A DARPA Perspective on Broadband Wireless Systems

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Outline

• Setting The Stage

• DARPA Programs
  • Current
    • Global Mobile Communications (GloMo)
    • Small Unit Operations Situation Assessment System (SUO SAS)
    • Airborne Communications Node (ACN)
  • Future
    • Future Combat Systems (FCS) Program
    • Adaptive Spectrum Utilization Concept

• DARPA / Industry Cooperation
DARPA Mission

Innovation in support of National Security

• Solve National-level problems
• Enable Operational Dominance
• High Risk Technology Development, Exploitation
  -- Avoid Surprise
### Wideband Technology Components

<table>
<thead>
<tr>
<th>Commercial Thrust</th>
<th>Additional Defense Thrust</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frequency</strong></td>
<td><strong>Mobility</strong></td>
</tr>
<tr>
<td><strong>Waveforms</strong></td>
<td><strong>Low Probability of Detection</strong></td>
</tr>
<tr>
<td><strong>Coding</strong></td>
<td><strong>Featureless Waveforms</strong></td>
</tr>
<tr>
<td><strong>Multipath</strong></td>
<td><strong>Mobility</strong></td>
</tr>
<tr>
<td><strong>Interference</strong></td>
<td><strong>Anti-Jam</strong></td>
</tr>
<tr>
<td><strong>Networks</strong></td>
<td><strong>Mobility, Adhoc, and Assurance</strong></td>
</tr>
<tr>
<td><strong>Latency</strong></td>
<td><strong>QoS</strong></td>
</tr>
</tbody>
</table>

**Bandwidth Efficiency** (Turbo Codes)
Military Broadband Requirements

Future Projection

- Mobile Comms: 92% increase by 2005
- Point-to-point:: 60% increase by 2007
- Short Range: 600MHz increase by 2005
- Surv. Radars : 35% increase
- Fire Con Radars : 68% increase
- SATCOM: 500% increase
Wireless Communications Technical Challenges

- Information Assurance
- Shared Channels
- Highly Dynamic Networks
- Scarce Radio Spectrum

- Encryption
- Spatial Diversity
- Multi-User Information
- Adapt to Changes in Topology
- Updates to Routing Algorithms
- Efficiency Drivers

- Time Criticality
- Signal Diversity
- Transmission Parameters
- Highly Dynamic Algorithms
- Integrated HW/SW Algorithms

- DoD Stressing
- Commercial Equal or More Stressing

DoD & Commercial Broadband Users Have Shared and Unique Challenges
DARPA Communications Focus - *Programs, Functions*

- **Assured**
  - Information Assurance, High Data Rates, Infrastructure
  - Global Mobile, Small Unit Operations, Future Combat Systems

- **Exploit**
  - Detect, Copy, Geo-locate
  - Novel Antennas

- **Deny**
  - Confuse, Jam
  - WolfPack

- **Airborne**: Assured (Global Mobile, Small Unit Operations, Future Combat Systems)
- **Assured**: Exploit (Detect, Copy, Geo-locate)
- **Exploit**: Deny (Confuse, Jam)
- **Deny**: Assured (Global Mobile, Small Unit Operations, Future Combat Systems)
GloMo technology enables mobile users to automatically form ad hoc networks and exchange voice, data and multimedia information.
SUO SAS is a mobile communications system with high data-rate capacity that is optimized for restrictive terrain.

**Applications:**
- Army and Marine Infantry
- Special Operations Forces
- EMT and Firefighters
- Law Enforcement

**All Terrain Radio**
- Clandestine, high AJ
- Adapts data rate and frequency to capacity of channel (10 bps to 4 Mbps)

**Autonomous Adaptive Networking**
- Self-forming, self-maintaining
- Simultaneous voice, record and multimedia services
- 10-100 times the TI capacity

**Continuous Position/Navigation and Targeting**
- D-GPS when available plus INS and altimeter
- Radio ranging inside buildings, urban canyons, etc.

**Wearable Computer/Radio**

**Distributed Information Management**
- Consistent tactical picture tailored to each warrior mission and personality
- Integrates blue situation with organic and non-organic sensors
Bursts exploit short term channel characteristics

NND = network neighbor discovery
RTS = request to send
CTS = clear to send and what channel
MSG = message fragment
ACK = acknowledgement of message

• Operating Frequency Range: 20 MHz to 2.5 GHz
• Hybrid direct sequence / frequency hopping
• Spectrum adaptive data rates
  • Data Rates: 96 kbps - 6 Mbps
• Security

Each radio monitors activity on the signaling channel and can predict some link states
Each radio selects a channel to use in response to a RTS

256 ms bursts

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Dynamic Broadband Waveform Technology (SUO SAS)
Airborne Communications Node (ACN) Concept

ACN provides continuous communications services to widely dispersed (Beyond Line of Sight) mobile forces.
ACN: A Convergence of Communications and SIGINT

Common Functionality
- Antenna Beamsteering
- Wideband RF Front End
  - 20 MHz -> 18 GHz
  - 90 dB Dynamic Range
  - 50 - 100 MHz BW
- High Speed MODEM
  - 3 - 10 GFLOP
  - AM, FM, QAM, QPSK

Opportunity for multi-mission platforms
Synergistic capabilities
- SIGINT can find “holes” in spectrum for transmission
Future Combat Systems
- Assured Real-time Connectivity

**Mobile Ad Hoc Networks**
- Dynamic
- Re-configurable
- Low Latency
- Multi-user

**Assured Communications**
- High Data Rates
- Low Probability of Detection
- Anti-jam

**Connectivity Level**
- 10s of Mbps
- Mbps BW
- kbps BW

**Network Centric Force**

- Small Unit UAV
- Robotic Direct Fire
- Robotic Sensor
- Robotic NLOS Fire
- Manned C2/Infantry Squad

Other Layered Sensors
Adaptive Spectrum Utilization

**Concept:**
- Adaptive Spectrum Sharing - employ unused spectrum (frequency, time and power) when and where available using special waveforms, protocols and etiquette to overlay and underlay frequencies without interference
- Tactical Adaptation- adapting locally, at the individual link level, for temporary connections

Individual radios monitor the local environment to identify opportunities to establish connections

Spectrum Adaptation can be done locally, without interference, and be stealthy
DARPA-Industry Cooperation

• Common technical requirements exist between commercial and military broadband wireless systems
  - Military unique needs drive extensions in the areas of assured connectivity, LPD waveforms and jam resistance

• Future military wireless systems will be “modular”
  - Military users benefit from the rapid assimilation of low cost commercial sector technology developments

• DARPA is investigating ways to rapidly transition technology to/between DoD and commercial applications
  - DARPA is familiar with the role of technology “Venture Capitalist”
  - Cooperative relationships are encouraged
  - Additional information can be found on DARPA’s web page (www.darpa.mil)
Channel Capacity Commercial Solution: Increase Bandwidth

Commercial trends have been to higher data rates, requiring greater bandwidth, leading to higher frequencies.
Military Frequency Allocation

World-wide Military Frequency Allocation is going down

Requires: More efficient use of the remaining asset