Ad Hoc Networks
Winter 2007/2008

University of Freiburg
Computer Networks and Telematics
Prof. Christian Schindelhauer

Christian Schindelhauer
schindel@informatik.uni-freiburg.de

Bachelor-Arbeit in der Informatik

University of Freiburg
Institute of Computer Science
Computer Networks and Telematics
Prof. Christian Schindelhauer

- **12 ECTS-Punkte für Arbeit**
  - 4/5 der Note
  - Umfang 3 Monate
- **3 ECTS-Punkte für Präsentation**
  - 1/5 der Note
  - hochschulöffentlich
  - vor zwei Prüfern (mit Beisitzer)

Master-Arbeit in der Informatik

University of Freiburg
Institute of Computer Science
Computer Networks and Telematics
Prof. Christian Schindelhauer

- **Arbeit**
  - 27 ECTS-Punkte
  - 6 Monate
  - englischer oder deutscher Sprache
- **Präsentation**
  - 3 ECTS-Punkte

- **Siehe auch**
  - http://www.informatik.uni-freiburg.de/studienberatung/master/index.htm

Lab Course, Projekt, Teamprojekt

University of Freiburg
Institute of Computer Science
Computer Networks and Telematics
Prof. Christian Schindelhauer

- **Projekt im Bachelor of Computer Science**
  - Plan im 5. Semester
  - 6 ECTS-Punkte
- **Lab Course im Master of Computer Science oder Applied Computer Science**
  - Plan im 2. Semester
  - 6 ECTS-Punkte
- **Teamprojekt im Master of Computer Science oder Applied Computer Science**
  - Plan im 3. Semester
  - 14 ECTS-Punkte
  - englischer oder deutscher Sprache
- **Siehe auch**
  - http://www.informatik.uni-freiburg.de/studienberatung/bachelor/index.htm
  - http://www.informatik.uni-freiburg.de/studienberatung/master/index.htm

Topics

University of Freiburg
Institute of Computer Science
Computer Networks and Telematics
Prof. Christian Schindelhauer

- **Wireless Sensor Networks**
  - Medium Access Protocol
  - Routing
  - Lifetime
  - Mobility and Scalability
- **Mobile Ad-Hoc-Networks**
  - 3-MANET
- **Peer-to-Peer-Networks**
  - TooFree
  - 3-Nuts
- **Storage-Area-Networks**
  - Insane (File Area Network over the Internet)
- **Telematics**
  - Integrated Simulations for Self-organizing Networked Robots
  - Swarmbats: Localization using environmental sound events

Lab Course/Projekt/Teamprojekt
Ad hoc Network

University of Freiburg
Institute of Computer Science
Computer Networks and Telematics
Prof. Christian Schindelhauer

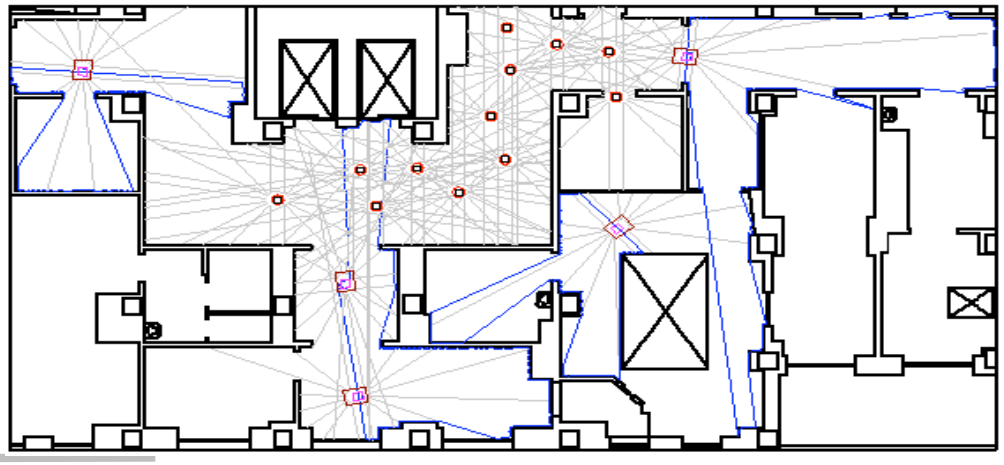
- **Two parts:**
  - Mobile Ad hoc Network (MANET)
  - Wireless Sensor Network (WSN)
- **Depending on the project scope, the number of each project member is up to three.**
- **Lectures will be given based on the requirements of the proposed projects.**
- **Project output may include:**
  - Specifications
  - Codes
  - Demonstration
  - Final presentation
- **Objectives**
  - To attain practical expertise with Hardware, Software and Design

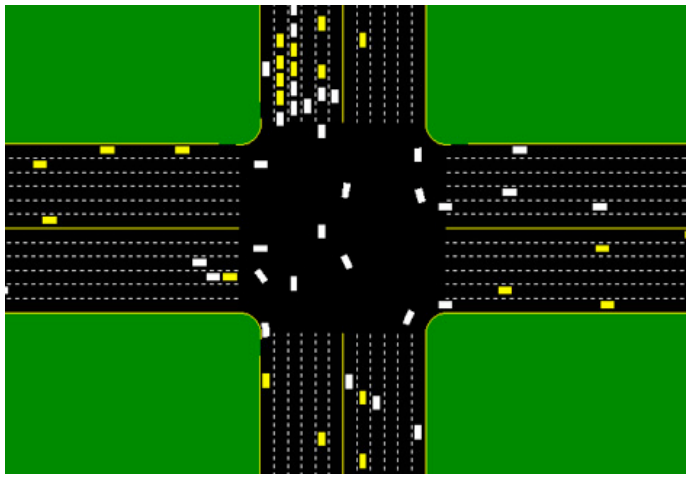
Part A:
Mobile Ad Hoc Networks

Lab Course/Projekt/Teamprojekt
MANET Projects

University of Freiburg
Institute of Computer Science
Computer Networks and Telematics
Prof. Christian Schindelhauer

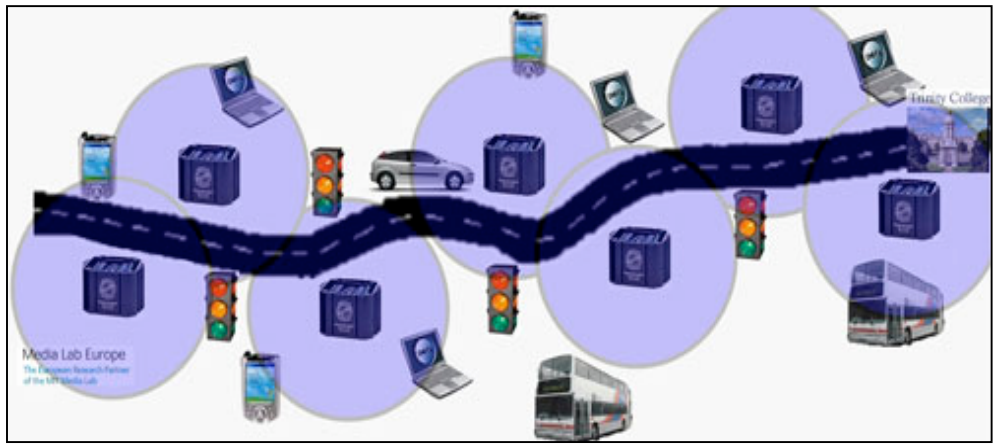
- **Simulation-based:**
  - Network simulators: Omnet++, NS-2
  - Robot simulators: MissionLab, Player/Stage
  - Traffic simulators: SUMO
  - Combination of the above
  - Create your own simulator
- **Implementation-based:**
  - Construct MANET test bed using Gumstix with Wi-Fi-stix (and optionally GPS-stix, robo-stix), moving toys, laptops, you, bikes, etc.

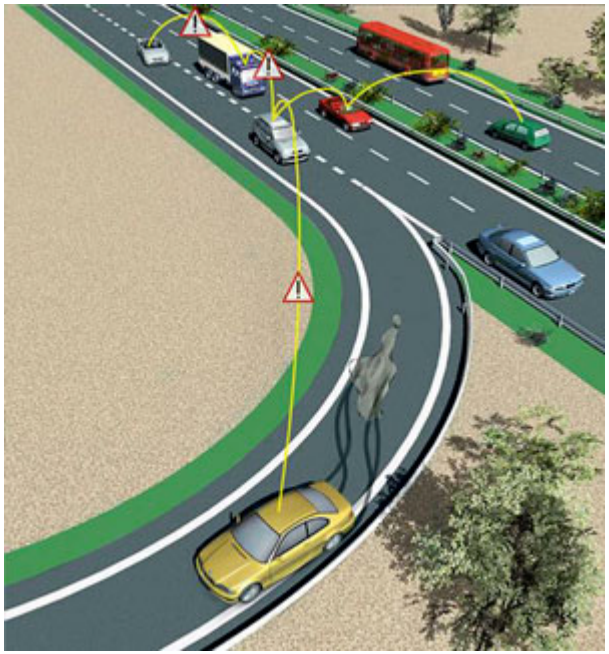




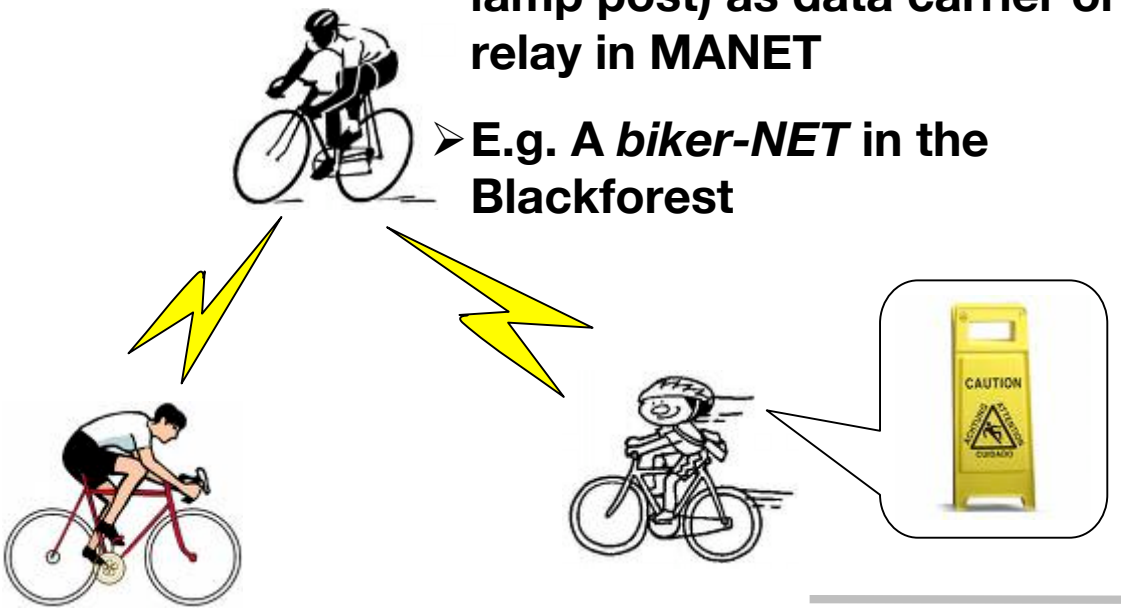
MANET Application I: Vehicular Ad-hoc NETwork (VANET)

University of Freiburg
Institute of Computer Science
Computer Networks and Telematics
Prof. Christian Schindelhauer



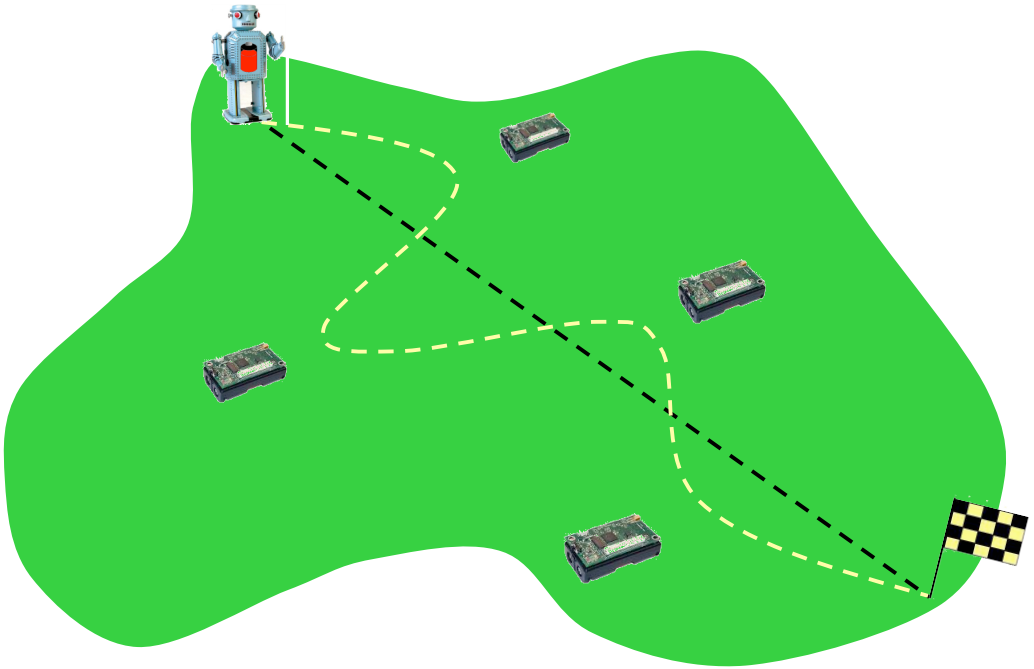


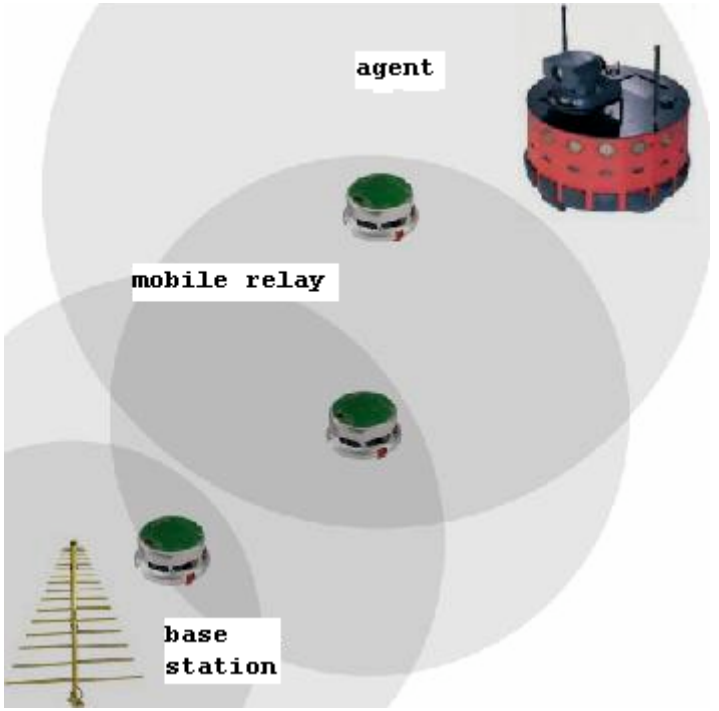
- **Integrated traffic simulator with network simulator**
- **Vehicle mobility-based routing strategy**
- **Make use of public transport (e.g. trams, trains, buses) or traffic facilities (traffic light, lamp post) as data carrier or relay in MANET**
- **E.g. A *biker-NET* in the Blackforest**



MANET Application II: Robot (-assisted) Ad hoc Network

University of Freiburg
Institute of Computer Science
Computer Networks and Telematics
Prof. Christian Schindelhauer



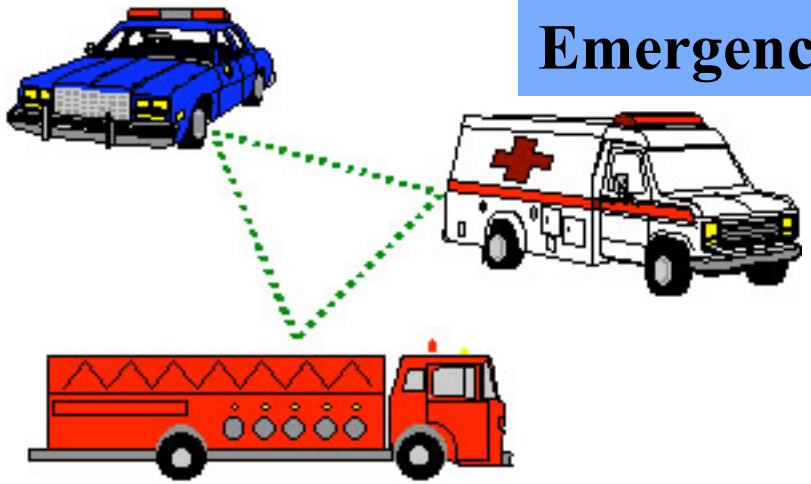


- **Mobile robots moving around wireless sensor network**
  - to collect/send data from/to sensors
  - to aid in localization
- **Mobile robots serve as relay in MANET**
  - How to guarantee connectivity?
  - How to conserve energy?

MANET Application III: Others

University of Freiburg
Institute of Computer Science
Computer Networks and Telematics
Prof. Christian Schindelhauer

Search & Rescue / Emergency Services



MANET Project Ideas (I)

University of Freiburg
Institute of Computer Science
Computer Networks and Telematics
Prof. Christian Schindelhauer

Followings are some project ideas based on the example MANET applications above:

- **Realistic mobility analysis**
  - Collect traces of human-beings' movement. Analyze the data and propose a mobility prediction algorithm to improve current MANET protocols.
- **Modeling radio propagation**
  - For indoor or outdoor environment. Examine its impact to data communications in MANET.
- **Energy consumption analysis**
  - Analyze power usage of different components of computing devices, e.g. radio, CPU, sensors, of Gumstix/laptops/sensors. Propose and evaluate the techniques to reduce the cost.

MANET Project Ideas (II)

University of Freiburg
Institute of Computer Science
Computer Networks and Telematics
Prof. Christian Schindelhauer

- **Route selection algorithm**
  - Develop a route selection algorithm for MANET protocols to determine the best strategy for different network conditions. Evaluate the performance of the proposed algorithm.
- **QoS in MANET routing protocol**
  - Improve any MANET routing protocol to maintain route and guarantee data delivery.
- **Real-time multimedia streaming in MANET**
  - Identify limitation of wireless link and problem in MANET for multimedia streaming. Enhance routing protocol to be robust to network dynamics.
- **Application development**
  - Develop an application for Gumstix, considering the hardware constraints. E.g. Gumstix phone.

University of Freiburg
Institute of Computer Science
Computer Networks and Telematics
Prof. Christian Schindelhauer

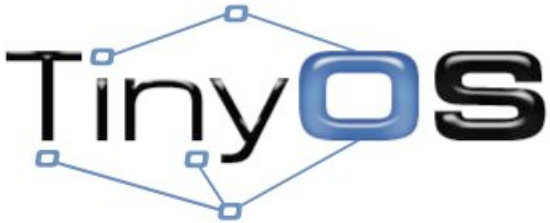
Part B:
Wireless Sensor Network

Wireless Sensor Network: Lecture

University of Freiburg
Institute of Computer Science
Computer Networks and Telematics
Prof. Christian Schindelhauer

- **There will be introductory lectures about following.**
  - TinyOS
  - B-MAC
  - Mica-2 and ScatterWeb hardware
  - C crash course *if required*!

MICAz 2.4GHz



Project-1: Architecture

University of Freiburg
Institute of Computer Science
Computer Networks and Telematics
Prof. Christian Schindelhauer

- **Design and implement software architecture of Sensor Network**

- **Skill Needed:**
  - Software design, Object oriented design, Design Patterns, C, TinyOS

- **Details:**
  - Numerous MAC layer and energy management protocols are designed, with no inter-operatability.
  - They have different assumptions and provide different interfaces.
  - Aim of this project is to develop a software architecture that provide common interfaces for different protocols, facilitating independent development and selecting process of protocols.

Project 2: Energy Conservation using HICA

University of Freiburg
Institute of Computer Science
Computer Networks and Telematics
Prof. Christian Schindelhauer

- **Implement Hardware Independent Connectivity Algorithm (HICA) to increase network lifetime.**

- **Skills Needed**
  - TinyOS, C and introduction to B-MAC-interface

- **Details**
  - HICA increases network lifetime by putting sleep redundant nodes
  - Nodes are carefully elected to be part of *connected dominating set*.
    - These node assure network connectivity.
  - Rest of the nodes are put to sleep mode for a *fix period of time*
    - After that fix period new set of nodes are re-election to be part of connected dominating set.
  - Aim of this project is to implement HICA on mica-2 and possibly improve its design.

Project 3: Localization using HILA

University of Freiburg
Institute of Computer Science
Computer Networks and Telematics
Prof. Christian Schindelhauer

- **Implementation of Hardware Independent Localization Algorithm (HILA)**

- **Skills Needed**
  - TinyOS, C, and introduction to B-MAC interface

- **Details**
  - Localization algorithm usually required special hardware:
    - Example: GPS, light omitting/reflecting devices, special transceiver etc
  - HILA required no hardware support
  - It uses two-hop neighbors information to estimate relative nodes locations
  - This project aim is to implement HICA on real sensor networks and improve its design.

Project 4: Sensing Robots

University of Freiburg
Institute of Computer Science
Computer Networks and Telematics
Prof. Christian Schindelhauer

- **Build sensing robots using off the shelf hardware**

- **Skills Needed**
  - Hardware architecture, TinyOS, C

- **Details**
  - Mobility increase sensors coverage and connectivity. Sensor network available in market have two disadvantage
    - Too expensive
      - ≈150$ per sensor mote
    - Usually no built-in mobility mechanism
  - Aim of this project is to design sensing robots using either solar energy or very energy efficient.
    - Robots should be able to software programmable and support TinyOS

Project 5: SOA Application (Open Project)

University of Freiburg
Institute of Computer Science
Computer Networks and Telematics
Prof. Christian Schindelhauer

- **Suggest, design and implement a state of art application**

- **Skills**
  - TinyOS, C and others

- **Details**
  - Application should be useful in real life.
    - May be some commercial value!
  - Rest of details you decide.