Presentation to WNAN Proposer's Day

Connectionless Networks Program Overview

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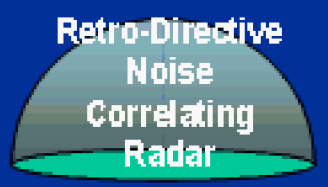
Preston Marshall
preston.marshall @darpa.mil

Defense Advanced Research Projects Agency
Advanced Technology Office



Are We (Really) Wireless Yet?

These are Wireless . . .

But Not for Long!

Today's Choices in Sensor Networking Technology

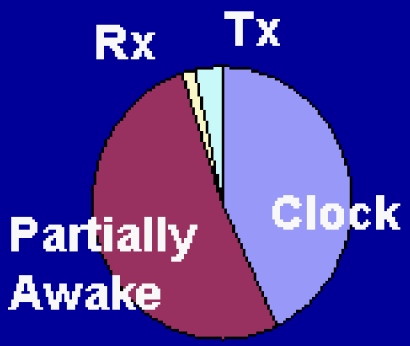
- High Performance (and High Energy)
  - Wide Dynamic Range Receiver Front Ends
  - High Peak Transfer Rate
- Low Energy (and Performance)
  - Limited Dynamic Range Front Ends
  - Constrained Peak Throughput

Neither Choice Desirable

- Current Radio Technology Not Appropriate for Intelligent Sensor Networks
  - Short Message, Bursty Applications
  - Receiver Energy Use Dominated
  - Network "Maintenance" Driven Traffic
- Available Network/Transport Protocols Poorly Suited to Episodic or Dynamic Environments

Connectionless Networking

- Size/Weight/Power of Sensing and RF Components Continue to Drop
  - Sensing and RF Components Soon to be Able to Leverage MEMS/Nano Technology
  - Digital Processing Power Requirements Drop by 1.6/Year
- Energy Required to Send a Bit Remains Constant
  - Driven by Shannon's Law and Physics
- Energy Required by RF Link and Protocol Design Limits Lifespan, Miniaturization, Covertness, …



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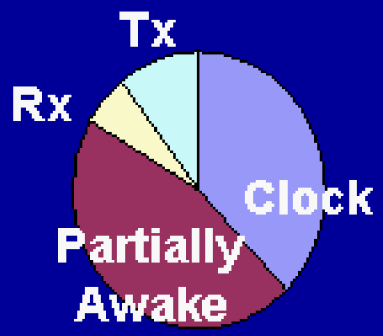

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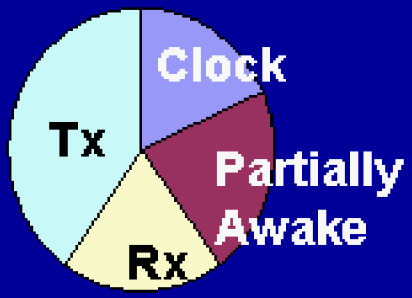

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Ad-Hoc, Low Duty Cycle Networks Require a Different Kind of Radio

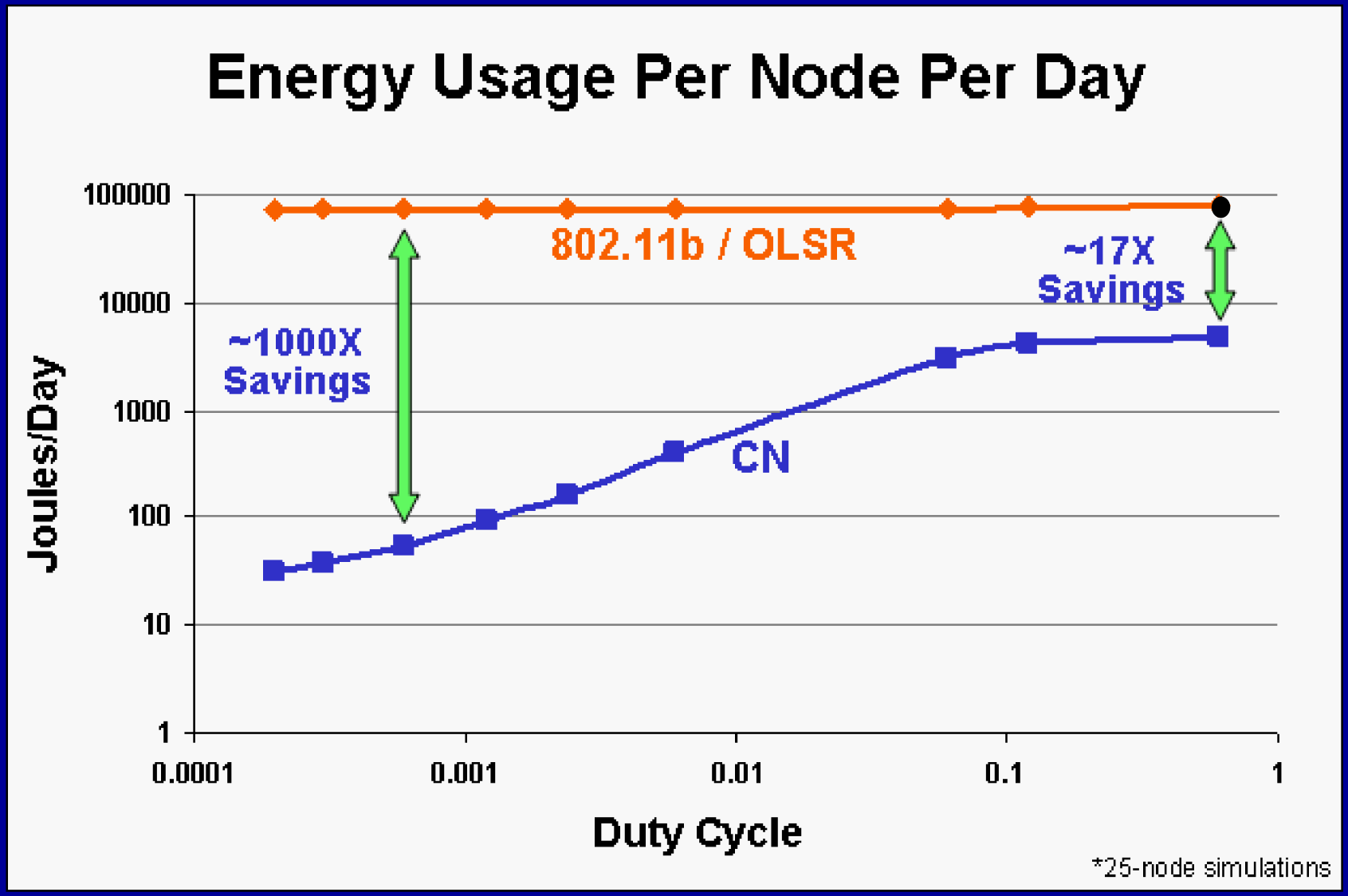
Connectionless Networks Precepts

- Develop Physical Layer and Protocols Specific to Low Energy Operation
  - Focus on Receiver Energy (Time) Management
  - Exploit Correlated Nature of Sensor Traffic
  - Adaptive Selection of Network Operating Points
  - Investment Strategy (Energy Cost vs. Efficiency Gains) Driven
- Leverage Digital Processing to Reconstruct Information Normally Transmitted at PHY Layer
  - Examine Multiple Hypothesis Regarding Phase Tracking, Block Boundary, Equalization

Technologies Being Developed by CN

- **Low Power Sleep/Wakeup**
  - Low data rate, energy optimized wakeup waveform
  - High data rate time and frequency hopping data waveform, optimized for packet length
  - Scheduled awake/receive times minimizes receiver energy, which is dominate in low duty cycle applications
- **Cross-Layer Information Sharing**
  - Minimizes redundant over-the-air transmissions
  - Maximizes overhead efficiency
  - E.g. Point-to-point caching of End-to-End information, allowing dynamic re-routing with minimal re-transmissions
- **Hazy Sighted Scoping**
  - Information about distant nodes updated less frequently than nearby nodes
  - Saves energy while retaining the ability to generate near-optimal routes
- **Energy Conserving Multipoint Relaying**
  - Minimizes the aggregate power required for all one-hop broadcasts
  - Metrics based on transmission energy vice topology
- **Energy Efficient Delivery Assurance**
  - Minimizes dropped packets
  - Reduces energy required to reliably transfer data between two end points
  - Reduces overall system energy in the presence of lost nodes

CN Sensor Networking Performance (Simulated)



CN - Schedule

Task	FY04	FY05	FY06	FY07
Phase I – Integrated Layer Design and Performance Prediction: - Reduce Acquisition time to 0 seconds - Obtain factor of 10^{25} reduction in predicted energy usage with a duty cycle of > 10^{-2}	Phase I Simulation Results			
Phase II – Development and Testing: - Obtain at least 1% energy efficiency with a duty cycle of >10^{-5}			Phase II Laboratory Demo	
Phase III – Scalability and Demonstration: - Obtain an efficiency reduction of > 3% over 3 orders of magnitude of net duty cycle				Phase III Field Demo

Today

Transition Targets : Wolfpack, Blue Radio Users, Mobile & Fixed Sensors