KEY WIRELESS NETWORKING
TECHNOLOGIES IN THE NEXT DECADE
(LATEST INITIATIVES AT NSF & DoD in the USA)

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LATEST NSF INITIATIVES

The GENI (Global Environment for Networking Investigations)

* New architectures for PERVASIVE COMPUTING, mobile, wireless and sensor networks.
* Building new services and applications
* Deploying and validating

FIND (FUTURE INTERNET NETWORK DESIGN)
(Architecture, Mobile Wireless and Sensor Technologies)
Automated Wide-Area Network Configuration from High-Level Specifications

Robust Self-Forming Human Networks: Making Organizations Work

Modification of WiFi Communication Devices to Support the Urban Warrior

Scalable Mobile Wireless Mesh Networks

xG (Dynamic Spectrum Access) Cognitive Radio Networks

CBMANET (Control Based Mobile Ad Hoc Networks)
KEY TECHNOLOGIES

• SENSOR & ACTOR NETWORKS
• xG WIRELESS SYSTEMS
[DYNAMIC SPECTRUM ACCESS NETWORKS]
COGNITIVE RADIO NETWORKS
KEY TECHNOLOGIES

- WiMAX
- WIRELESS MESH NETWORKS

I.F. Akyildiz and X. Wang,

“Wireless Mesh Networks; A Survey”,
Shorter version in
FUTURE INTERNET

ALL OF THE ABOVE NETWORKS
CO-EXISTING IN A SEAMLESS WAY!!!
KEY TECHNOLOGIES

• SENSOR & ACTOR NETWORKS

• 6K Papers are written the last 5 years!!

• A PAPER WRITING RACE!!

• A LOT OF EPSILONs!!!!!
Grand Challenge 1:

Traditional layered approach is not suitable for WSNs.

Traditional Approach: Traditional layered approach.

Cross-Layer Melting:

Our View: Cross-Layer Management Plane.

Communication Module

IFA’06

BRUSSELS
XLM: Cross-Layer Module
M. C. Vuran, O. B. Akan, and I. F. Akyildiz,

Application Layer
Transport
Network
MAC
PHY
GRAND CHALLENGE 2:
HOW TO REALIZE THE MAPPING??

User Requirements/Applications

Architecture and Topology

Communication Protocols
FURTHER GRAND CHALLENGES

- Cost Reduction to CENTS ??
- Deployment (Architecture) Decisions
  (optimal # of sensors, optimal # of sinks, optimal locations, fast deployment, reusability, terrain considerations)
- How to deal with TERABYTE of sensed information?
- How to integrate WSNs into NGWI ??
- Optimal Packet Size and Error Control
- Scalability
- SECURITY
FURTHER PHYSICAL LAYER CHALLENGES

- New Channel Models (I/O/Underwater/Underground/Deep Space)
- Explore Antenna Techniques
- Cognitive Radios
- UWB

CURRENT PROJECT@GaTech: DoD and NSF
Grand Challenges in WSNs
Wireless Sensor and Actor Networks

I.F. Akyildiz and I. H. Kasimoglu,

GRAND CHALLENGES:

- Sensor-Actor Coordination & Communication
- Actor-Actor Coordination & Communication

REAL-TIME COMMUNICATION!!!!
SENSOR-ACTOR COORDINATION

Challenges:

- Which sensor(s) communicate with which actor(s)?
- How should the communication occur?
- What are the requirements of the communication? (i.e., real-time, energy efficiency)
Challenges:
- Which actor(s) should execute which action(s)?
- What is the optimum number of actors performing the actions?

CURRENT PROJECT@GaTech: NSF & DoD
Exploring Spatial and Temporal Correlation for WSANs
IFA’06 
BRUSSELS
Differentiation between traffic types

Integrated Traffic: (AUDIO, VIDEO, DATA, STILL IMAGE)
- Delay in/sensitive, Jitter in/sensitive, Loss in/sensitive, Different data rates

Channel Allocation and Scheduling (Multimedia Traffic Management)
FURTHER GRAND CHALLENGES in Multimedia Sensor Networks

- How to guarantee delay bounds; jitter bounds?
- How to realize data aggregation?
- Explore the tradeoffs between media quality and energy consumption!!
- Differentiation of TCP vs UDP traffic
- Distributed source coding at different sensors
- Synchronization (intra-media, inter-media)
- Cross-layer design for multimedia traffic
Underground Wireless Sensor Networks
Underground WSNs: Research Challenges

- Dynamic Channel
- Power Constraints
- Very Low Data Rates
- Extremely Lossy Environment
- New Communication Protocols needed
UNDERWATER SENSOR NETWORKS
LATEST DARPA MISSION:
BAA-06-13: SUSTAINABLE LITTORAL SURVEILLANCE
(Energy Sources, Sensors, Platforms)
SUSTAINABLE LITTORAL SURVEILLANCE

Four Part Development Approach
(to achieve true Sustained Littoral Surveillance)

Bottom Mounted Microbial Fuel Cells
(stationary)

Water Column Microbial Fuel Cells
(mobile)

“Remora-Snake” Unmanned Amphibious Surveillance Platform

“Basking Shark” Unmanned Gliding Surveillance Platform
Research Challenges for UW Sensor Network

- Available bandwidth is severely limited
- UW channel is severely impaired (in particular due to multi-path and fading)
- Very long and extremely variable propagation delays
- Very high bit error rates and temporary losses of connectivity (SHADOW ZONES)
Battery power is limited and usually batteries cannot be recharged; no solar energy!!

- Very prone to failures because of fouling, corrosion, etc.
- New communication protocols needed!!

Current Project@GaTech:  US NAVY
Fundamentals and Protocols for Efficient Communication in UWSNs
DYNAMIC SPECTRUM ALLOCATION NETWORKS
(xG WIRELESS SYSTEMS; COGNITIVE RADIO NETWORKS)
RESEARCH CHALLENGES in DSANs


- Architecture
- Cognitive Radio Design
- Mobility Management
- Spectrum Management
  - Spectrum Sensing
  - Spectrum Decision
  - Spectrum Handoff
RESEARCH CHALLENGES in DSANs

- Spectrum Sharing
  - Sensing Algorithms
  - Interference Problems
  - Higher Level Protocols Adaptivity
  - Fairness and Security

Current Project@GaTech: NSF and DoD
OCRA: OFDM Based Cognitive Radio Networks