

2006 Workshop on Real-Time Knowledge Processing for Wireless Network Communications

Stanford
29 March, 2006

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Today's Agenda



- 1 – 1:30 Introduction
- 1:30-3:00 Panel Session: *Problems and Perspectives in Scaling Mobile Ad Hoc Wireless Networks – What AI Can Contribute*
- 3:00 – 3:15 Break
- 3:15-5:00PM: *Panel Session and Open Mic Q&A: Research Areas for Investigation, and Where the Dollars Are.*
- 5:30 – 7:30PM: *Reception (Sheraton)*

DARPA Interests in Knowledge-Based Networking

Wireless Network After Next
Adapt,
Morph,
Proliferate

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Rescue
Ratio

Defense Advanced Research Projects Agency
Advanced Technology Office

Radio-Isotope
Micro-Power
Sources

Connectivity
Networks

Wolfpack
One of
DARPA's top
5 programs!
Defense News, June 3, 2009

Polarization Rotation
Modulation

Photonic
Avionics
XG
Next Generation Communications

Sto-Direct
Noise
Correlating
Radar

Disruption
Delay Tolerant
Networking
Tolerant
Networks

Opinions expressed are those of the authors, and do not represent the position of DARPA, the Department of Defense, or the United States Government



Some Observations



- Our Focus on Wireless Networking Has Forced Us into Regions Where Classic Networking Technology Is Not Sufficient
- Have Tried to “Lash Together” Existing AI Tools/Technology
 - Tools Are Partitioned by Technology
 - Ill-Suited for Running 24/7 in Radios, Routers, ...
 - Not Conceived with This Type of Problem
- Research Community is Partitioned into Radio, Networking and AI Expertise
- Problems of Scale, Self-Organization, and Adaptation Force Us to Solve these Problems



This Workshop



- **Today's Plan**
 1. Present Some of the Key Challenges in Wireless Networking
 2. Discuss Research Investment Needs and Opportunities
- **Objective:**
 - Initiate Collaboration Among the Three Specialized Research Areas
 - See How Existing Funding Sources/Programs Could Fund Some Activities
 - Identify Areas Where New Funding is Needed



How Can We Operate in a Wide Range of Environments, Missions, Densities, ...



- **Device Adaptation is Key to Needed Technology**
 - Self Organize to Operate **Without Infrastructure**
 - But Leverage Whatever Infrastructure is Available
 - Locate Unused Radio Spectrum
 - While Ensuring no Interference to Other Users
 - Continuously Measure Environment
 - Avoid Need for Detailed Pre-planning, Deconfliction, ...
 - Morph Physical and Media Access Layers
 - Leverage Multi-path with MIMO
 - Select Waveforms, bandwidths, Access Control Mechanisms
 - Apply Multiple Network Topologies
 - Optimize Packets, Streams, Multicasts, ...
 - Adapt Topology to Mission and Opportunities
 - Opportunistic (instead of Fixed) Topology
 - Continuously Adjust Topology to Meet Instantaneous Network Needs
- **And Do All this at New Levels of Affordability**
 - Essential to Achieving Required Density
 - Adaptation Can Mitigate Engineering Performance Compromises and Use Less Costly Devices



Some Wireless Networking Research Programs at DARPA



- **neXt Generation Communications (XG)**
 - Develop Technology to Sense and Situationally Adapt Spectrum Usage for a 10 Times Increase in Spectrum Access
- **Disruption Tolerant Networking**
 - Extending the Network Framework to Include Storage and Delivery for Episodic Networks
 - (Leverage Whatever Connectivity is Available)
- **MnM Mobile MIMO**
 - Extending Multiple Input/Multiple Output Technology to Mobile Platforms for a 9 times increase in Throughput
- **Wireless Network After Next**
 - Develop the Technology for Dense, Low Node Cost (Under \$500) Networks with High QOS
- **Connectionless Networking**
 - Dynamically Adapting Network Time Synchronization, Routing, Energy Strategy to Achieve High Performance at 100th the Energy



Some Wireless Networking Research Programs at DARPA (Continued)



- **Connectionless Networking**
 - New Protocols and Physical Layers to Achieve a 100 Times Reduction in Energy for Low Duty Cycle
- **Polarization Rotation Modulation**
 - Encode Information in Polarization to Achieve a 9x More Space to Space and Space to Ground Bandwidth
- **Radio-Isotope Micro Power Sources**
 - Power “Manufactured In” for Life of Device
- **Ultra-wideband Networking (NETX)**
 - Close in LPD Communications in Harsh Environments
 - Very High Accuracy Positioning
- **Spatial Optical (Air/Air and Air/Ground)**
 - “Wireless Does Not Always Mean RF!”
 - Adapting for the Reliability of RF, and Speed of Fiber
 - Air to Air and Air to Ground Providing for Wireless Communications at Fiber Speeds (ORCLE)
 - Passive Optical Tags that provide 100’s of Kilobits/Sec



XG Policy Compliant Behavior



• Rejected Notion that General Solution to Adaptive Radio Could be “Just Code”

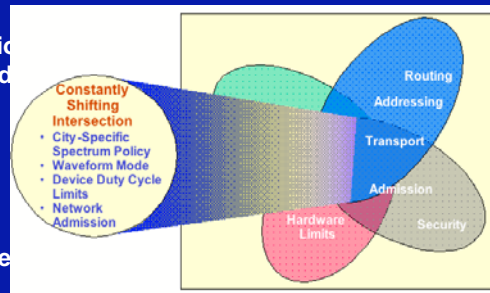
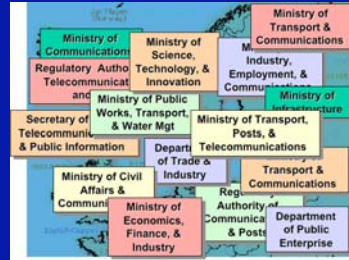
- Almost 200 Sovereignties
- Thousands of Bands
- Emerging Technologies

• Investing in Computer Science Structure for Policy Reasoning

- Reasoning Technologies to Control Real-Time Process
- Declarative Language Expression
- Provable Policy Expression and Implementation

• Partitioned Policies into Two Categories

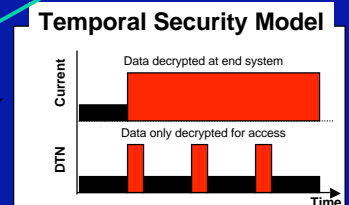
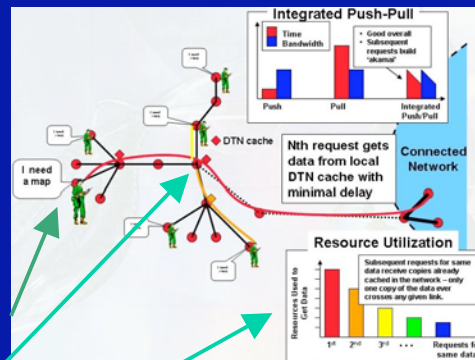
- Policy Enforcement (Permitted Operation)
- Optimizing (Network and Above)



DTN Network Persistence Can Solve Fundamental Shortfalls

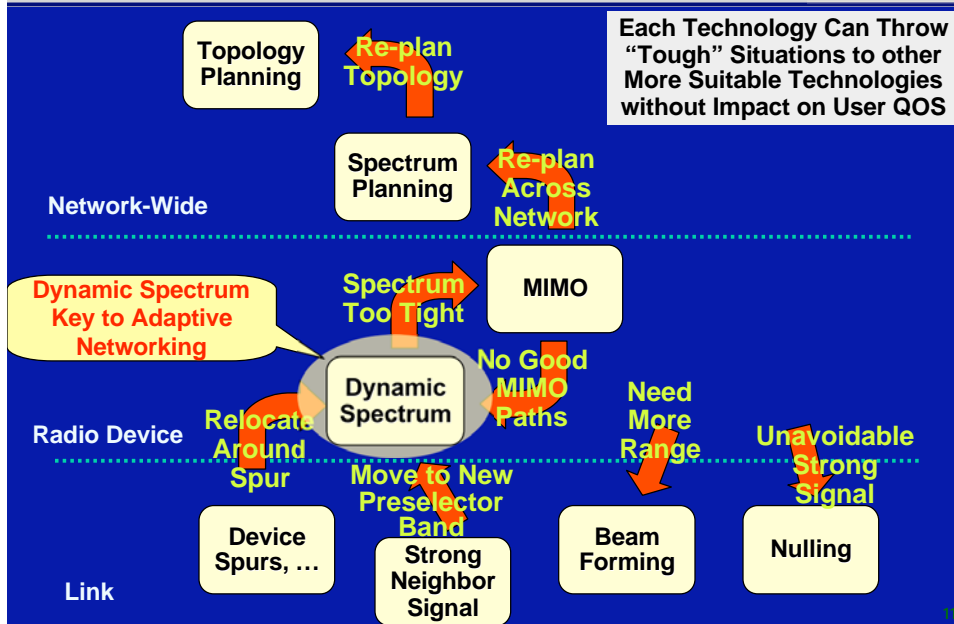


- DTN makes applications over disrupted networks robust
- DTN is also an *Opportunity* to solve *Fundamental Problems* we've never before had a handle on, using *Network-Managed Persistence*
 - Access information by content or type rather than by network address
 - “I want maps for my area” instead of “I want to ftp to 192.168.4.17”
 - Retrieve once, provide to local users as requested
 - Learn from actual network usage
 - Exploit in-network storage and pub/sub protocols to create a dynamic and self-forming Cache
 - Use *temporal* security rather than *physical* security





WNAN/WANN Adaptive Radio Uses All Network Layers to Resolve Issues



Thank You!

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Panel Session 1



Problems and Perspectives in Scaling Mobile Ad Hoc Wireless Networks – What AI Can Contribute

Chairman – Don Hillman, Lehigh University

Members:

- Rajesh Krishnan, BBN Technologies
- Bob Durst, MITRE Corp.
- David Wilkins, SRI International
- Mitch Kokar, Northeastern University
- Jeff Heflin, Lehigh University
- Charles Bostian, Virginia Tech

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Panel Session 2



Panel Session and Open Mic Q&A: Research Areas for Investigation, and Where the Dollars Are.

Moderator:

Joe Evans, University of Kansas (ex-NSF)

Instigator:

Paul Kolodzy, Kolodzy Consulting (ex-DARPA)

Sirin Tekinay, NSF

Steve Griggs, DARPA ATO

Preston Marshall, DARPA ATO

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