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ENERGY SCIENCES NETWORK

Extending ESnet to the Wireless Edge: Lessons Learned

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U.S. DEPARTMENT OF ENERGY

Office of Science

BERKELEY LAB

Science Motivations

ESnet is researching how to incorporate 5G/Wireless and better support field science.

1) What are the right support models for scientists engaged in field research?
2) As we “grow into” ESnet6 capabilities, how do we want to posture Wireless for:
   a) Edge compute / HPC backhaul
   b) Intelligent network management
   c) Automation, etc
   d) other….

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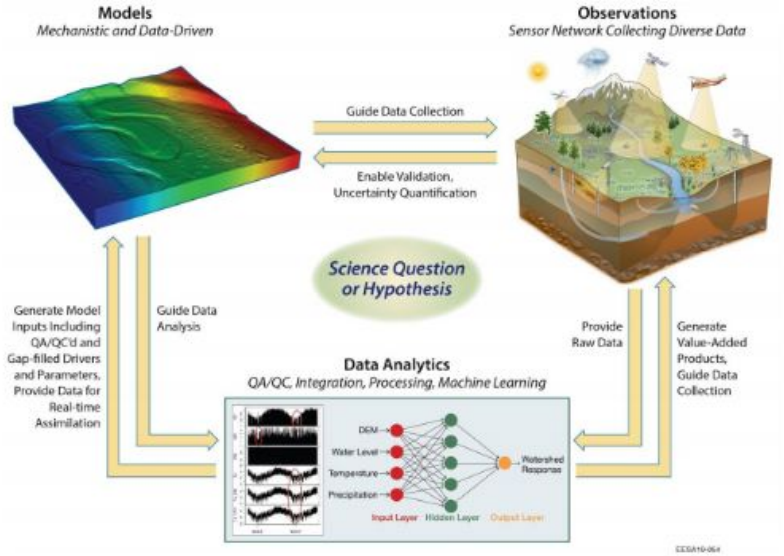
Self-Driving Field Laboratories

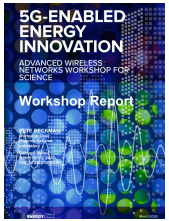
The explosion of performance and options for wireless data connectivity offers unprecedented opportunities for measurement of the world, integration of "Models-Observation-Data Analytics"

This is a potential competitive advantage for open science laboratories - connecting to the tapestry of sensors that will be out in the world, and to bespoke scientific instruments.

Challenges: all three have to be solved simultaneously, current focus is often just the first two.

- Locating compute resources? (edge, elsewhere)
- Data analytics & workflows (ML, dynamic sampling, etc)
- Wireless connectivity for science → how does this work as part of the entire REN stack for scientific data movement?





Varadharajan, Charuleka, Deborah A. Agarwal, Wendy Brown, Madison Burrus, Rosemary W. H. Carroll, Danielle S. Christianson, Baptiste Dafflon, et al. 2019. "Challenges in Building an End-to-End System for Acquisition, Management, and Integration of Diverse Data From Sensor Networks in Watersheds: Lessons From a Mountainous Community Observatory in East River, Colorado." *IEEE Access* 7: 182796–813.

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Demand Drivers for Science

IoT hardware makes instrumentation cheap, in some cases disposable

Eas(ier) to deploy in all kinds of settings

The entire ecosystem is driven by development requirements that are not related to science (wireless edge/commercial cloud, edge services, ML, API, etc. etc.)

ESnet needs to understand what is coming, develop proficiency, and the capability to modify standards, hardware, and capabilities to meet our science specific needs

- Harsh environments
- Use limitations (EM restrictions, power, weight, etc)
- Get “it” to play nicely with HPC, with workflows, Authentication, Cyber needs, etc.
- Procurement and business models, supply chain requirements, etc

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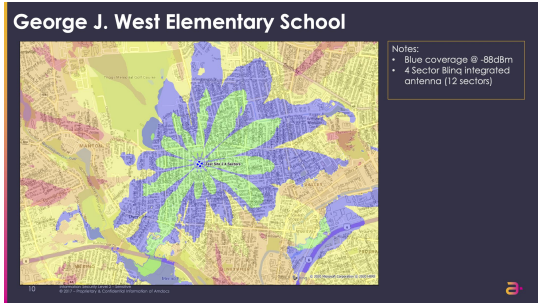
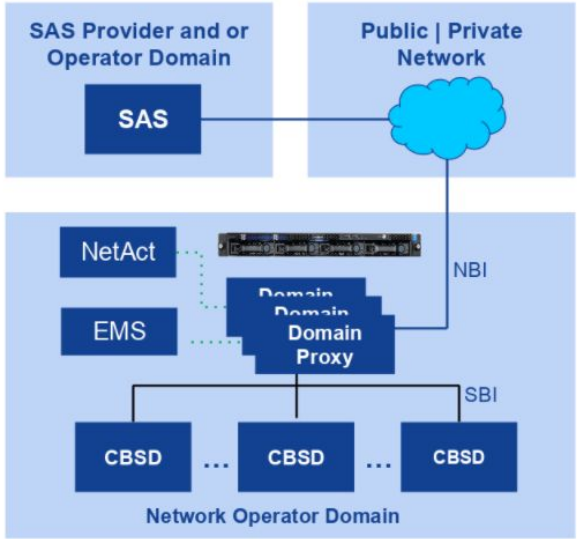
Shared Spectrum & CBRS

- Citizen Broadband Radio Service (CBRS) is a 150 MHz frequency band created by the FCC in 2019 for unlicensed 4G/5G use. **This lets anyone set up a 4G LTE/5G network**.
- CBRS (also called Band 48) is between 3.55-3.7GHz so it has **good internal and external propagation** and range.
- Part of Band 48 is used by US Navy ship radars so Citizens Broadband Radio Service Devices (CBSD) must be enrolled in a Spectrum Access System (SAS)





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Learning by doing

Faced with uncertainty, building general capability to track, identify and respond “what is happening” in science use of wireless is the best strategy.

Activities within ESnet:

1) Understanding opportunities for integration of ESnet6/7 Automation and SDN capabilities (Mariam Kiran, Xi Yang, Wenji Wu, Josh Bailey) and Advanced Network Technologies)
2) Understanding how scientists are using IoT and Advanced Wireless (focus of this talk - Science Engagement Team)

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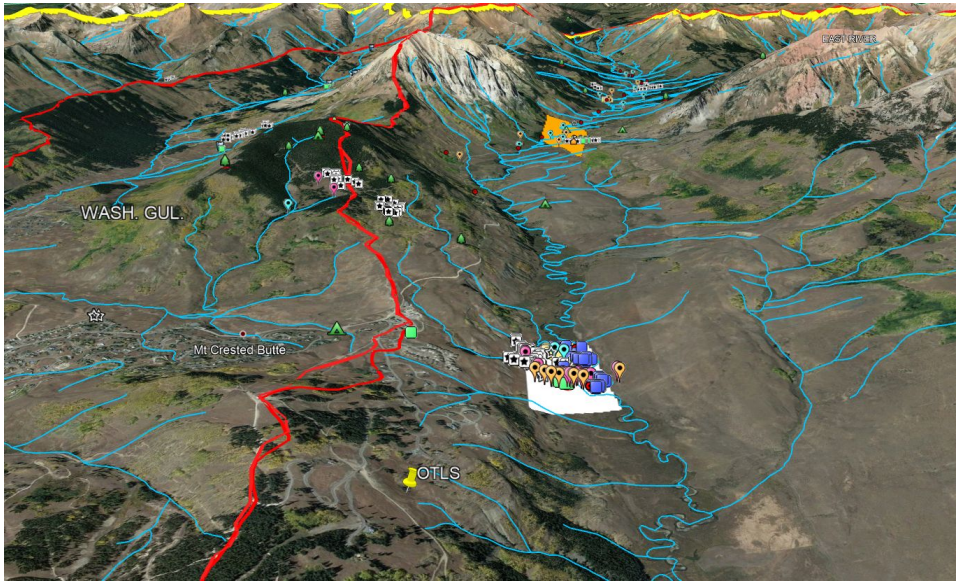
Env. Field Science in Colorado

1) Sensor fields (in white) covered by CBRS antenna/base station placed near Mount Crested Butte SAIL X-band radar site (marked in yellow).
2) Sensors connected either through cellular directly, or via 1-2 solar cellular-wifi routers deployed by this project in the sensor fields.
3) Backhaul at the SAIL radar site through fiber and Starlink terminals (in collaboration with Starlink)



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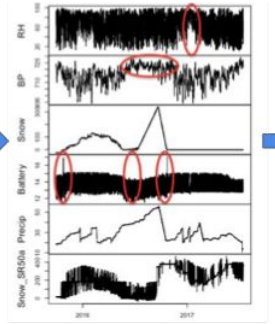
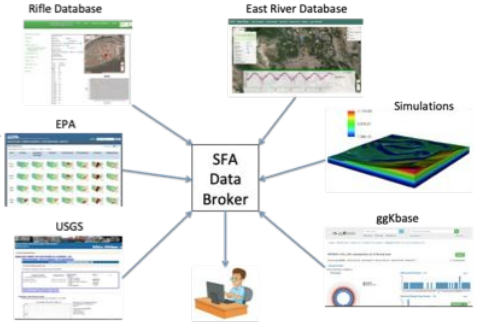
Initial Workflow

(a) Sensor Network Acquiring 100+ Variables x 50+

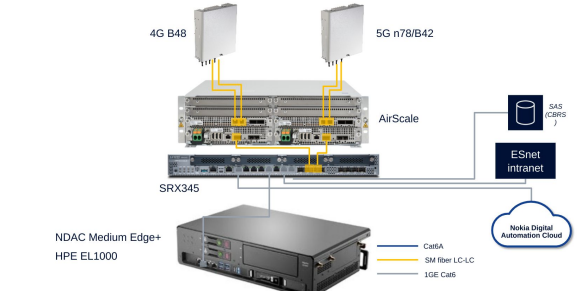
(b) Telemetry and Storage into a Queryable Database

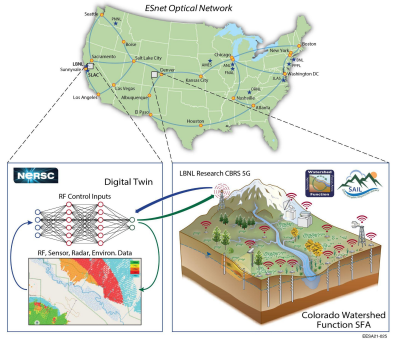


(c) Semi-Automated QA/QC Algorithms



(d) Diverse Data Integration with External Sources via BASIN-3D Broker





Adapted from Varadharajan et al, IEEE (2019) and Hubbard et al, VZJ (2018)

Deployment Schedule

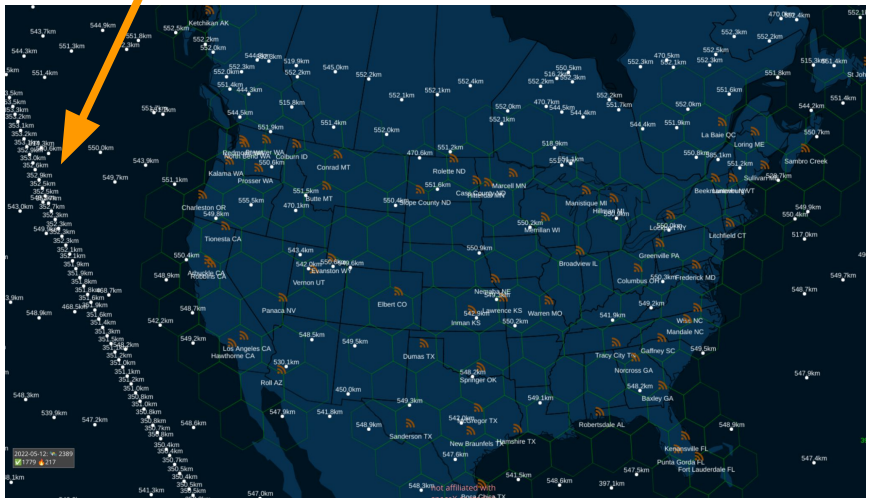
- LBL ESnet CBRS Radio Core deployed at LBNL: May 2022
- Radiohead and WFSFA Base deployed in CO and initial sensor connectivity with ARM/SPLASH: May-June 2022
- Backhaul and Network Testing: June-July 2022
- Summer sensor connectivity campaign, network adjustments: August 2022
- Full Operation (year to year): October 2023

FY22: SFA Data Team to work with ESNet on data backhaul to NERSC and scope storage, integration with existing SFA data infrastructure

Starlink

- Procured 3 MT, and deploying in CO to provide CBRS backhaul
- Working on peering and ensuring high quality connections to ESnet as DOE/Science use grows
- CBRS backhaul of mutual interest, as some telcos begin to use CBRS to support remote area build-out via Starlink as well. Many interesting lessons to learn.

This blows my mind



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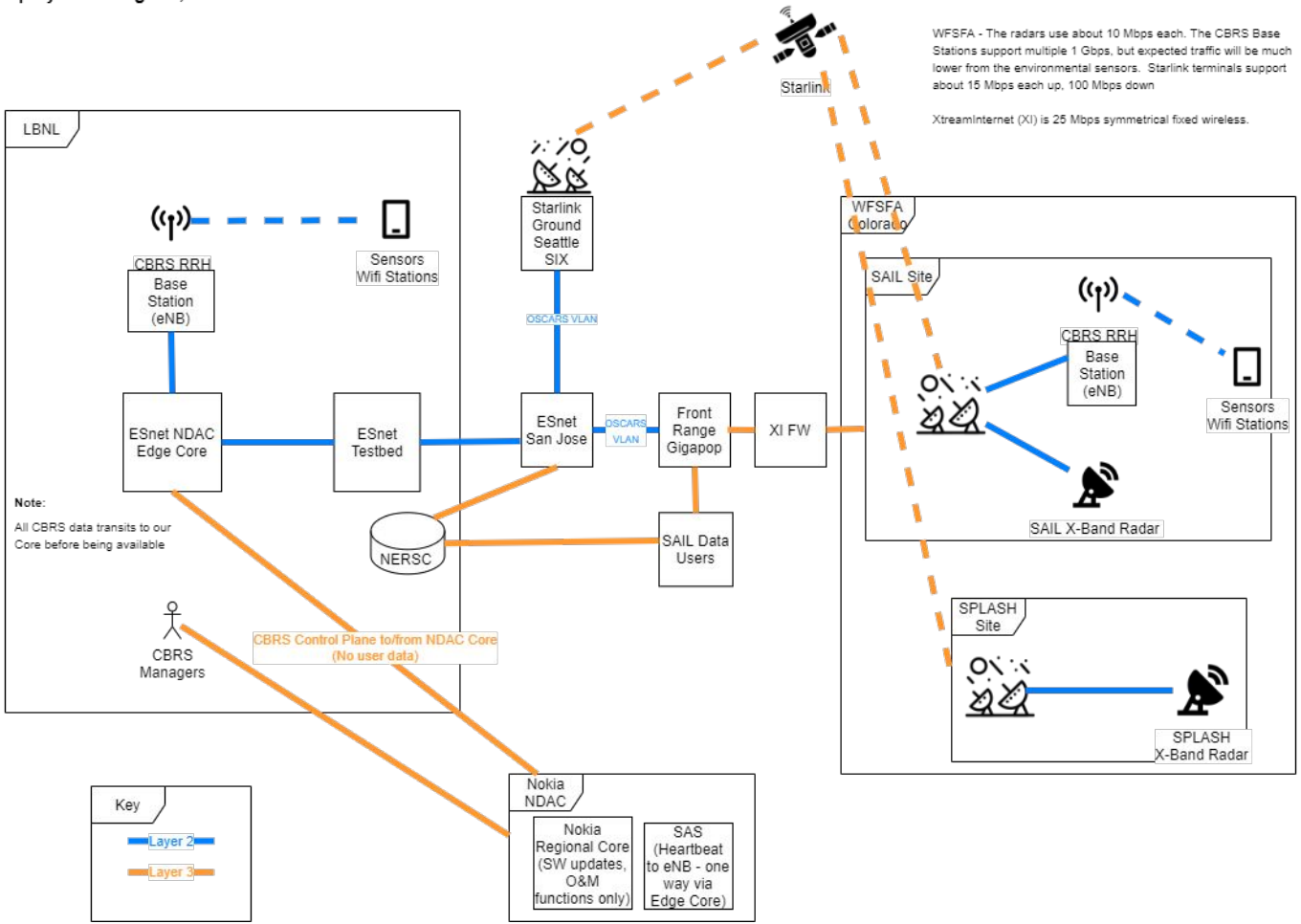
ESnet CBRS Testbed & Watershed Function Science Focus Area (WFSFA) Colorado Deployment Diagram, 10/22/21



Service model(s): how to integrate 5G/LEO from the perspective of the scientific workflow

- Providing information - a wireless section on fasterdata, etc
- Providing performance support - perfsonar, network monitoring, etc
- Providing a design model - ScienceDMZ but for wireless deployment or wireless integration with DTN
- Providing wireless access services - helping to deploy CBRS/federate with our systems, interconnecting with new services, troubleshooting and consulting
- Providing wireless access - extending our CBRS system/other systems we may deploy out to the field to support a science campaign

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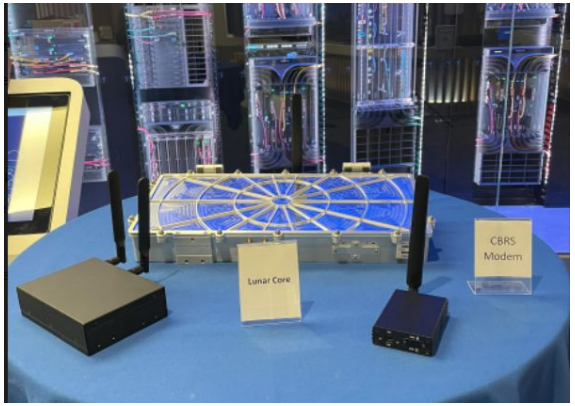
Technology (things to watch)

- DoD is a big gorilla here - 5G/LEO for battlefield uses will have a lot of spinoffs for science field use
  -rugged equipment, alternate power sources, integrated satellite/terrestrial, increased merging of commercial and other infrastructure (cloud, LEOsat, etc)
- Proliferation of small-sat technologies
  - LoRa
  - Shared Spectrum “CBRS-like” from orbit
- Better power options for remote deployment
  - Power/antenna tradeoffs become easier and deployment in wider settings more possible



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