May 16, 2022

ICC 2022 Workshop: Spectrum Sharing Technology: Opportunities, Challenges, and Roadmap

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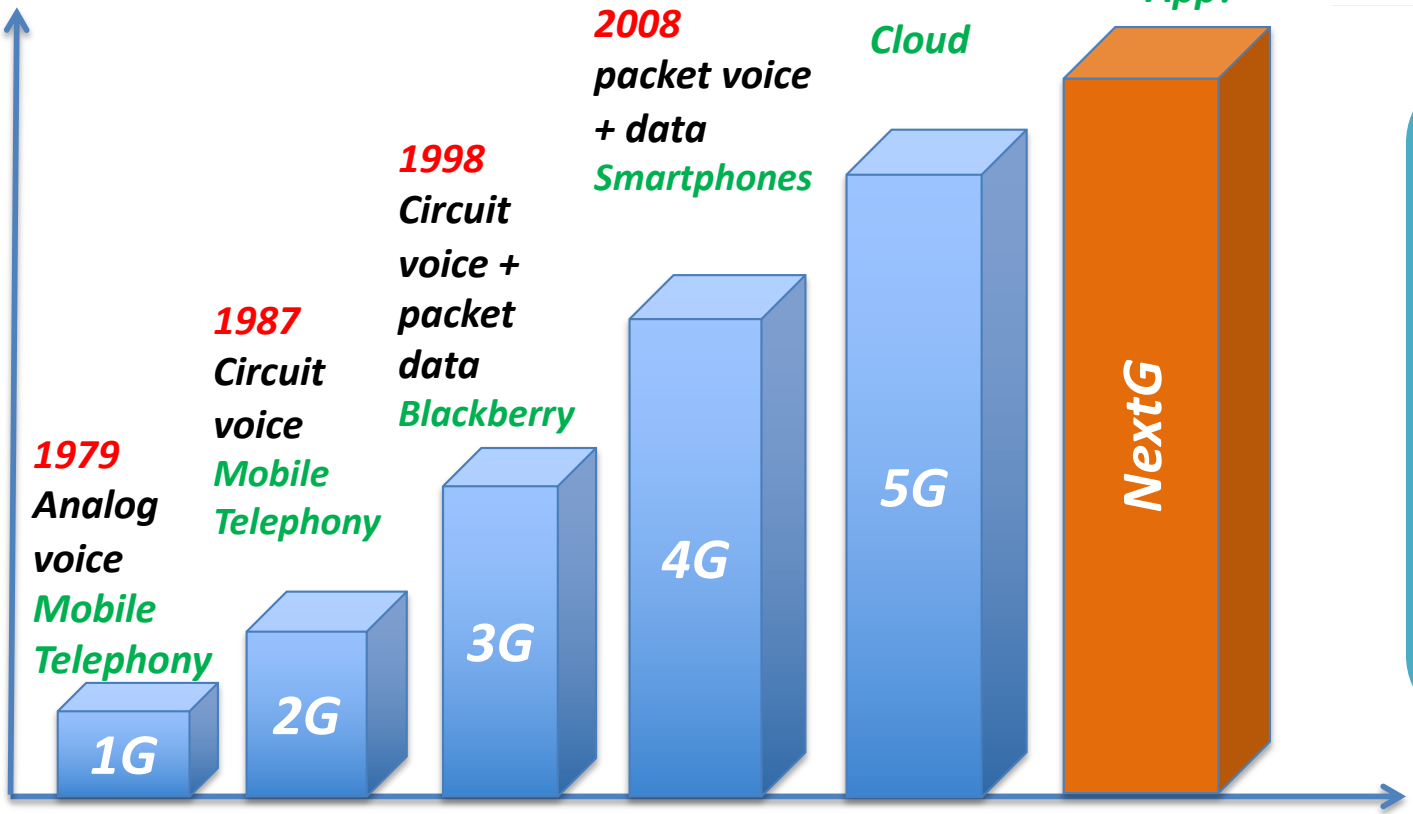
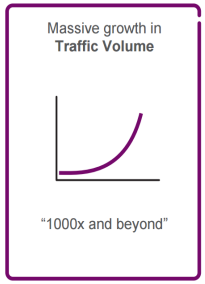
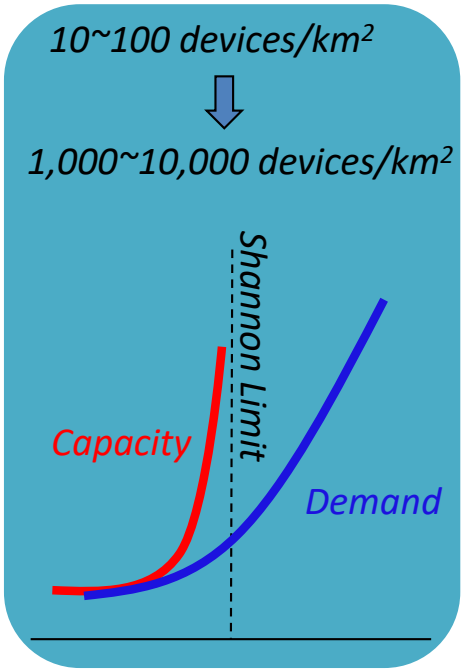
How did we come here?







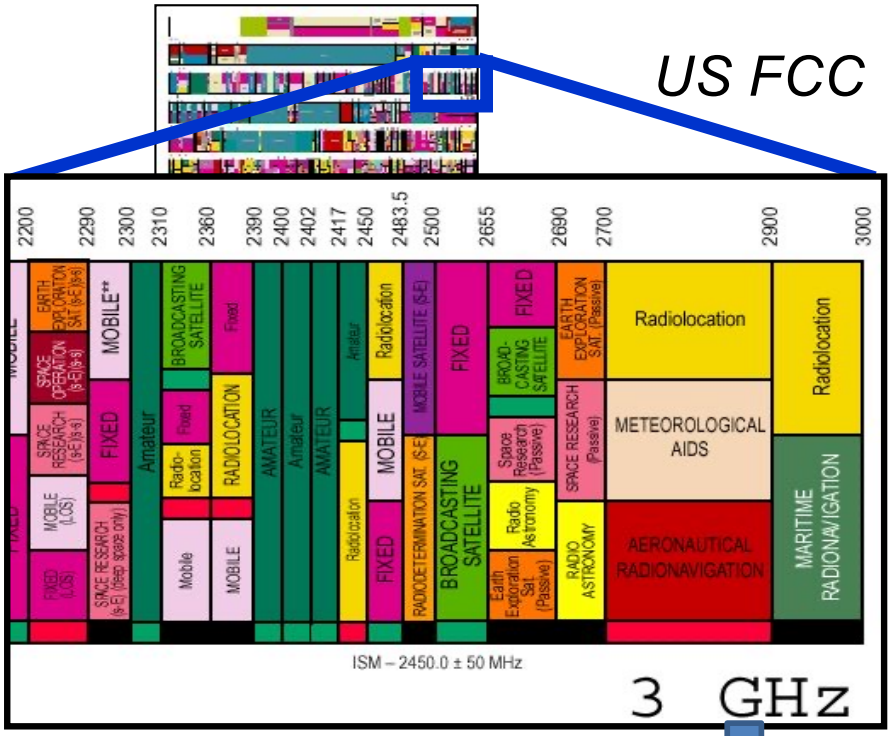
CTIA estimates at least 800 MHz more spectrum needed over next 5 years

The Use of the Radio Spectrum is Integrated into the Fabric of Our Society

- High-growth demand for spectrum exists across multiple sectors: Public Safety, Commerce, Healthcare, Weather Forecasting, Transportation, Homeland Security, National Defense – all increasingly data-driven

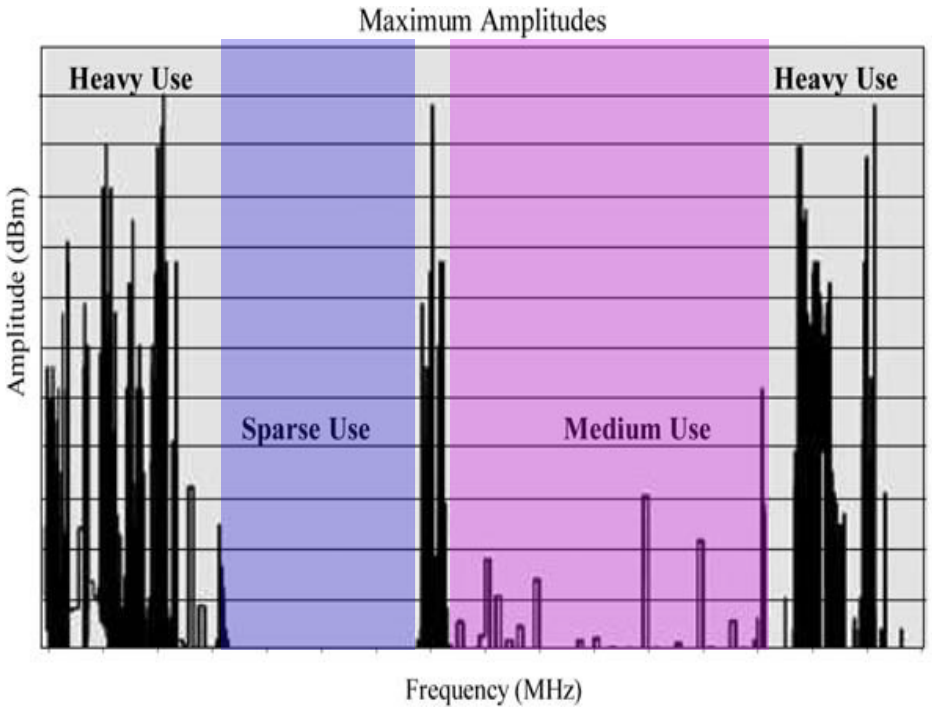
- Industry experts estimate that the indirect impact of wireless is ~**10% of U.S. economy**, or about **$1.4 trillion** annually

No surprise: Scarcity vs Underutilization



fixed spectrum access policies have useful radio spectrum pre-assigned

inefficient utilization



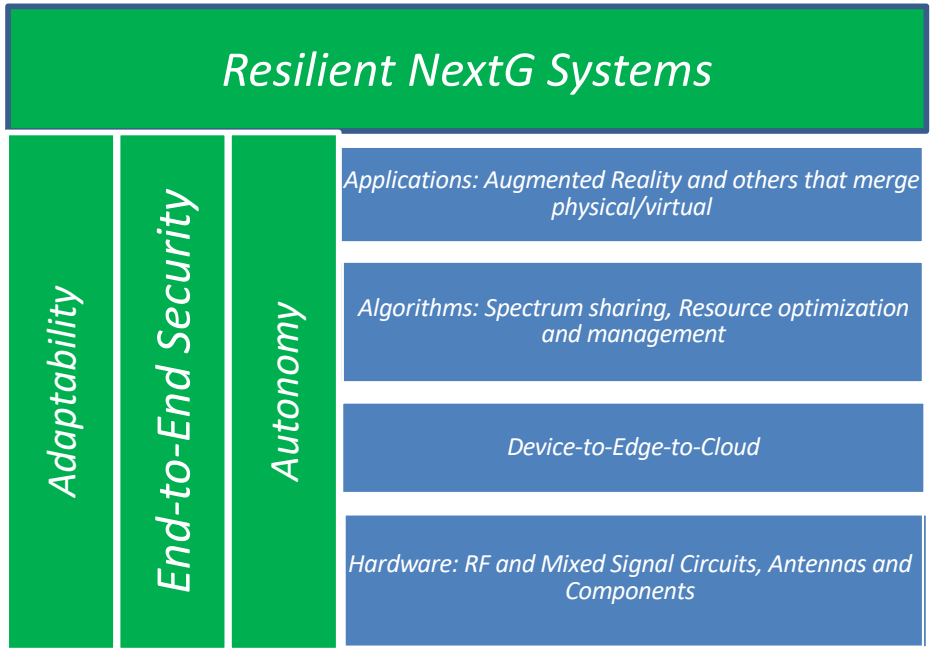
at any time and location, most spectrum is unused

Computer Networks, 50: 13, Sep 2006, page 2130

Evolution of NSF Programs on Enhancing Spectrum Access

- 2012-2016:
  - Enhancing Access to the Radio Spectrum (**EARS**)
- 2017-2019:
  - Spectrum Efficiency, Energy Efficiency, and Security: Enabling Spectrum for All (**SpecEES**)
- 2020-2022:
  - Spectrum and Wireless Innovation enabled by Future Technologies (**SWIFT**)
- Cross-cutting program: ENG, CISE, MPS, GEO, SII.
- Consistent funding to research the fundamentals

Resilient & Intelligent NextG Systems (RINGS)

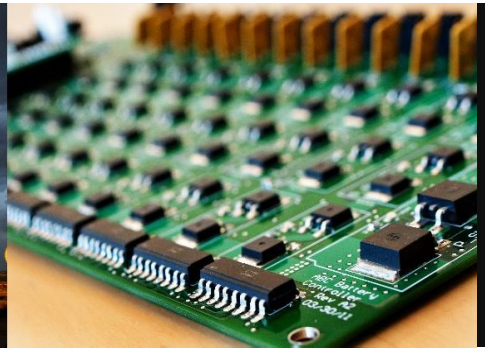
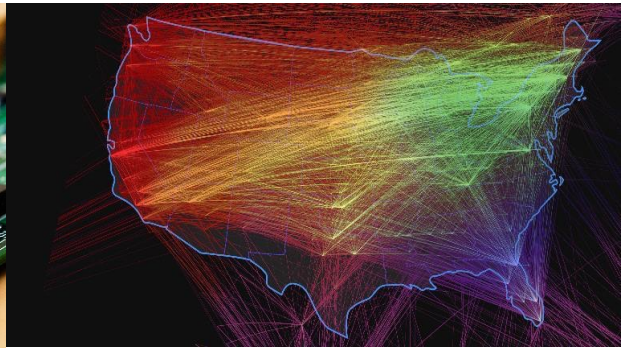


- *Augments current investments in networking, computing, and spectrum sharing research*
- *Resilience-motivated ideas*

- $37.5 M effort
- Diverse partnerships
- Awards made recently

NSF's Spectrum Innovation Initiative

Cross-Directorate, housed in MPS Office of Multidisciplinary Affairs (OMA)
(via a stewardship model similar to other NSF Big Ideas)


I. National Radio Dynamic Zone (NRDZ)
II. National Center for Wireless Spectrum Research
III. Spectrum Research Integrative Activities
IV. Education and Workforce Development

NSF Supported Testbeds

- Testbeds for Spectrum Sharing
  - Places for R&D, demonstration, validation of new spectrum sharing solution
  - Accelerate the evolution of spectrum management practice
  - Enhance trust in new mechanisms

- Spectrum Sharing for Testbeds
  - Enhance spectrum access and reduce delays for R&D (all R&D, not just wireless comms systems)
  - Accelerate innovation and support for national priorities
  - Enable experimentation/training on systems that use spectrum in unusual ways

- NSF is active in both areas and seeks collaboration
  - Current testbeds: PAWR
  - Future: Spectrum Innovation Initiative: National Radio Dynamic Zones (SII-NRDZ)

PAWR Testbeds

- PAWR platforms were chosen to be geographically diverse and research focus independent

POWDER

Salt Lake City, UT

Software defined networks and massive MIMO

COSMOS

West Harlem, NY

Millimeter wave and backhaul research

AERPAW

Raleigh, NC

Unmanned aerial vehicles and mobility

ARA

Ames, Iowa

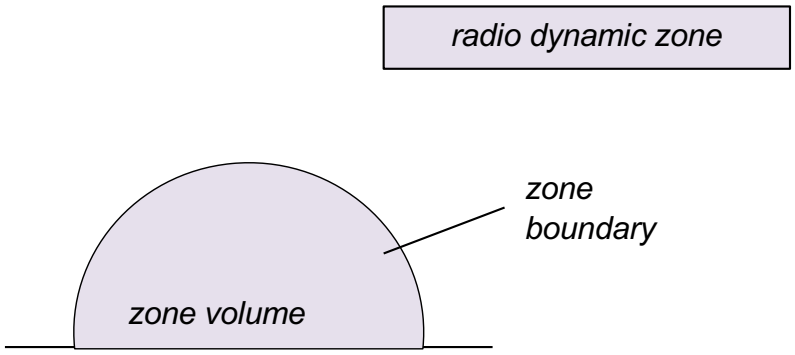
Rural broadband and precision agriculture

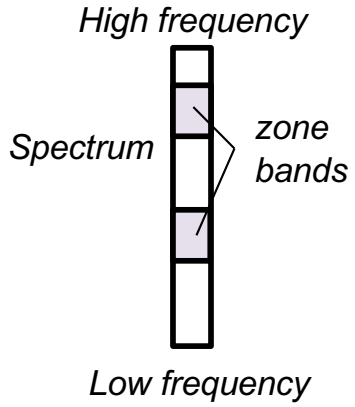
Colosseum – *World's largest RF emulator, located at Northeastern University in Boston*

OAX – *An end-to-end open source 5G software lab*

Spectrum Innovation Initiative: National Radio Dynamic Zones (SII-NRDZ)

- Radio Zone Concept: An area or volume with automatic spectrum management mechanisms that control EM energy entering, escaping, or occupying the zone





- Program solicitation recently released – NSF 22-579
- Goal: Advance the use of dynamic spectrum sharing
- Method: Extended field trials of radio dynamic zones
- Vision: Radio dynamic zones enhancing spectrum access for multiple facilities and applications

Leveraging the Synergy

NRDZ Webinar - March 2022

Using the POWDER Platform to Explore the Feasibility of NRDZs

Kobus Van der Merwe & Neal Patwari

For more information:
powder-contact@powderwireless.net, kobus@cs.utah.edu, npatwari@wustl.edu

Washington University in St. Louis

The University of Utah

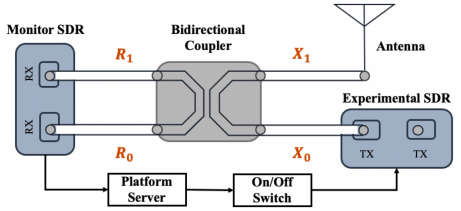
How can we ensure spectrum compliance?

Testbed operator is legally obligated to ensure spectrum compliance, and monitoring ambient spectrum use is needed for sharing. If experimenter has bare-metal access to processor & SDR, how can we do this? Note the cable between front end & antenna has both TX and incident signal.

We use a wired SDR before antenna via a bidirectional coupler to capture signals that are different linear combinations of incident and experimental signals.

Pros: 2 eqns, 2 unknowns

Cons: Coupled signals not perfectly separated; unknown fcn of freq, time.



AERPAW

https://aerpaw.org/

PAWR Project Office

AERPAW: Aerial Experimentation and Research Platform for Advanced Wireless

NSF NRDZ Project Update Webinar
Mar. 16, 2022

Ismail Guvenc, Professor
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North Carolina State University
Email: iguvenc@ncsu.edu

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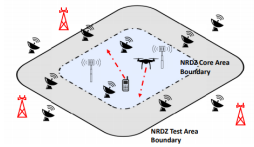
Part-2: AERPAW NRDZ Research – Main Thrusts and Goals

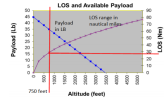
Main Thrusts

- Conceptualizing NRDZs
- Propagation Measurements and Modeling with Aerial Nodes
- Collaborative Spectrum Sensing and Coverage Characterization
- Millimeter-Wave Sensing

Integration/Extension to AERPAW

- mmWave Hardware Development
- Helikite (acquire) and UAV Platforms
- Acquire and Deploy new RF Sensors





Task	Description	Year-1	Year-2	Year-3	Year-4
Research					
Task-1	Conceptualizing NRDZs				
Task-2	Propagation Measurements/Modeling				
Task-3	Collaborative Sensing and REM				
Task-4	mmWave Sensing				
Development					
Task-1	Acquire Helikite and Conduct Experiments				
Task-2	Install RF Sensors, Develop Test Software				
Task-3	mmWave SDA Development and Testing				
Task-4	Acquire and Deploy Servers				

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Colosseum and NRDZs

NRDZ Goals

Create a safe playground for spectrum experiments that are not allowed under current regulations

Bring together passive and active users to explore new uses of spectrum and spectrum sharing

Institute for the Wireless Internet of Things at Northeastern University

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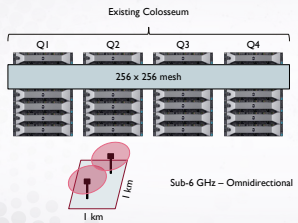
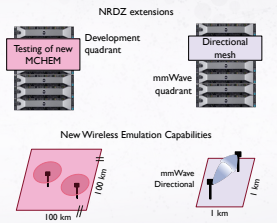
NRDZ and Colosseum





Institute for the Wireless Internet of Things at Northeastern

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Challenges and Opportunities

- **Challenges**:
  - Wideband flexible high-power RF front-ends
  - Diverse requirements, bandwidth, applications, capabilities
  - Protecting science users
  - Multiple entities: policy makers, operators, users, …
  - Technical challenges: wideband sensing, fading, complexity/power limitations (IoT)
- **Opportunities**: joint sensing/communications + intelligence , novel protocols

ML/AI, model + data, sparsity, cooperative sensing, cross-layer, HW+SW