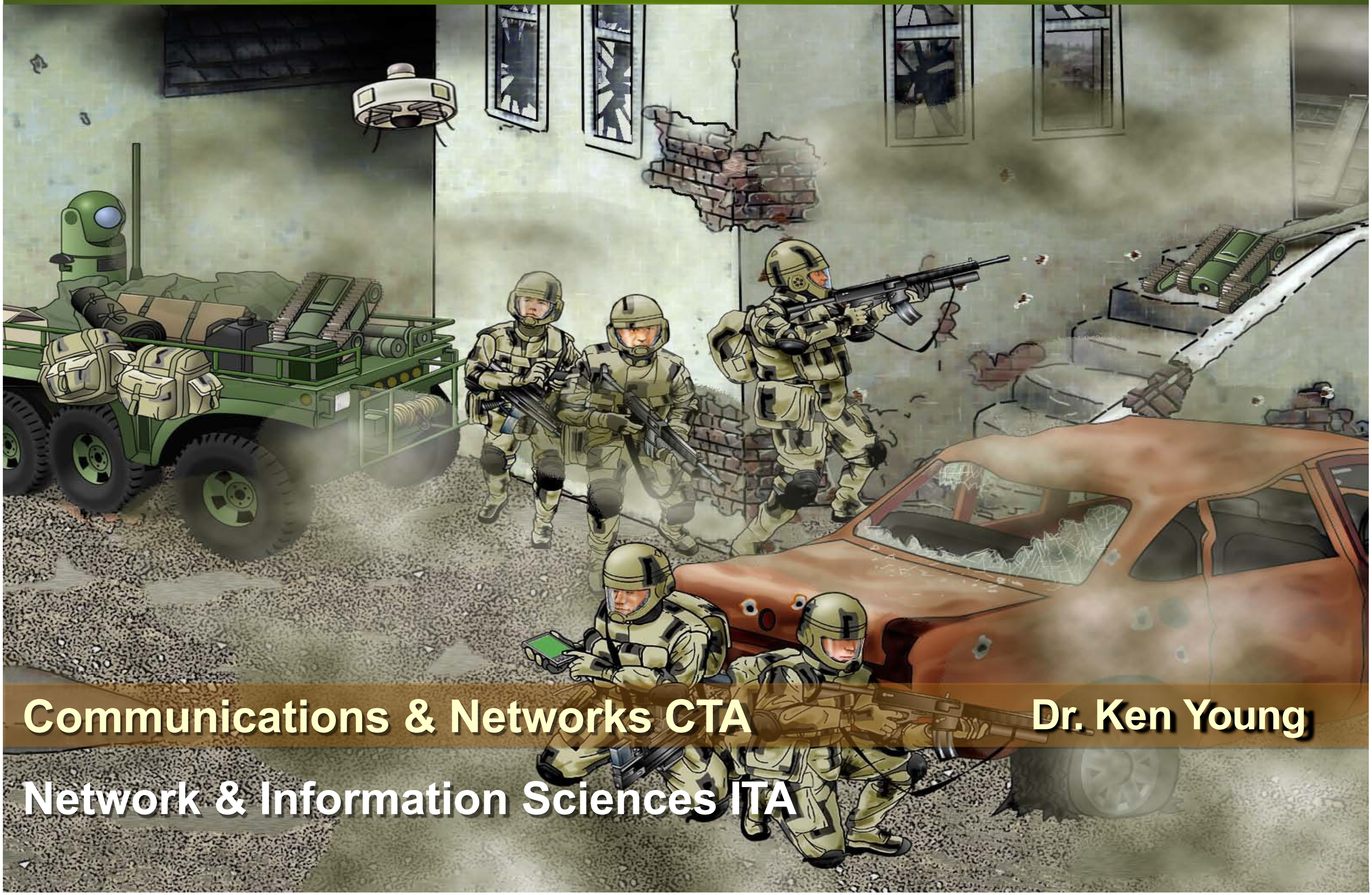
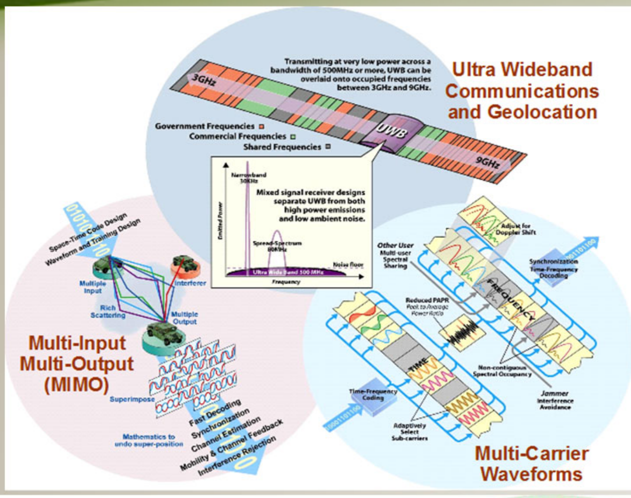
# C4I for the Current & Future Force

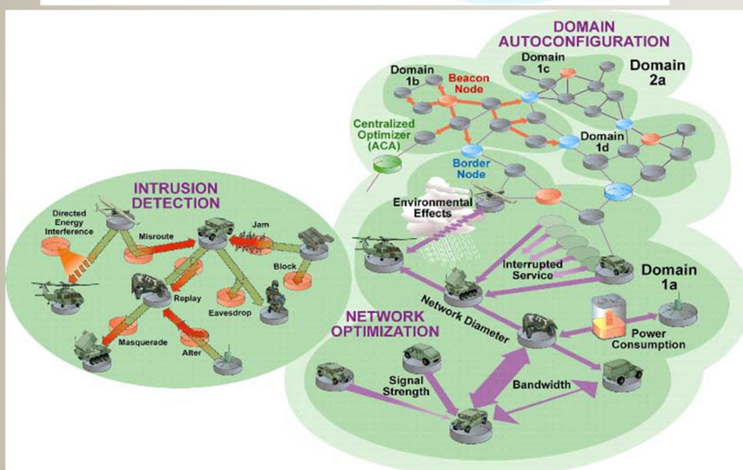


## Communications & Networks CTA

Dr. Ken Young

## Network & Information Sciences ITA




# Communications and Networks

***Greg Cirincione***
*ARL Collaborative Alliance Manager*

Telcordia
***Ken Young***
*Consortium Manager, Telcordia*

# Communications and Networks Collaborative Technology Alliance

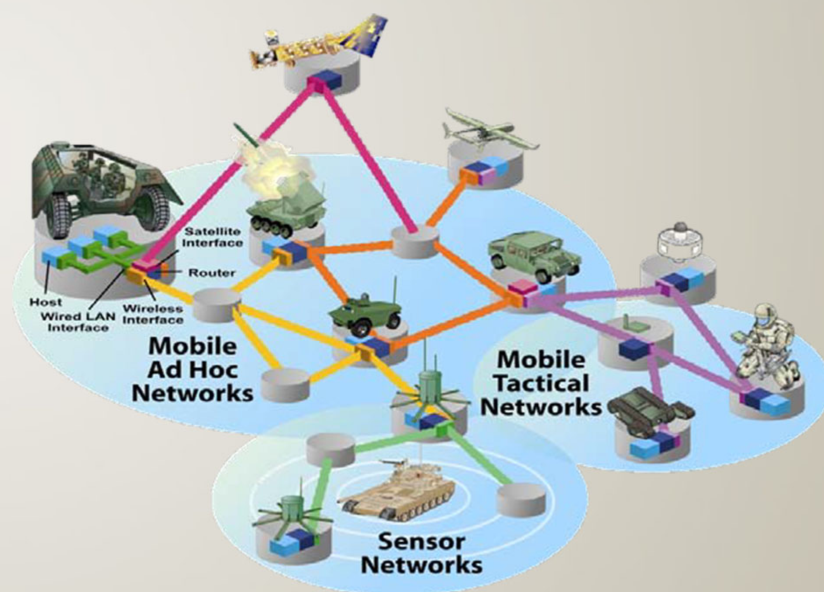
**Vision:** **Enable a fully-mobile, agile, situation-aware, and survivable lightweight force with internetted $C^4I$ systems**

## Impact and Relevance:

- Enables the Soldier to operate while on-the-move with a highly mobile network infrastructure, and
- Under severe bandwidth and energy constraints
- Provides the soldier with jam-resistant comms in noisy hostile environments
- Enables dynamic spectrum, resource, and network management
- Provides efficient security services that protect wireless MANETs without reliance on strategic services

## Technical Areas:

- **Survivable Wireless Mobile Networks**
- **Signal Processing for Secure Comms and Networking**
- **Tactical Information Protection**



# C&N CTA Team Overview

## ACADEMIA

1. Carnegie Mellon University
2. City College of New York
3. Cornell
4. Georgia Tech
5. Princeton
6. Morgan State University
7. Stanford
8. Texas A&M
9. University of California - Davis
10. University of California - Riverside
11. University of Delaware
12. University of Maryland
13. University of Michigan
14. University of Minnesota
15. University of Washington


## INDUSTRY

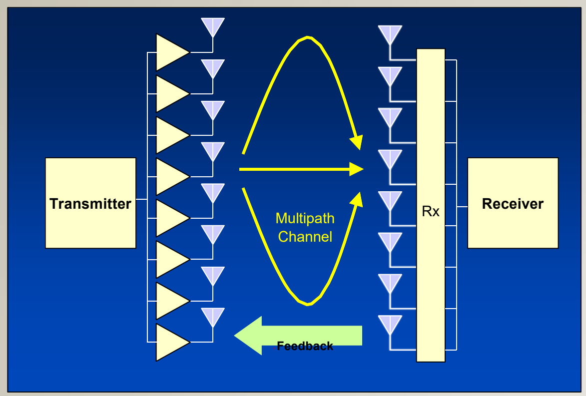
16. Telcordia Technologies (LEAD)
17. SPARTA
18. BBN Technologies
19. General Dynamics

Blue = full Consortium members,

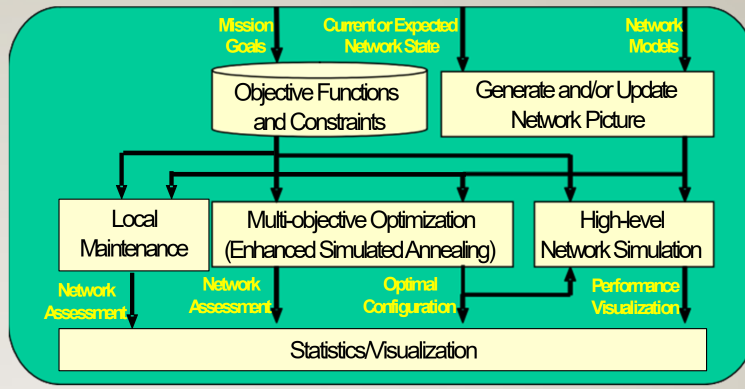
Black = non-member participants

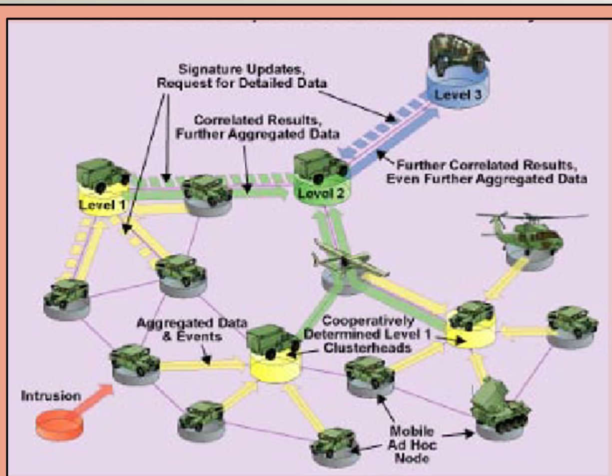
# Significant Transitions

## MIMO to Classified CERDEC programs; collaboration with ACIN




## MONOPATI to CERDEC Net Design

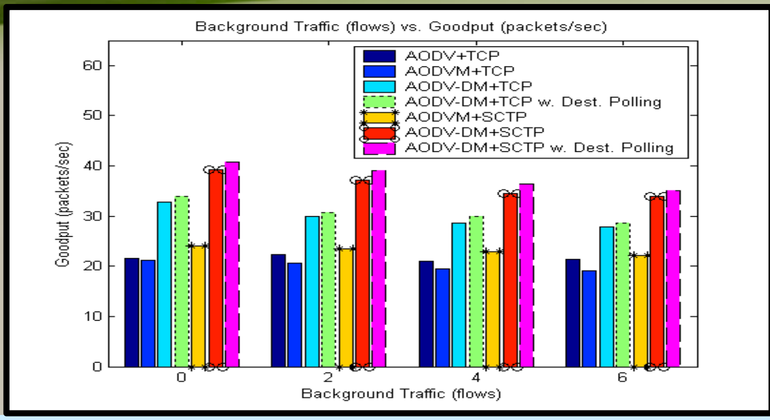



MANET Intrusion Detection Algorithms to TWNA ATO and FCS TTA

## DSRC-T to CERDEC PILSNER

# Survivable Wireless Mobile Networks

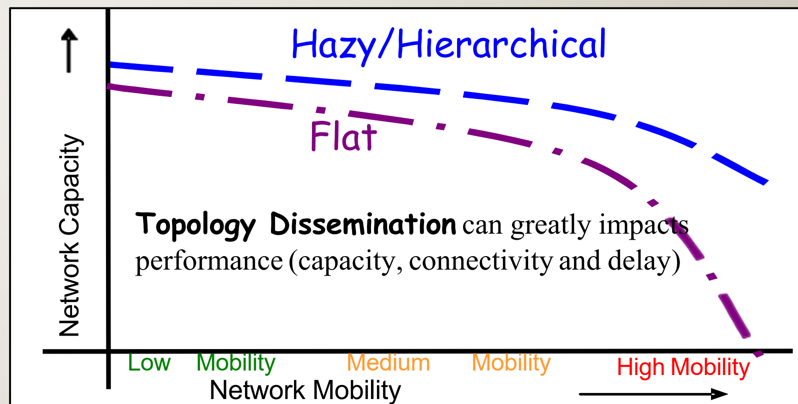



**FY06-07**

- **Developed Controlled Dissemination Filter technology**
- **Developed MONOPATI network configuration toolset**
- **Characterized link lifetimes based on mobility**
- **Developed POMDP approach to optimal transmission scheduling**

**FY08-09**

- **Domain auto-configuration with social networking**
- **Component-based routing analysis and design**
- **Network modeling; capacity and scalability analysis techniques**
- **Dynamic and survivable network resource control for multicast flows**

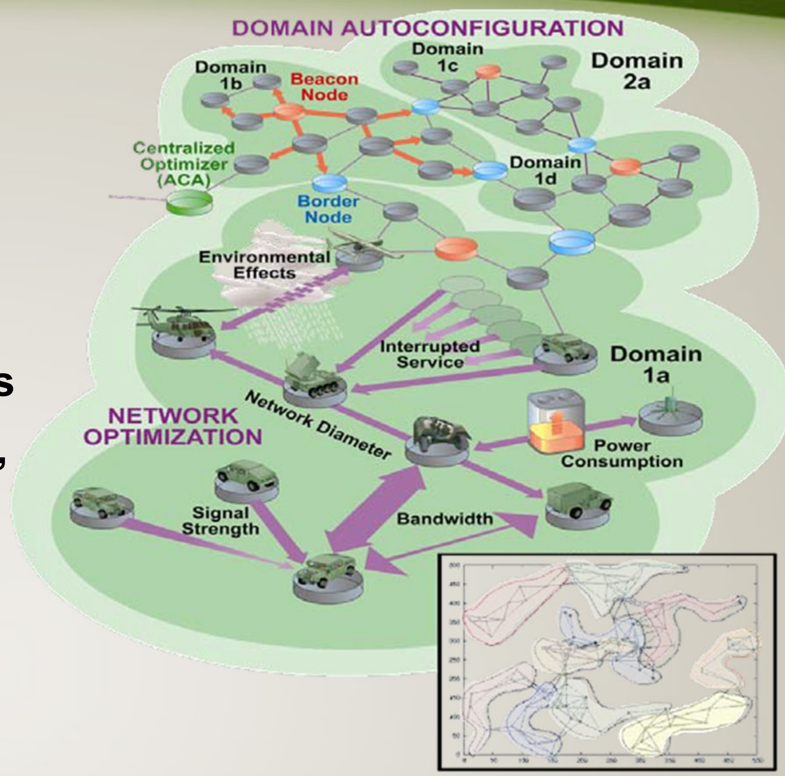



**Objective: Develop networking capabilities to enable Army's Vision of information dominance**

# Survivable Wireless Networks: Advanced Structures for MANET

## Overall Plans

- Form advanced structures that improve key aspects of the underlying network.
- Develop a formal, versatile and efficient framework for diverse networks
    - Physical and logical network
    - Social, knowledge & resource networks
- Dynamically adapt structures as the mission, network and requirements evolve




## Social Networking Extensions

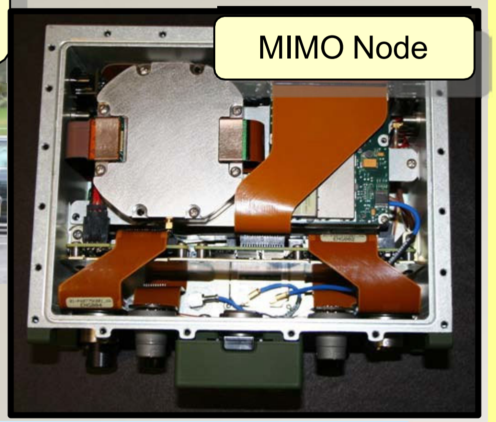
- Task assignment for efficient resource utilization and robust real time organizational adaptation.
- Dynamic network analysis based on real data collected from military installations
- Structures' optimality vs. adaptability

## Intrusion Detection Extensions

- Requirements for efficient and Byzantine attack-resistant network structures

**Objective: Design of a common, versatile, formal and algorithmic framework for efficient network configuration and assessment**

# Signal Processing for Secure Communications and Networks

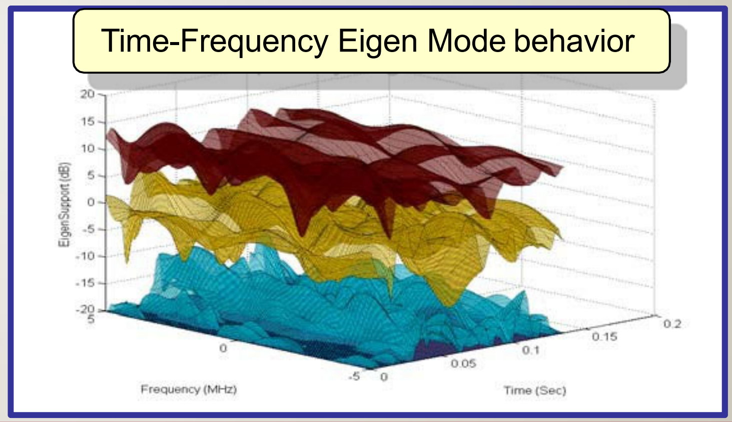




**FY06-07**

- **Turbo-MIMO algorithms and adaptive coding schemes for low-complexity spectrally efficient comms**
- **Developed & tested efficient OFDM channel estimation, and synch algorithms**
- **Error-exponent characterization of distributed inference in sensor nets**

**FY08-09**

- **MACs for MIMO, multi-packet reception and spectral agility**
- **Cross-layer design of MANETs and sensor networks**
- **UV and UWB communications**
- **Adaptive Cognitive MIMO Testbed experimentation**




**Objective: Signal processing foundations for advanced communications for tactical MANETs & sensor networks**

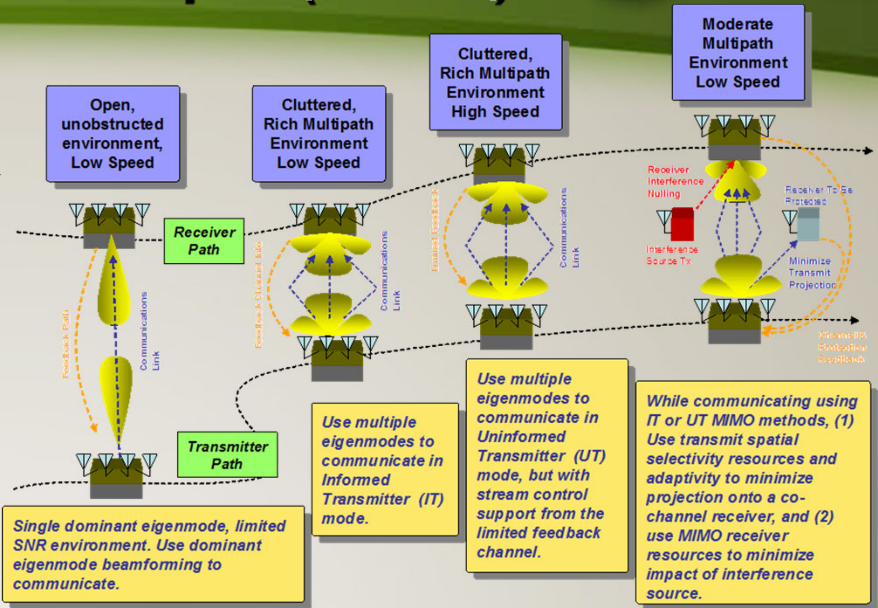
# SP for Secure C&N
# Multiple-Input Multiple-Output (MIMO)

## Research Challenges

- Best possible trade-offs between energy and spectral efficiency at manageable complexity
- Adaptivity to switch between high-rate and high-efficiency modes

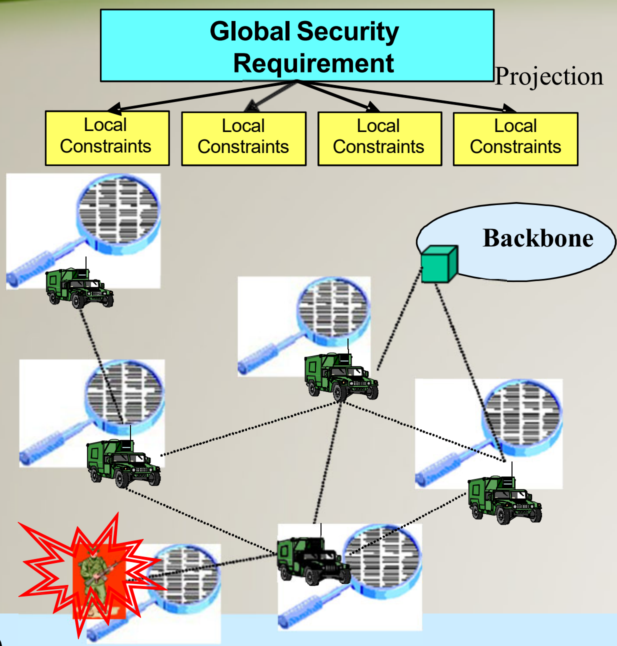
## Approach

- Adaptive MIMO signal processing, waveform design and experiments
- Distributed and co-located energy-efficient MIMO systems for anti-jam
- Distributed robust OFDM communications
- Detection and estimation in unknown MAI
- Wireless channel modeling and channel state information dissemination




**Objective: Jam-resistant links that are reliable in harsh propagation environments, capable of high throughputs in bursty channels**

# Tactical Information Protection

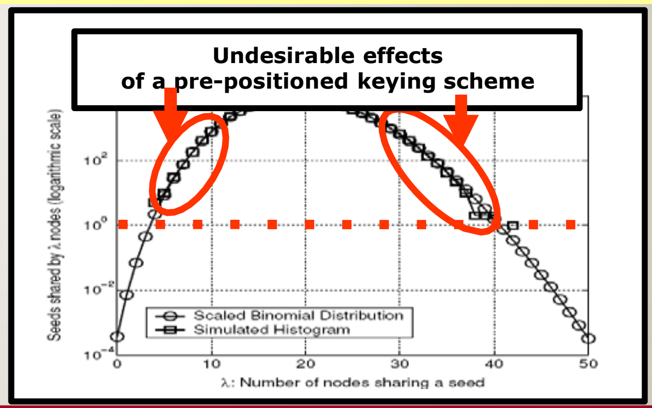



## FY06-07

- Distributed cooperative detection and localization of in-band wormhole attacks in MANETS
- Byzantine-resistant routing attack detection
- Efficient group key management
- Threat models for cross-domain information flows

## FY08-09

- Distributed dynamic trust management
- Efficient group key management
- Dynamic intrusion detection hierarchies
- Specification-based intrusion detection




**Objective: Automated detection of vulnerabilities and efficient security services to prevent attacks, without compromising agility**

# Byzantine-Resistant Routing Attack Detection

## Research Challenges

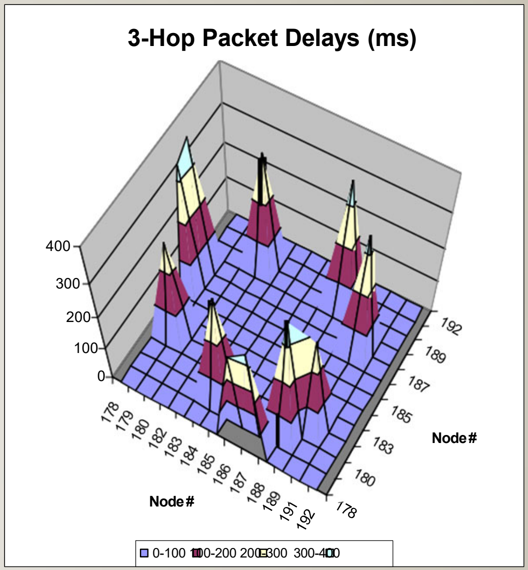
- Detecting attacks in which knowledgeable attacker controls subset of detection components
- Assessing susceptibility/resistance of detection techniques to subversion

## Approach

- Localizing in-band wormholes and other covert tunnels
- Stealthy path probing/detection of data plane attacks
- Resilient cooperative detection systems
- Characterizing effectiveness, costs, resilience, tradeoffs

## Research Team

- SPARTA, U Maryland, U Delaware, Georgia Tech, ARL



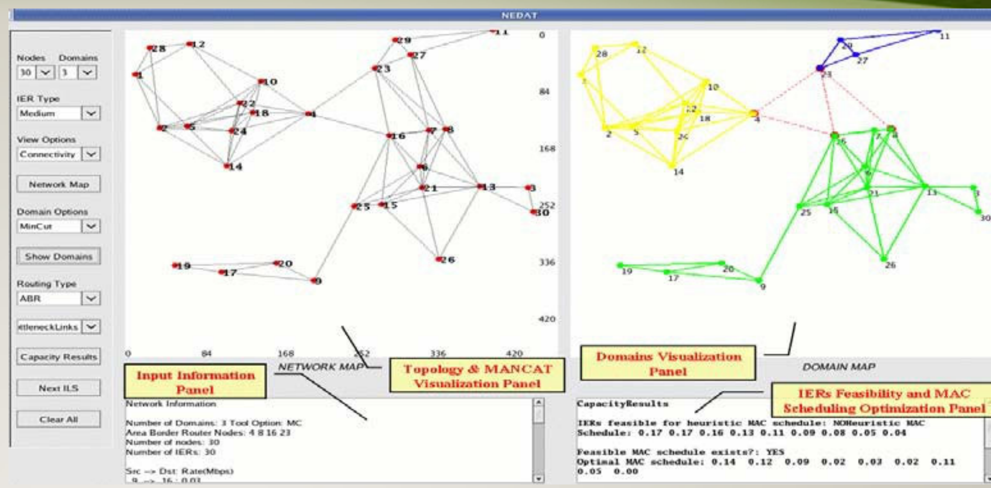

Paths across in-band wormhole link incur longer round trip delays

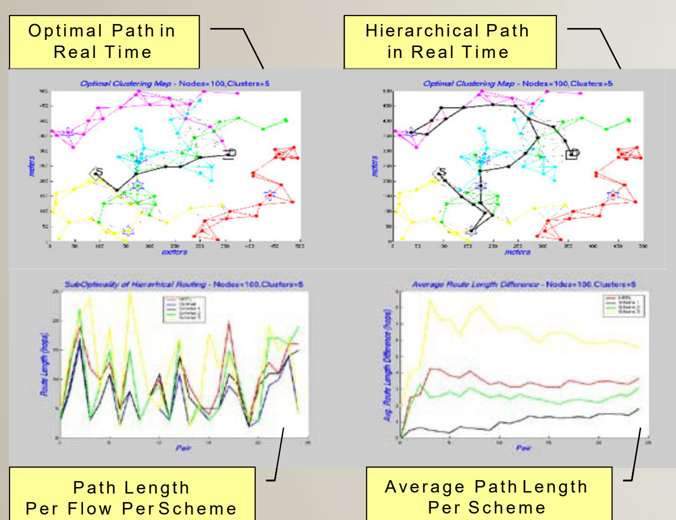
**Objective: Develop and model techniques to detect insider attacks on MANET routing and distributed intrusion detection systems**

# Transitions to CERDEC Network Design

## Research Challenges

- Lack of analytic methods and heuristics to understand impact of network design options and trade-offs
- Limitations of large-scale discrete-time, event-driven simulations




## Transitions from C&N CTA

- Network routing analysis & synthesis tools
- Domain formation analysis & synthesis tools
- Network resource optimization heuristics
- Network capacity and scalability analysis techniques
- Routing overhead analysis

**Objective: Develop capabilities to assess and analyze mobile *ad hoc* network designs for large networks, such as WIN-T and FCS**

# Communications & Networks CTA Summary

- Significant research results
- Highly collaborative
- Results transitioning to key programs and standards
  - CERDEC MOSAIC, PILSNER, TWNA, Network Design, I2WD programs
  - DARPA CN, XGEN programs
  - FCS LSI, FCS System Design and Development (Net Mgmt), TMOS
  - JTRS Cluster 5 and Navy Digital Modular Radio
  - IETF and IEEE 802.16

## Metrics through 1st Qtr FY07

| | |
|---|---|
| **Publications** | |
| • Journals | 314 |
| • Conferences | 546 |
| **Disclosures/Patents** | |
| • Invention disclosures | 39 |
| • Patent applications | 15 |
| • Patent awards | 10 |
| **Student Support** | |
| • PhDs graduated | 48 |
| • Masters | 21 |
| **Lectures** | |
| • Lectures | 38 |
| • Workshops | 5 |
| **Staff Rotation** | |
| • Staff rotations | 53 |