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Cross Layer Techniques for ad hoc networks: Implementations in WHYNET

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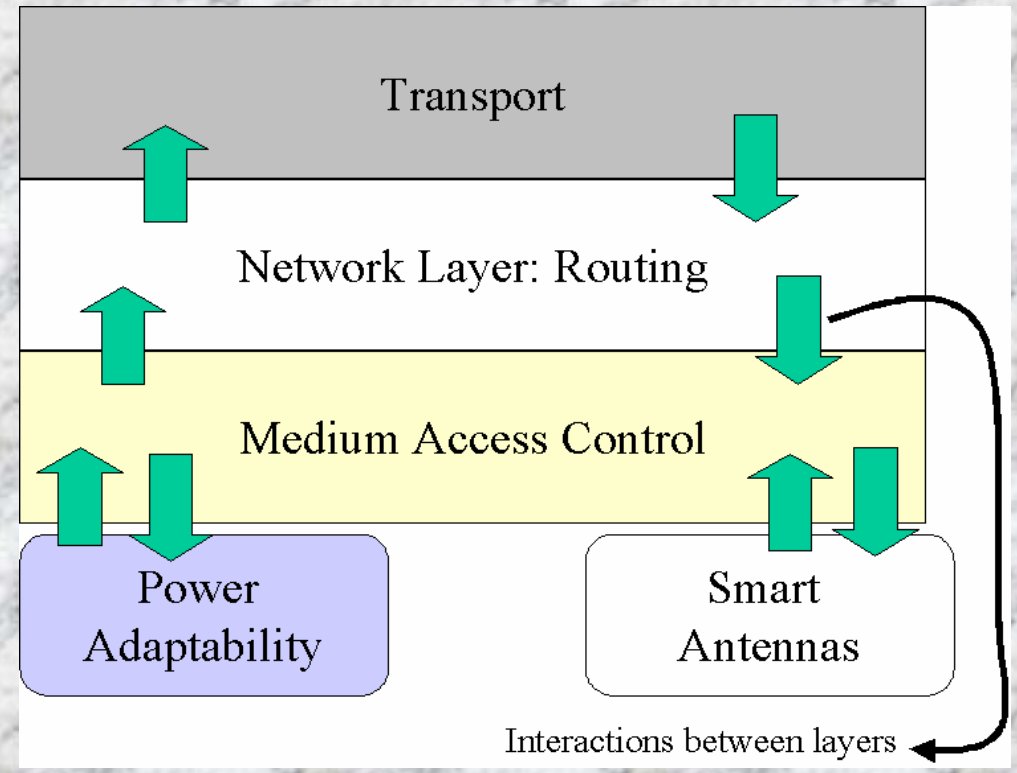
Objectives

- Design, develop and implement cross-layer architectures that exploit:
  - Ability to tune transmission power levels
  - Presence of Smart Antennas

Motivation

- Traditional protocols cannot be used as is: either fail or perform poorly.
- Current state-of-the-art protocols do not exploit the underlying mechanisms for power control or the presence of smart antennas efficiently. (Fairly recent work).
- Important details at the physical layer are not taken into account.
- Most of the current state-of-the-art protocols do not take mobility or traffic characteristics into account.

Cross-Layer Interactions



- Design of appropriate function calls, APIs to support exchange of information between layers
- Utilizing the information to perform appropriate tasks.

Power Management

- Power Control not easy in ad hoc networks.
- It can lead to energy savings and increased capacity.
- However it can also lead to asymmetry—traditional protocols perform poorly.
- Different layers must talk to each other—MAC, Routing and Transport.
- Does circular range accurately represent wireless transmissions ?
- Taking into account fading and the presence of obstacles.
- How does this affect power control ?

Smart Antennas

- Technological advances will make the use of such antennas in mobile terminals possible in the future.
- Need to track mobiles as they move via pilot tones or hello messages.
- Interaction of these tracking signals with the data transmissions not considered.
- Using directionality (or space time coding/decoding) at the transmitter and the receiver can yield benefits—but the transmitter and the receiver need to schedule their communication.
- How do much do these devices actually give us in terms of performance when fading is present?

Need for WHYNET

- More accurate simulation models at the physical layer — Qualnet
- Integration of these models with protocols.
- Design of new protocols to correctly cope with the behavior of underlying mechanisms / coping with fading and other physical impairments.
- Integration of protocols into WHYNET.
- Work with UCLA to use MIMO devices and testbed with directional antennas.
- Build a testbed with UCR — integrate with simulated framework.

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Working towards our goals

- Integrate MAC, Routing and Transport Layers
- Develop middleware that allows for interactions between layers in order to exploit the aforementioned physical layer features.
- Perform Simulation and Real Experiments within the WHYNET framework
  - Location of UCR offers a unique variety of geographic scenarios (mountains and plains) that allow us to perform experiments in various settings.
- Measurements and trace analysis to evaluate the protocols and quantify the performance effects of a given layer on other layers.

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Plan and Relation to Other Partner Sites

- Construct local network with laptop computers and wireless devices for tests and measurements.
- Develop simulation models for cross layer architectures.
- Establish tunnel linking UCR research group with WHYNET testbed at UCLA using CENIC.
- Work with UCLA for the integration of simulation models with the base-line models.
- Participate in the construction of a unified WHYNET testbed with integrated simulation/real network scenarios.
    - The UCR site will be an integral part of the overall WHYNET test bed.

Plan for Year 1

- Design and develop simulation models to represent our cross-layer architectures.
- Perform experiments and measurements with off-the-shelf 802.11 network interface cards with varying power levels / data rates (as possible) in a local setting.
- Work with UCLA on preliminary integration efforts.
- Understand the MIMO and directional testbed available at UCLA and design a plan to use these facilities.

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Leveraging off Other Efforts at UCR

- "Secure Wireless Fault Tolerant Tunable Networks (SWIFT)" from DARPA FTN — Srikanth Krishnamurthy and Satish Tripathi.
- "CAREER: Cross Layer Architectures for Power Adaptive and Smart Antenna Equipped Mobile Ad Hoc networks" from NSF — Srikanth Krishnamurthy
- "Protocols for Group Communications in Ad Hoc Networks and Ad Hoc Arrays", from ARL and Telcordia Technologies — Srikanth Krishnamurthy
- "An Adaptive Dynamic Architecture for Scalable Sensor Networks" from NSF — Srikanth Krishnamurthy
- "Interface Design for High Performance Networking" from LANL — Mart Molle
- "Inter-Related Research in the Areas of Support for Voice Over IP, Directory Services and Security" from TCS and DiMI — Mart Molle and Satish Tripathi