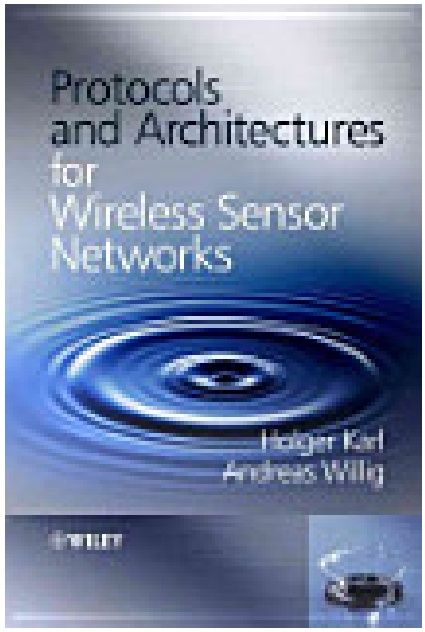
Literature 4

- Charles E. Perkins
  - *Ad Hoc Networking*
  - Addison-Wesley 2001
- A classic book
  - Little bit outdated
- Topics:
  - mainly routing algorithms, like DSDV, Cluster-based Routing, DSR, AODV, ZRP, Link Reversal



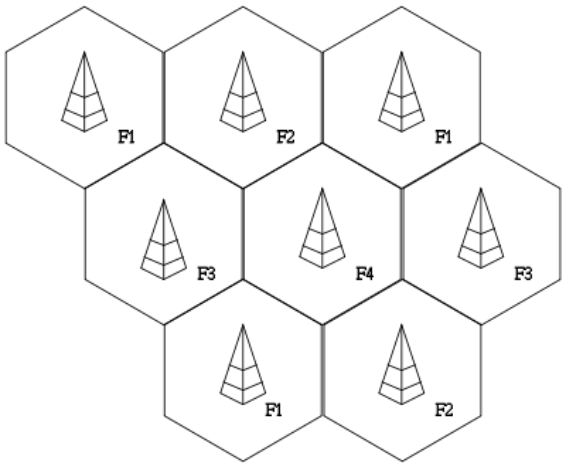
Literature 3

- Protocols and Architectures for Wireless Sensor Networks
- Holger Karl, Andreas Willig
  - John Wiley & Sons, 2006



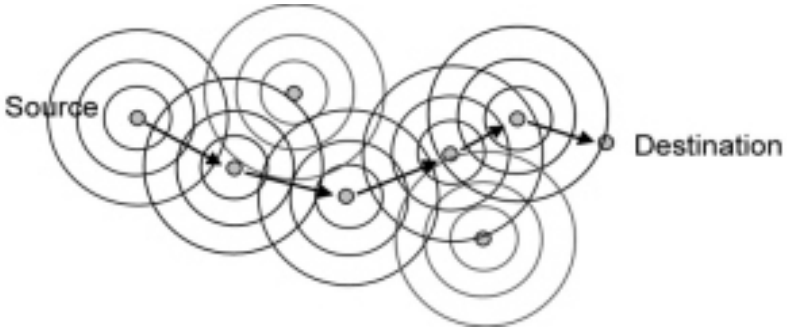
Types of Wireles Networks

- Cellular Networks
  - base stations distributed over the field
  - each base station covers a cell
  - used for mobile phones
  - WLAN can be seen as a special case



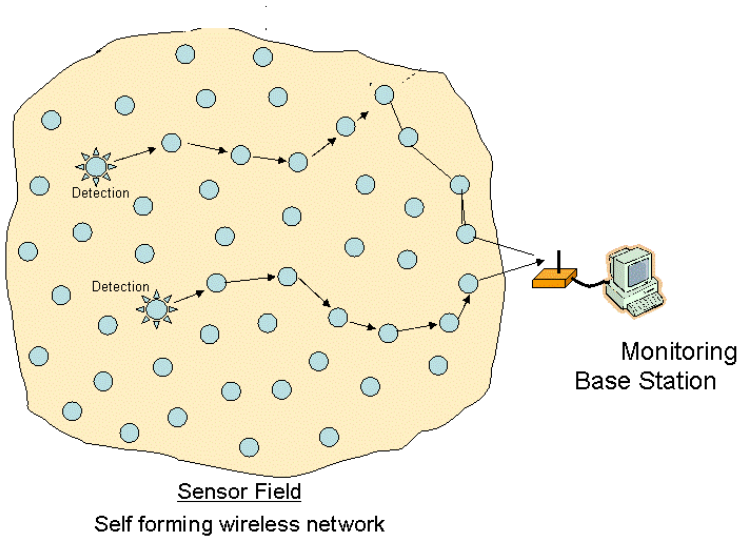
Types of Wireles Networks

- Mobile Ad Hoc Networks (MANET)
  - self-configuring network of mobile nodes
  - node serve as client and router
  - no infrastructure necessary



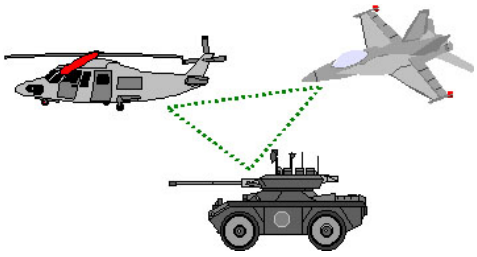
Types of Wireles Networks

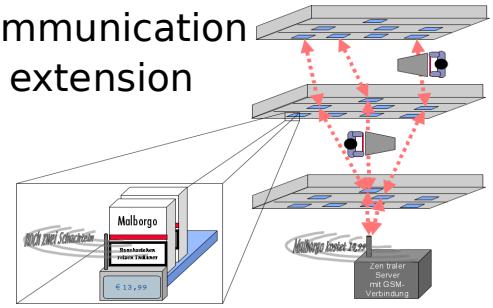
- Sensor Networks
  - network of sensor devices with controller and radio transceivers
  - base station with more resources

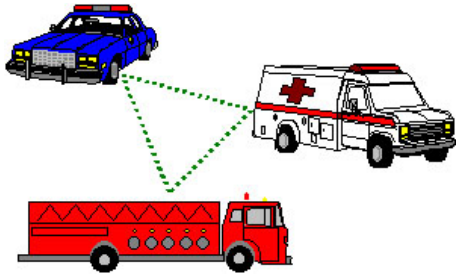


Applications of MANETs

- Military
- Deserted Areas
- Sensor networks
  - Environmental control
  - Intelligent Home
  - Supermarket
- Car technology
  - Inter-car communication
- WLAN hotspot extension
- ...







Challenges

- Self-construction, self-maintenance
- Scalability
- Reliability
- Resource efficiency
  - Energy
  - Storage
- Fault- / disaster-tolerance
  - Tolerates simultaneous (node/link) faults
  - Fast reconfiguration on detection of faults
- Mobility
- ...

Topics

- Physical backgrounds
- Medium Access Control
- Flows and network capacity
- Topology control
- Position based routing
- Distributed location services
- Energy, dilation, congestion trade-offs
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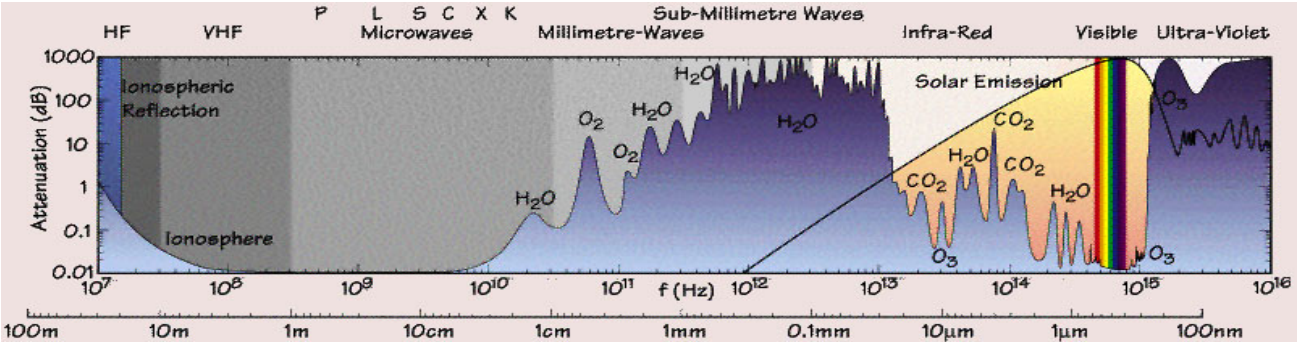
- Network coding

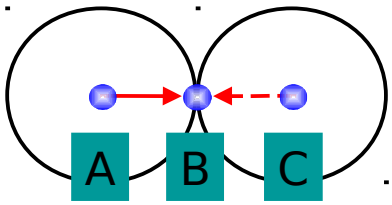
Physical Backgrounds

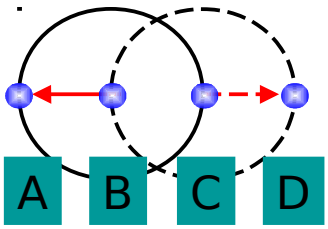
- Electro-magnetic waves
- Frequency bands
- Noise and interference, bit error rate
- Sharing the medium



Medium Access Control (MAC)

- Problems for MAC protocols



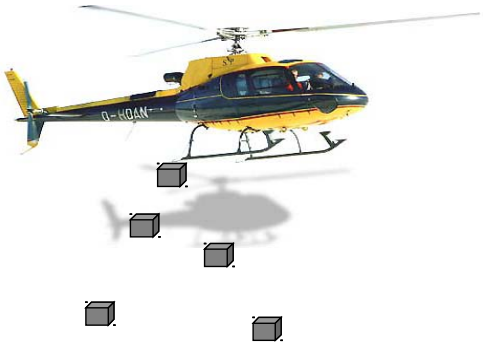


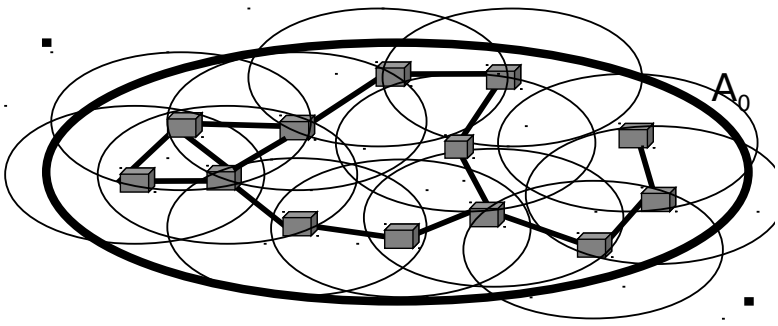
Hidden terminal Exposed terminal

- Protocols: MACA, MACAW
- Problem of using different transmission power

Capacity of Wireless Networks

- Random placement model
- Data flow in networks
  - Max flow, min cut
  - Multi commodity flows
- Minimum density for connectivity
- Capacity

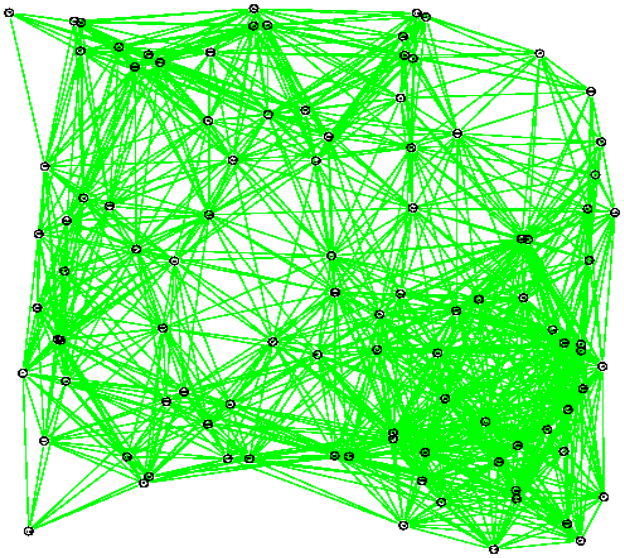




Topology Control

Example: no topology control

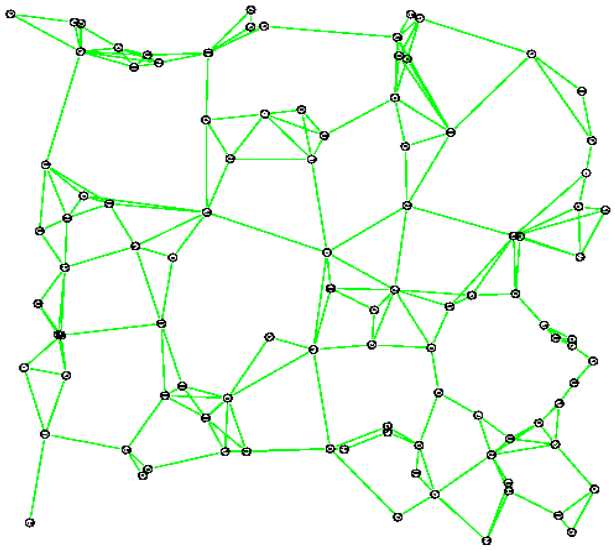
Maximum transmission distance *R*



- High energy consumption
- High amount of interference
- Low throughput

Topology Control

Example, using topology control

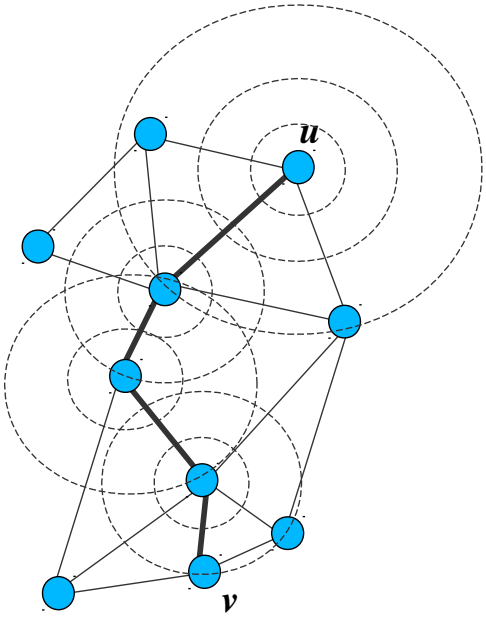


- Global connetivity
- Low energy consumption
- Low amount of interference
- High throughput

Topology Control

- Sparse topologies
- Low node degree
- Short paths, low energy paths
- Low load

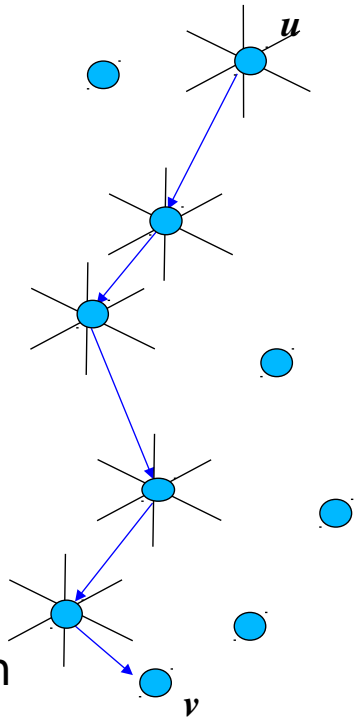
- Distributed construction and maintenance
  - scalability
  - fault tolerance
  - self-reconstruction



Position Based Routing

- The packets are forwarded „on the fly” to the next node based on the geographic position of
  - the current node,
  - the neighbors of the current node,
  - the destination node
- Routing table is not needed
- Support of geocasting

- How the position of the destination can be detected?



Distributed Location Services

Location service: provides position information for a requested node

Problems with centralized solutions:

- Each node must know the position of the location servers (a chicken-egg problem)
- High amount of traffic on the location servers and nodes in their environment

Desired properties of distributed location services

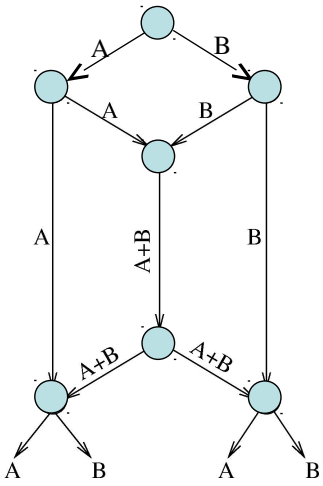
- Load is balanced over rhe nodes
- Low storage and communication costs
- Short paths for the position queries
- Fault tolerance

Mobility

- Mobility patterns
  - Pedestrian
  - Marine and Submarine
  - Earth Bound Vehicles
  - Aerial Mobility
  - Medium Based
  - Space
- Mobility models
  - Random Walk
  - Trace Based
  - Fluid Flow
  - Brownian Motion
  - Random Waypoint
  - Group-Mobility Models

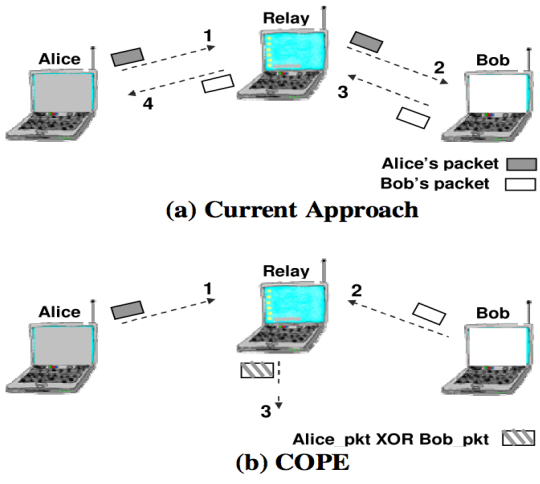
Network Coding

- The nodes of the network are able to combine the received packets.
- They send the combined packets through the links
- From a source node to a set of destination nodes the rate of the multicast can achieve the „cut bound” by using network coding



Network Coding

- Applications in wireless networks
  - increase traffic throughput in Ad Hoc Networks
  - decrease energy consumption in multicast
  - increase robustness and reduce the error rate
  - increase throughput in Peer-to-Peer Networks
  - increase throughput in Wireless Sensor Networks



Thank you!

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