

Spectral Efficiency & MAC Agility Key Technologies for High Speed, High Volume Wireless Networks

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San Diego Research Center Overview

- **Founded in 2001, small business, privately held**
- **Defense Sector wireless communications R&D**
- **Significant growth expected to continue**
- **Areas of Expertise**
 - Modems and LPI/LPD/AJ Waveform Design
 - Multi-channel beam forming
 - Communication system analysis
 - MANET with directional antennas and MIMO
 - PHY/MAC Networking
- **Customers:** DARPA, ARL, PEO STRI, Raytheon, Shared Spectrum Company
- **Current Projects:** FCS-Comms, Connectionless Networks, Spectrally Efficient Range Communications System, Modem and MAC for Directional Antennas, Next Generation (XG) Communications

How San Diego Research Center Uses QualNet

- QualNet is integral to our approach to building radios & networks
 - Highly parallel design & development process
 - Start with a concept architecture & set of fundamental trades; code these
 - Use existing features of QualNet to fill out system & localize investigations (e.g. Flexible Interoperable Transceiver [FIT] MAC)
 - Predict performance; reiterate and refine design/implementation
 - Result is “one pass code” -- Most is recompiled & downloaded to radio’s processor
 - Design decisions arbitrated quantitatively (e.g., no BOGSAT)

Current Projects Using QualNet (1 of 2)

- **Spectrally Efficient Range Communications System**

- Combination of MANET and backbone (not necessarily fixed)
- Agile in frequency, time, and rate

- **Dynamic Frequency Assignment w/ Multiple frequencies:** signal may arrive in any of the multiple frequencies assigned to efficiently use available spectrum

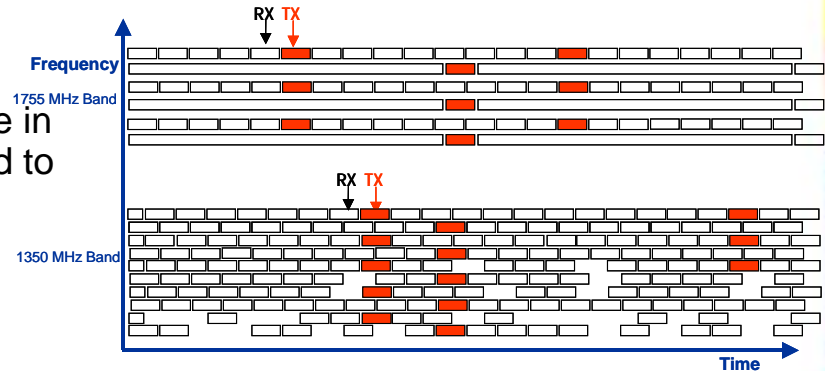
- **Dynamic Slot Assignment:** MAC is a combination of TDMA and contention-based; keeps the pipes full

- **Dynamic Data Rates**

- Allow support for different types of traffic(multiple types of data – CBR, bursty, stream - and voice)
- Under different conditions (channel to disadvantaged user is lower rate than fat pipe to HQC3)

- **Dynamic Resource Allocation:** Able to dynamically “move around” spectrum capacity in response to density (clusters of troops) and demand (fire fight causes surge)

- **Crosslayer “stack flattening”** allows some applications to have direct interaction with the signal structure



Current Projects Using QualNet (1 of 2)

- **LiSI/D: Link Scheduling (LiSI) MAC for directional antennas**

- SDRC's sub-band beamforming technique enables practical implementation of multiple-beam smart antennas
- Our scanning techniques for neighbor discovery enable two distant nodes, with no prior knowledge of each other's relative location or direction, to find each other
- We are developing an end-to-end prototype, in QualNet, of an antenna-aware MANET that exploits key intersection points and cross-layer interactions

- Guarantee delay bounds and QoS to applications
- Robust performance in a dynamic high mobility environment
- Support multicast traffic efficiently

- Comparison with ROMA predicts that LiSI's strongest advantage is reducing computational complexity

Protocol	ROMA	LiSI
Metric		
Basic Premise	Node scheduling - EXPLICIT, 2-hop information	Link scheduling with Reservation - IMPLICIT, 1-hop information
Throughput	Similar	Similar
Delay	Similar	Similar
Jitter	Poor	Better
Fairness	Every node is treated equally	Reservation based on traffic requirements
Impact of Mobility	High impact - Performance degrades	Impact limited to current reservation
Quality of Service	No QoS mechanism	Reservation of slots through negotiation
Multicast Support	None	Minimize number of copies
Scalability: Network Size	Moderate	Good
Computational Complexity	$O(N^2)$	$O(1)$
Memory	Similar	Similar
Performance at Higher Data Rates	Good	Moderate

*Poor = Protocol cannot guarantee the performance metric; Moderate = Protocol performs properly to a certain point

Going Forward

- **Future plans for use of QualNet: LiSI/M**
 - MANET for mobile MIMO (multiple-input-multiple-output) whereby both Tx and Rx are diverse in time and space via multiple antennas/channels to significantly increase the system's capacity and coverage
 - One major problem is the trade between
 - Channel training - enough knowledge of the multiple channels so that the multiplier effect can be realized; and
 - Minimal overhead so that the maximum network throughput can be achieved
 - LiSI/M: Efficiently coordinates the transmission and reception of multiple varying data streams via an adaptive combination of reservation and contention
- **What's missing from QualNet?**
 - MatLab interface
 - More comprehensive documentation
 - Object orientation *ala* JTRS/C++