SPECTRUM COLLABORATION CHALLENGE

The world's first collaborative machine-intelligence competition to overcome spectrum scarcity.

Application Challenges for SC2

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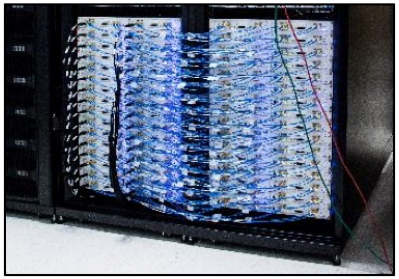
Where This Talk Fits in the Overall Workshop

Spectrum Collaboration Challenge – Challenges

Collaborate Without Co-Design

Create radio networks that work with others without knowing how they "think"

Engineer Emergent Effects



Discover and solve issues that only arise in large-scale realistic settings

Communicate Without Constraints

too specific

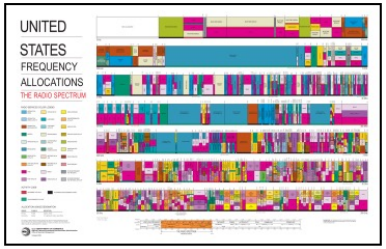
frame 15, slot 7

too general

A B C → D

Create a protocol that supports evolving new forms of collaboration

Evolve The Ecosystem



Change radio design, applications, and spectrum management to enable and leverage collaboration.

Thumbs-up image source: http://sr.photos3.fotosearch.com/bthumb/CSP/CSP880/k8803233.jpg
Pencil image source: http://www.pngall.com/wp-content/uploads/2016/03/Pencil-PNG.png

Canonical Use Cases

- Wildfire response or military coalition operation (horizontal)
  - Rapidly assembled coalition
  - Rapid deployment to any of a wide range of environments
  - Complex propagation with some advantaged nodes
  - Global traffic prioritization
- Mobile broadband sharing with polar satellite earth station or radar incumbent
  - Incumbent has intermittent gain towards any specific terrestrial node
  - Manage aggregate interference
  - If radar, information that can be shared is strictly limited
- Local IOT sharing with broad-area IOT (horizontal)
  - Long-range receivers protected from short-range transmitters
- Secondary LAN sharing with primary vehicle-to-vehicle communications
  - Primary moves along normally-predictable paths

These are examples from a larger set of use cases

Applications of CIRN Technology Compared to WiFi

- CSMA/CD (WiFi) is appropriate when:
  - All coexisting networks can use the protocol
    - Challenge: use cases like those described on previous slide
  - Nodes of other networks hear packets/ACKs as well as the intended receiver
    - Challenge: highly directional antennas
    - Challenge: high-noise links
    - Challenge: advantaged nodes
  - Networks need not act collectively
    - Challenge: manage aggregate interference
    - Challenge: situations where equal division of channel access is not optimal
  - The MAC may consume a substantial portion of the spectrum capacity
    - Challenge: congested environments that require high efficiency

- CIRN technology aims to overcome these limitations

CIRN Technology: Application Requirements

- Shared
  - Spectrum access is not divided a priori by frequency, space or time
- Heterogeneous
  - No single authority can mandate a common technical solution
- Interactive
  - The sharing entities are willing to give each other feedback
- Connected
  - The sharing entities can exchange information via an internet
  - Not necessarily The Internet

All of the above must be present in an application

CIRN Technology: Application Drivers

- High uncertainty operating environment
- Limited time for engineering
- Requirement for collective action

Any of the above may be present in an application

Application Driver
High Uncertainty Operating Environment

- Nomadic or mobile sparse nodes
  - CIRN benefit: protect where they actually are, not where they might be
- Uncertain propagation environments (terrain, urban, ducting)
  - CIRN benefit: activate coexistence mechanisms only for interacting node pairs
- Directional antennas, reoriented over time
  - CIRN benefit: only constrain nodes the antenna is pointing at

Application Driver
Limited Time for Engineering

- Many potentially coexisting system types N
  - CIRN benefit: Engineering cost for coexistence reduced from $O(N^2)$ to O(N)
- Many potential operating environments E
  - CIRN benefit: Engineering cost for coexistence reduced from O(E) to O(N)
- Rapid operational change after deployment
  - CIRN benefit: Adapt coexistence mechanisms to new environments in minutes, not months/years

Application Driver
Requirement for Collective Action

- Partition spectral resources efficiently
  - CIRN benefit: Rapid convergence to optimal solution through explicit interaction
- Protect receivers from aggregate interference
  - CIRN benefit: Avoid operating restrictions caused by worst-case analysis
- Manage congestion when the global optimum is not equal division
  - CIRN benefit: Adjust spectral allocation according to priority of queued traffic

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