



ARO MURI PROJECT

"SPACE-TIME PROCESSING FOR TACTICAL MOBILE AD-HOC NETWORKS"

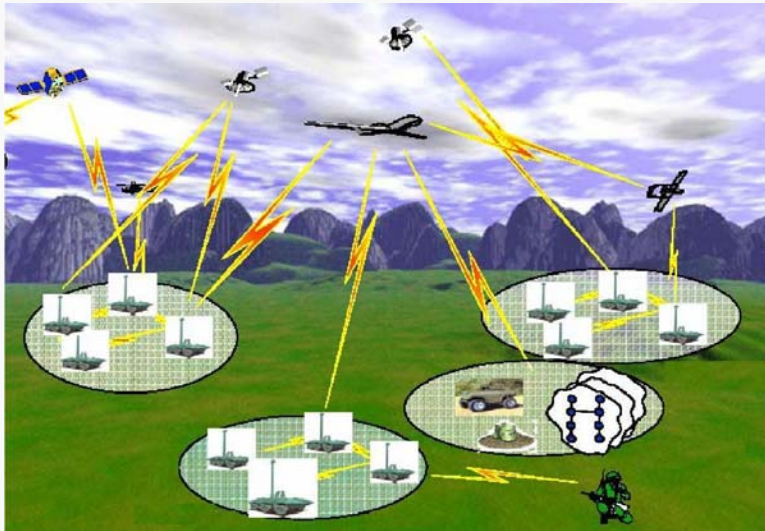
ANNUAL REVIEW *OCTOBER 16, 2008*

James Zeidler, UCSD

MULTI-UNIVERSITY RESEARCH INITIATIVE (MURI)

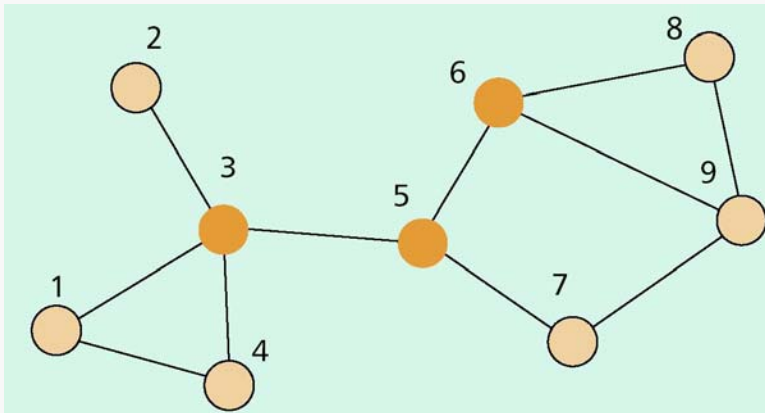


Tactical Ad-Hoc Networks

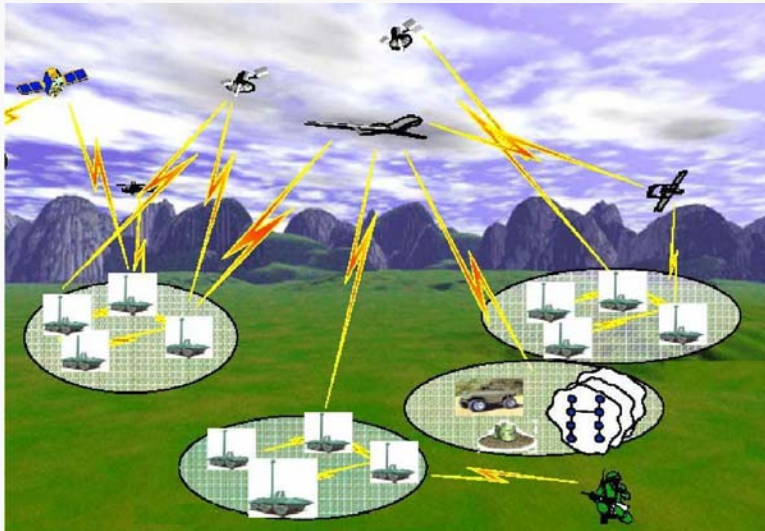


Baseline System Model

- 30-100 nodes
- Up to 6 antennas/node
- Mobile Nodes
- No centralized control
- Jamming and physical destruction of nodes
- Shadowing of Nodes
- Hostile interception
- Multi and uni-casting
- Wideband Voice/Data

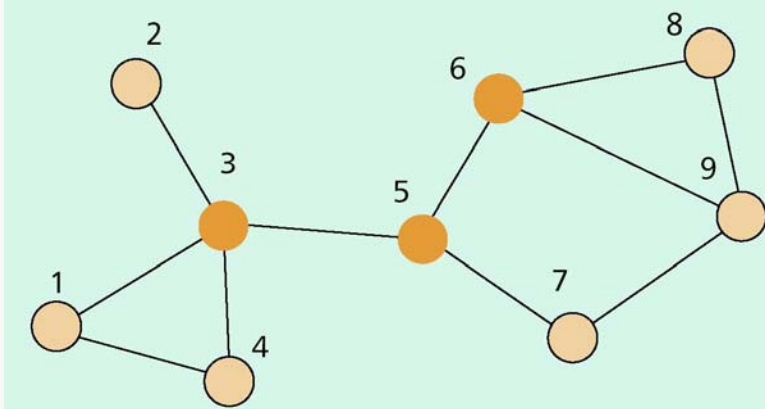


Tactical Ad-Hoc Networks

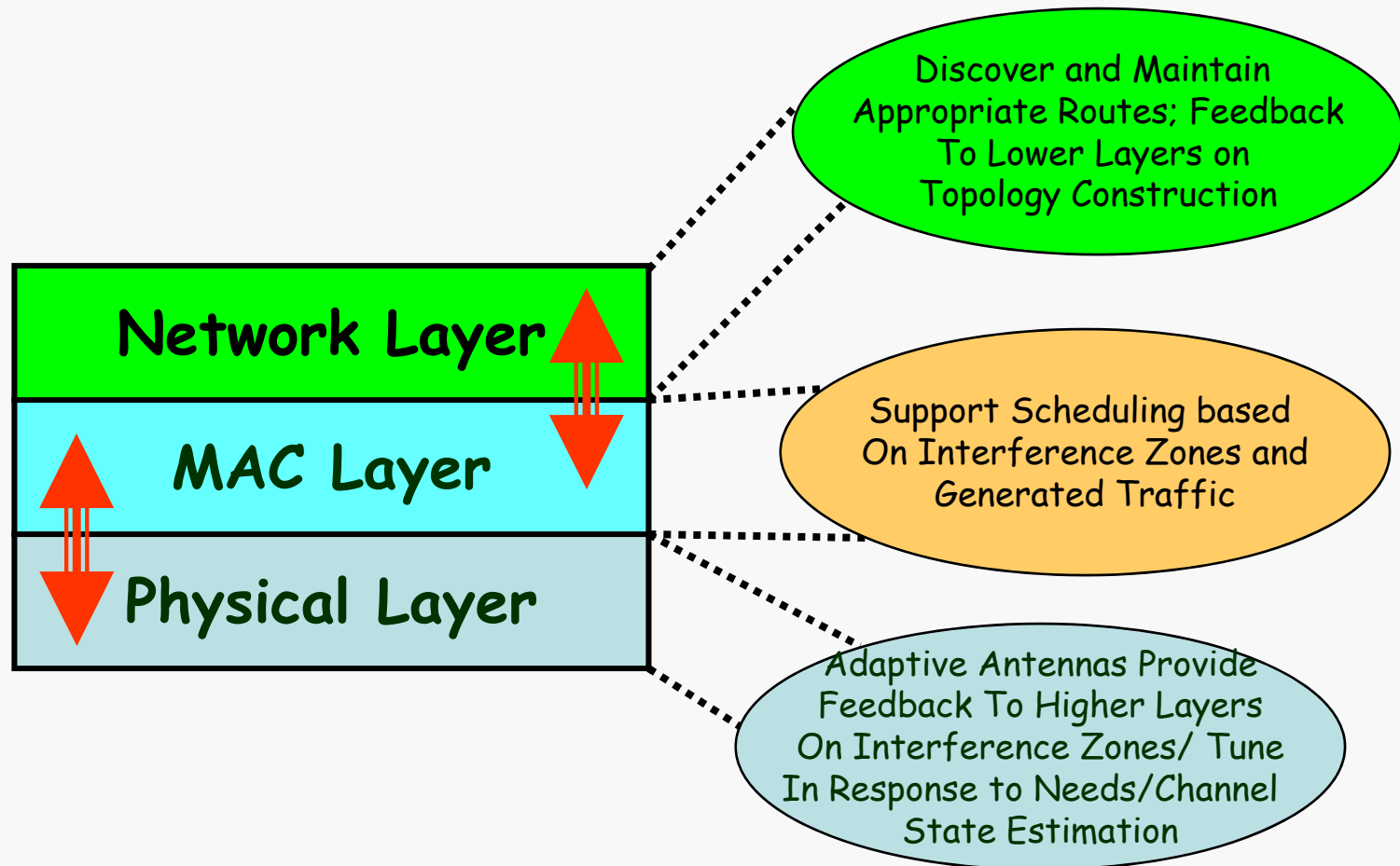


Research Goal:

Define the best way to utilize multiple transmit and receive antennas at each node to improve the robustness, capacity, and quality of service of the network



Architectural Outlook: Emphasis on Cross-Layer Design



Technical Issues

- Many forms of diversity available
 - Space, time, frequency, network, etc.
 - Diversity is critical to improve the reliability and minimize the need for retransmission. This is important for delay-sensitive applications.
- Cross-layer optimization required to exploit PHY layer diversity at the network layer.
- Waveforms must be resistant to jamming and intercept
- Antenna configurations must account for imperfections encountered in combat conditions-mutual coupling of elements, antenna heights, non-ideal spacing, etc.
- Multihop transmissions required to overcome shadowing and allow network reconfigurability. How many hops are desirable for robustness? for capacity? How do nodes cooperate?
- Which links are maintained and used? How much power is required to discover and maintain links? How can distributed scheduling be accomplished?

Technical Issues (2)

- Time-scales associated with routing and scheduling are longer than the time scales for channel variations at the PHY layer. How is the frame format modified to incorporate CSI information from the PHY layer?
- How is MIMO channel estimation incorporated into MAC protocol design? How do the MAC and routing layers interact?
- Maintenance of link requires maintenance of CSI but how detailed must the CSI be for scheduling and routing? Are channel statistics sufficient? When do you require CSIR? CSIT? How much time/power should be devoted to channel estimation in mobile channels?
- How much feedback between transmitters and receivers is required? How many bits of information and how frequently must they be transmitted in different time varying channel conditions? What is the effect of latency and noisy CSI for mobile nodes?

Technical Issues (3)

- Frame formats need to be adjusted to facilitate simultaneous transmissions and receptions when spatial multiplexing is used. What are the tradeoffs between network throughput and robustness?
- Can diversity and spatial multiplexing co-exist? If so, how do they interact? How do you combine the benefits of diversity/coding gain from STC with the array gain from beamforming?
- How do you control multi-access interference and jamming? Beamforming, waveform selection, space-time coding, MAC layer,...?
- Collision rules must be modified for MIMO.
- A key issue is determining which transmitters are active at any time.
- How do you provide broadcast and multi-access unicasting network capabilities with QOS guarantees?

MURI Project Team



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Simon Haykin



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"Space-Time Processing for Tactical Mobile Ad-Hoc Networks"



Thursday, October 16th, 2008

7:00 *Breakfast and Registration*

Project Overview

8:00 Robert Ulman, ARO/ James Zeidler, UCSD

Cross-layer Network Design in Service of Delay Sensitive and Bursty Information

8:30 Tara Javidi, UCSD

Space-Time Power Scheduling – From Wireless Intranet to Wireless Internet

9:00 Yingbo Hua, UCR

Cross-Layer Design and Analysis of MAC and Routing Protocols for Ad Hoc Networks with Multiple Antennas

9:30 Michele Zorzi, UCSD

10:00 *Break*

The Impact of MIMO : Interplay between the PHY and the higher layers

10:15 Srikanth Krishnamurthy, UCR

Cooperative MIMO and Spatial Processing Tradeoffs between MC DS CDMA and MC CDMA

10:45 Larry Milstein, UCSD

11:15	The cubature Kalman filter: An approximation to the Bayesian filter that preserves second order information about the hidden state Simon Haykin, McMaster
11:45	Application of Game-Theory to Multi-user Detection in MIMO Ad Hoc Interference Networks Lee Swindlehurst, UCI
12:15	<i>Lunch</i>
13:30	A New Perspective on The Capacity of Wireless Networks: Realistic Roles of MIMO, Network Coding, and Channel Division Techniques JJ Garcia-Luna-Aceves, UCSC
14:00	Network beamforming and interference cancellation Hamid Jafarkhani, UCI
14:30	Feedback MIMO Systems Bhaskar Rao, UCSD
15:00	Instantaneous and Average Rate Maximization in Multi-User, MIMO Channels with Linear Processing James Zeidler, UCSD
15:30	<i>Break</i>
15:45	Random Multi-hop Networks: Assessing the Impact of Physical Layer Techniques and Characterizing Delay and Throughput Kostas Stamitou, UCSD
16:15	MIMO in Mobile Environments: Channel Modeling and Robust Multi-User Signaling Techniques Mike Jensen, BYU
16:30	Summary and Conclusions James Zeidler, UCSD
16:45	Government Caucus (Eucalyptus Point Conf. Room)/ PI Meeting
18:00	Conclude