

# The Challenges of Scaling WISPs

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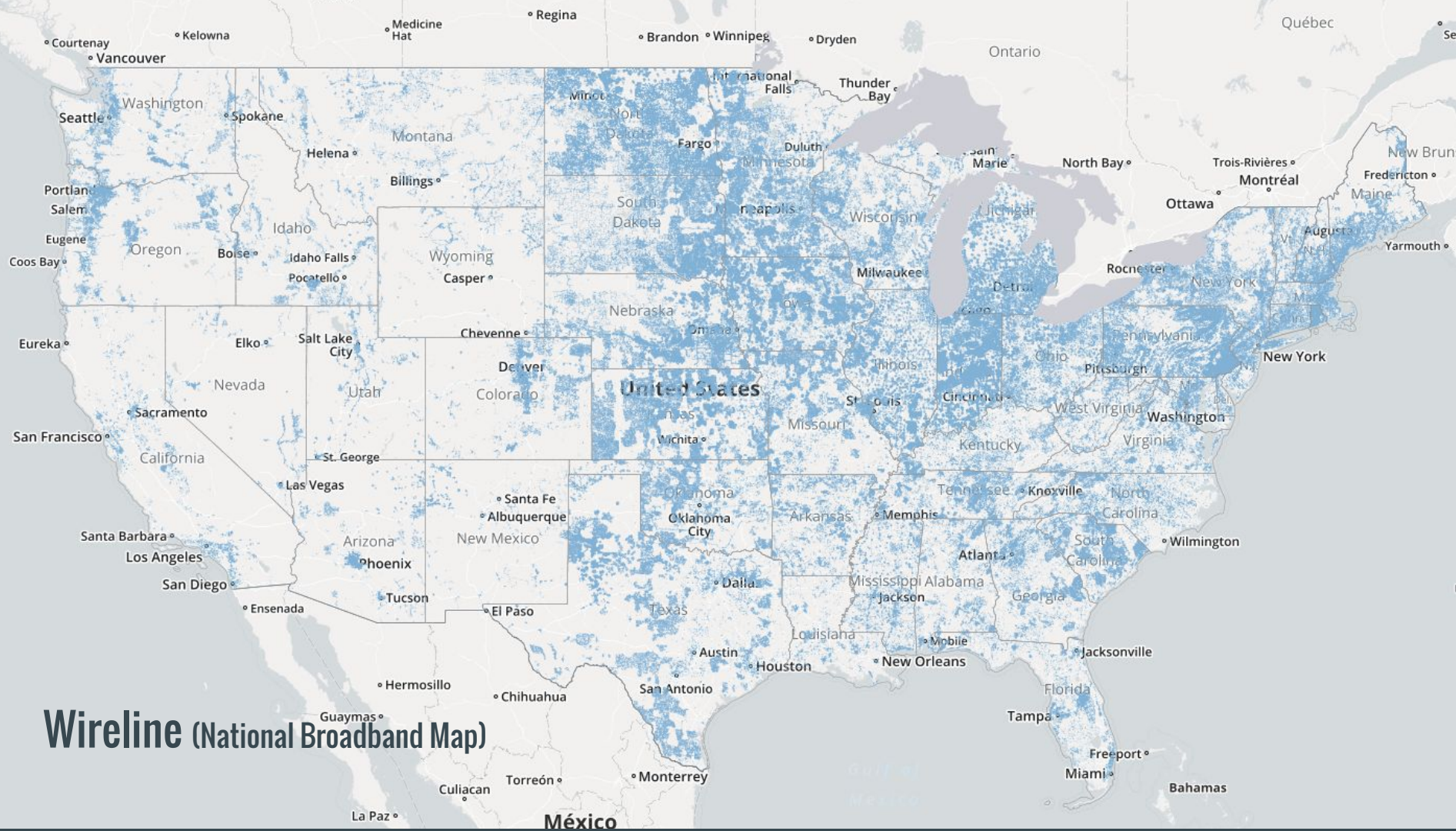
UC Berkeley, De Novo Group, Sudo Mesh, ICSI

The background of the image is a dark, charcoal grey. It is filled with intricate, ethereal wisps of smoke or vapor. These wisps are rendered in lighter shades of grey and white, creating a sense of movement and depth. They swirl and drift across the frame, with some forming more defined, loop-like structures while others are more diffuse and misty. The overall effect is one of delicate, organic complexity.

# WISPs

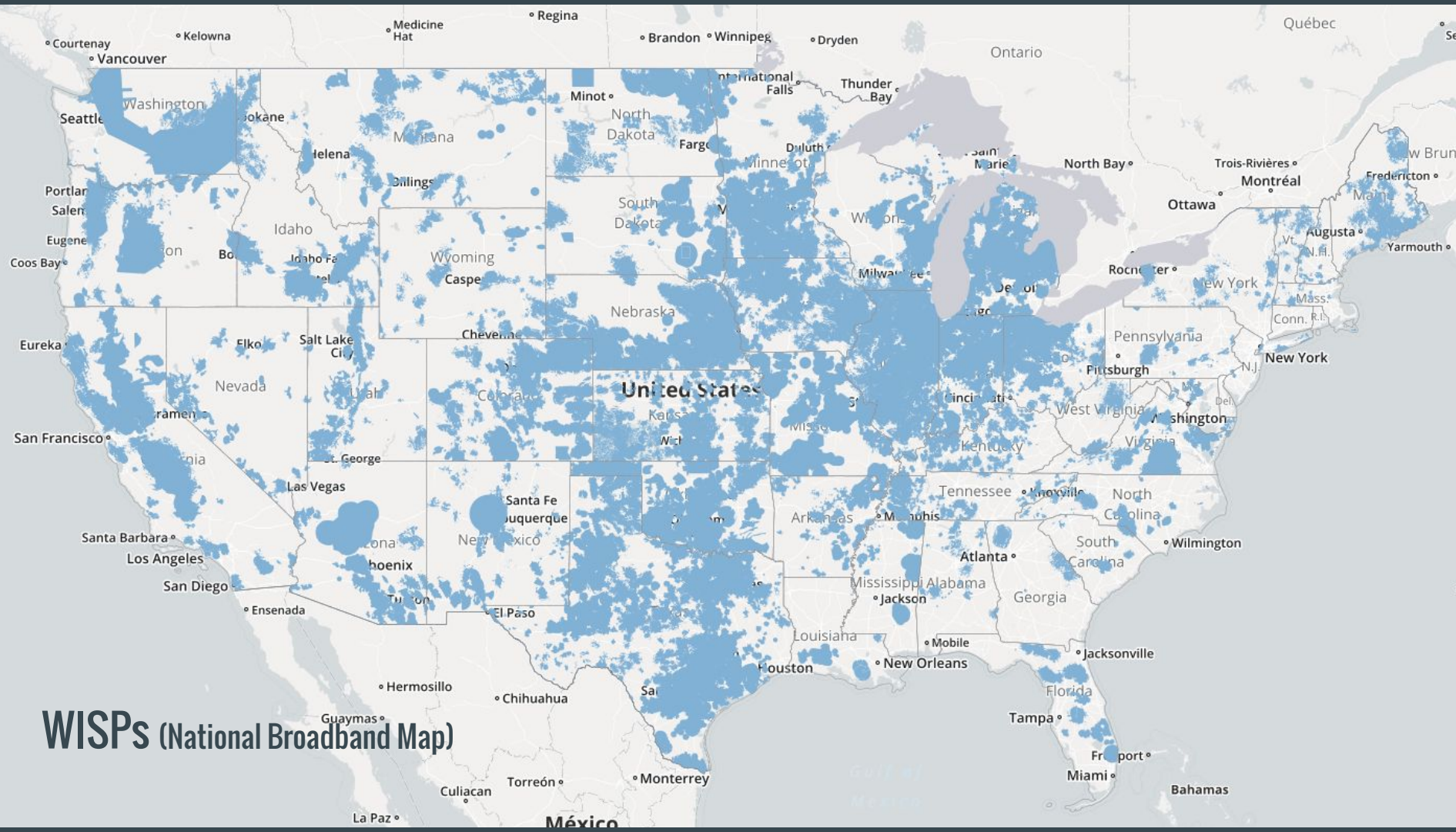


# Wireless Internet Service Providers



# Wireline (National Broadband Map)



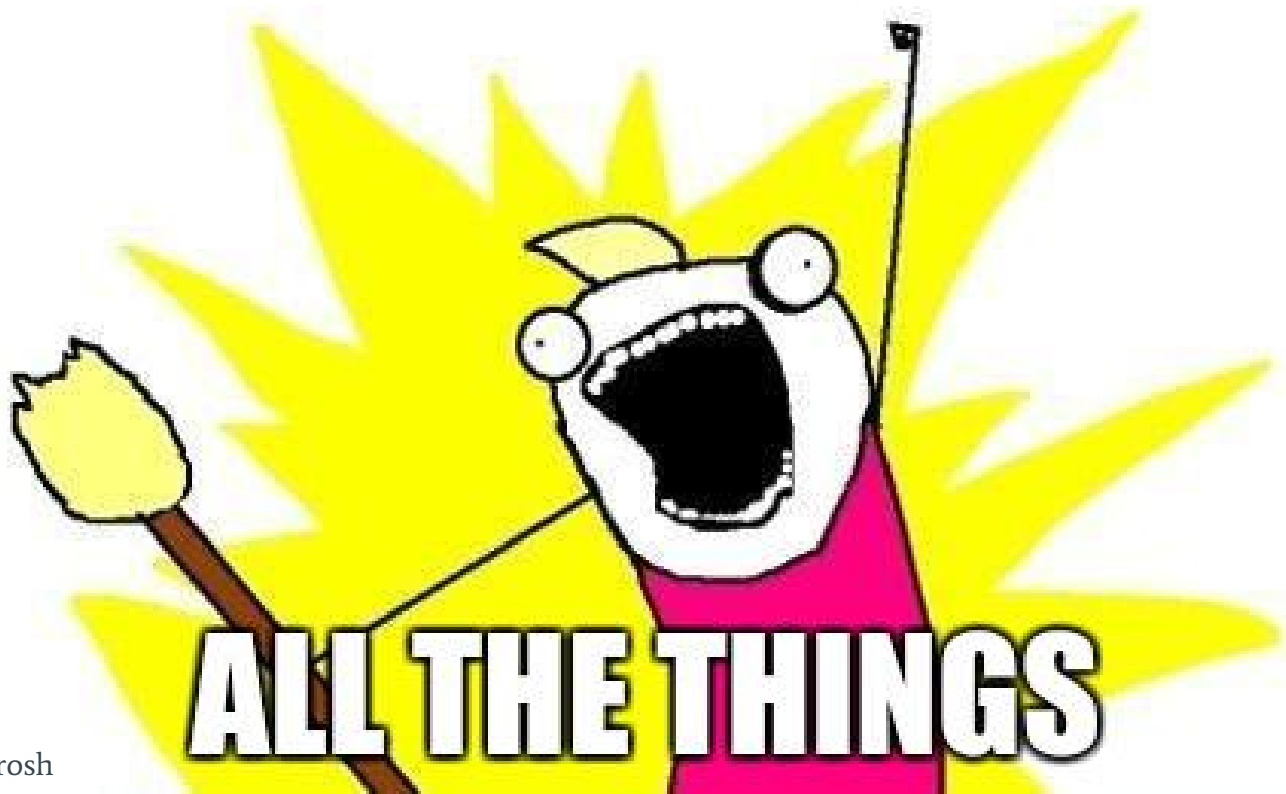




**Idea:**  
**SDN can help build more  
efficient WISP networks.**



# SOFTWARE DEFINE





**SOFTWARE DEFINE**



**ALL THE THINGS?**

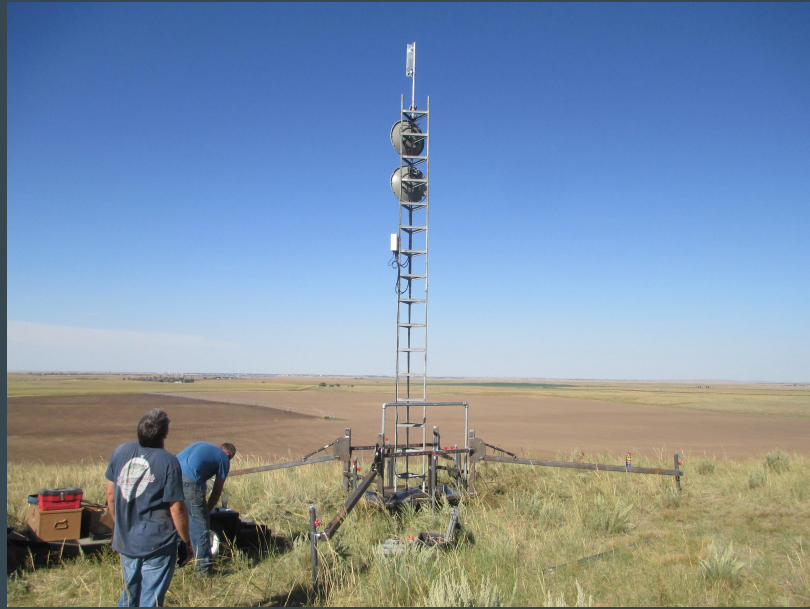
# In this paper...

- **Survey and interviews** of Wireless ISPs in the United States
- **Deployment** of a rural WISP in northern California
- Development of **Celerate**, a platform for managing WISPs

# Study on WISPs

- Online Survey: 75 respondents
- 13 Follow-up interviews
- Nationwide, range of rural and urban WISPs
- Asked about **scale, network management, failure rates, and growth.**

# Two (main) types of WISP





< 1000 subs

49% of survey respondents

< 5000 subs

96% of rural survey respondents

< 5 people

42% of survey respondents

# Unlicensed

Backhaul and Access Networks



# Network Management Strategies

“We don’t route at towers. I designed the network that way because routing has its place, but I want to be able to take a vacation and not have to pay someone 80 or 100 grand a year. It complicates the network that much more. I designed the network to make it as easy as possible to train new employees to be able to operate within our environment. That’s why we’re a layer two network; it’s mainly for easier deployment and training.”

# Network Management Strategies

Azotel: “The customer is entered into our Azotel system, and then it monitors the bandwidth based on their IP address. [...] It comes back to our NOC, and before it goes out to the Internet, Azotel controls how much bandwidth they get.”

Powercode: “[To enforce usage caps] we use a product called Powercode. It’s our CMS, billing, everything all rolled into one.”

# Local Connections

“We had a regional sales VP [for Charter] as one of our customers, and he wanted more bandwidth. I said, ‘If you want more bandwidth you’ve got to get me a pipe.’ He got the right people involved and got us a fiber connection in the middle of nowhere. ”

# Local Connections

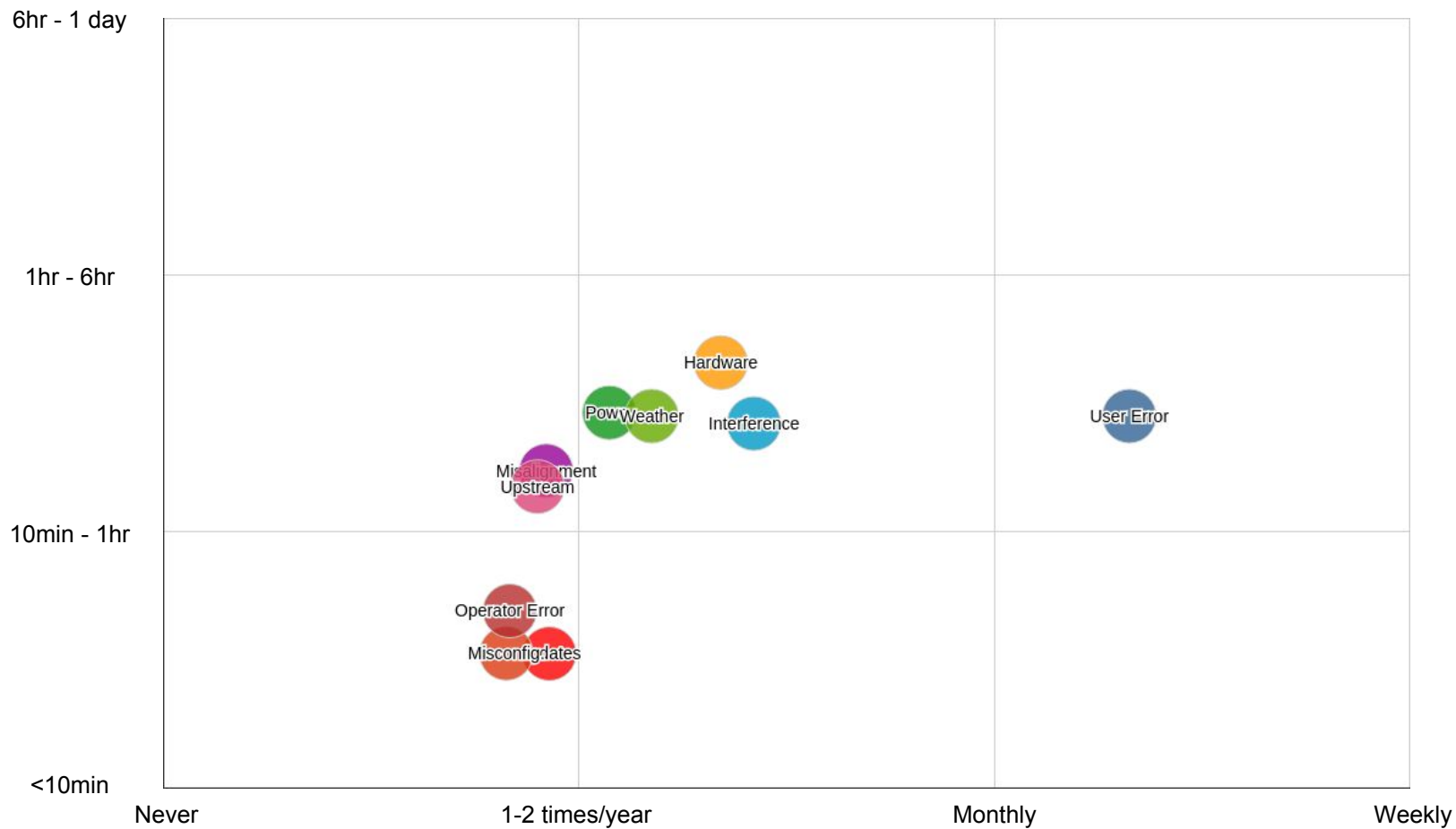
“[Our tower costs are] extremely low [...] What I’ve tried to do is make this a community effort. [...] Why are we doing this? In order to provide some economic lift to the county and also to help students get access to the Internet. We are capitalists and we do need to make money, but it isn’t all about the money.”



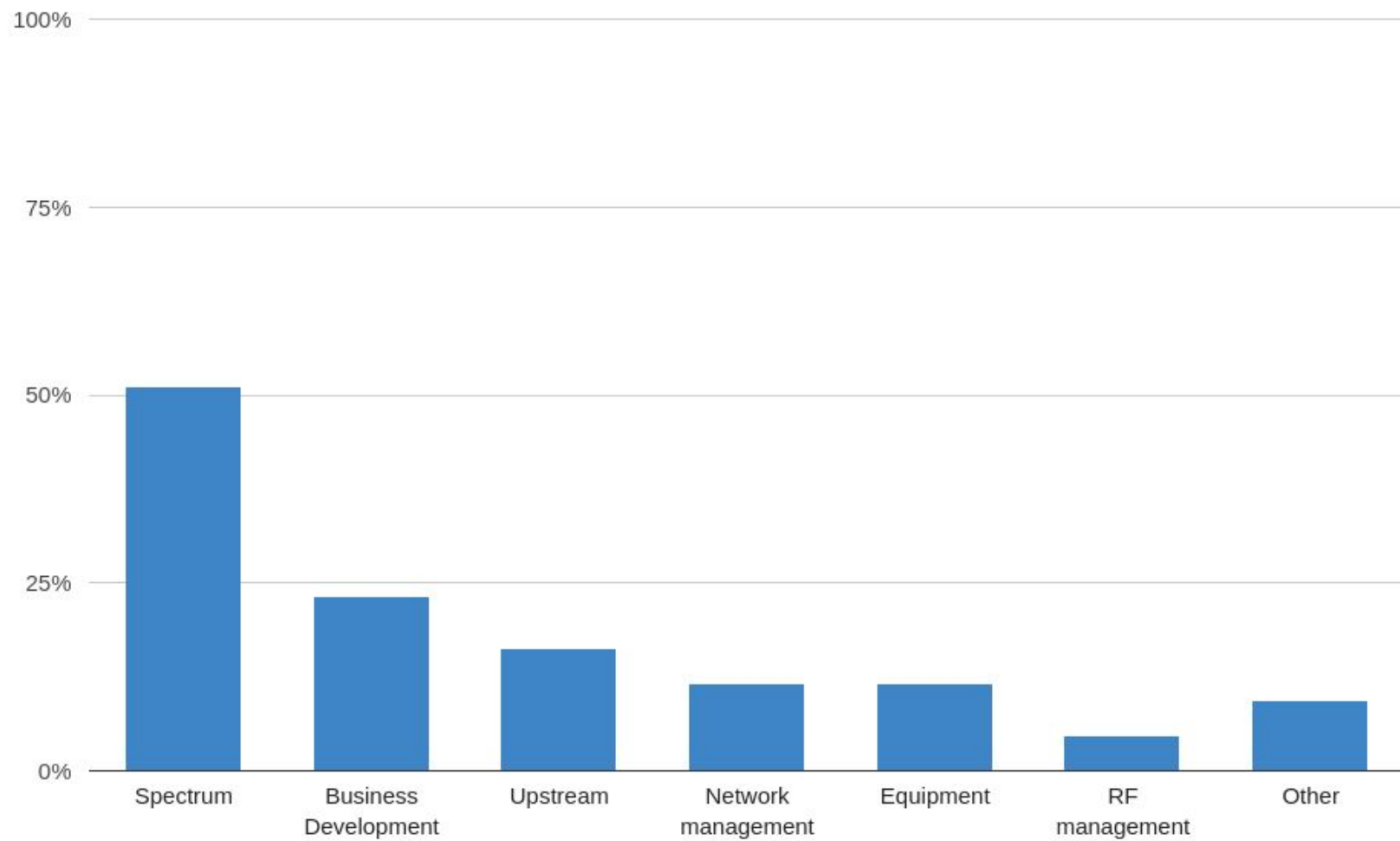
# Mutual Support

“Generally, if you have any question about anything there’s someone out there in WISPA [industry association with active email list] that knows the answer to it. It doesn’t matter what it is. They know. They’ve been in the business forever.”

“We’ve actually spawned a co-op. Right now, it’s five ISPs that formed this legal entity. [...] The idea, to start with, was for buying power. [...] One of the things we also talked about is sharing call center people.”



**Largest perceived challenge faced by WISPs**



# Bottlenecks: Spectrum

- Most WISPs operating in 5.8GHz or 900MHz
- Key problem: self-interference on tower
  - More APs = more subscribers
  - Limited bandwidth -> narrower channels
- 900MHz important for foliage penetration
  - Only 28MHz available
  - Shared with SCADA



# Bottlenecks: Funding

- High Capex + Low ARPU = Low ROI
- Challenging to get subsidies due to small scale
- Geographic constraints lead to step functions in expansion costs

# Further Reach

- A research WISP in Northern California
- Completely greenfield deployment
- ~350 subscribers today
- Non-profit: initially funded by Google.org grant

# Further Reach: Design Decisions

- Unmodified commodity hardware (Ubiquiti, Mikrotik)
- Unlicensed/lightly licensed spectrum
- Paid service
- Minimal new tower infrastructure
- Community Relays



# Lesson: Importance of funding

- Initially funded by a grant from Google.org
- High-end (though still commodity, unlicensed) equipment
- Long runway to make and learn from mistakes
- Plenty of capital for infrastructure installation
- Finding grant funding is very difficult for small WISPs...
  - USDA: Broadband grants require applicants to be CLECs
  - FCC: Experimental broadband grants require line of credit equivalent to grant size

In the matter of

WC Docket No 10-90

WC Docket No. 14-259

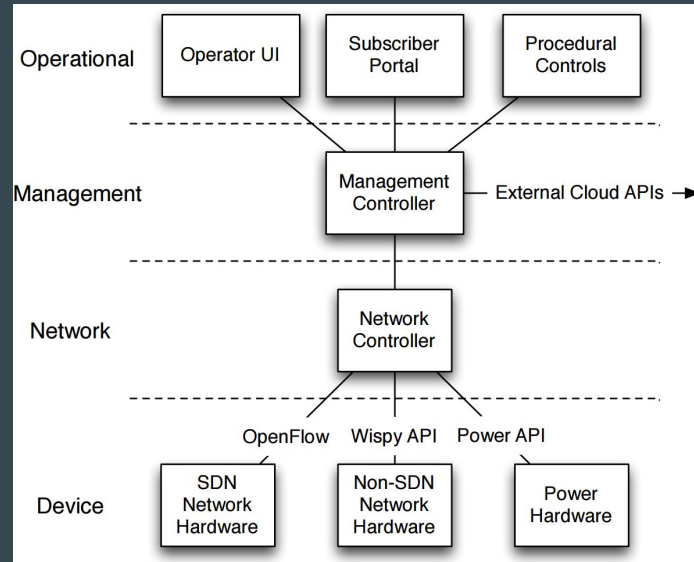
**Released: January 30, 2015**

15. IT IS FURTHER ORDERED that the petitions for waiver of the rural broadband experiments financial review requirements, which requires provisionally selected bidders to provide the most recent three consecutive years of audited financial statements, filed by AirNorth Communications, Inc.; Agile Network Builders, LLC; Brainstorm Internet Inc.; Chaffee County Telecom, LLC; Cricelli, Inc.; Crystal Broadband Networks, Inc.; Declaration Networks Group; De Novo Group; Donnell, Michael D. (d/b/a San Joaquin Broadband); Giant Communications, Inc.; Last Mile Broadband; Mercury Wireless Inc.; Rural Broadband Services Corporation, Inc.; Tower Communications LLC; and Worldcall Interconnect, Inc., ARE DENIED as described herein.

# Lesson: Expansion is a step function

- Growing the network means adding new tower sites
- Intrinsic costs associated with towers
- Lots of non-obvious costs
  - Travel time / fuel
  - Additional personnel
  - Learning how to deploy in new markets
- Geography is key!

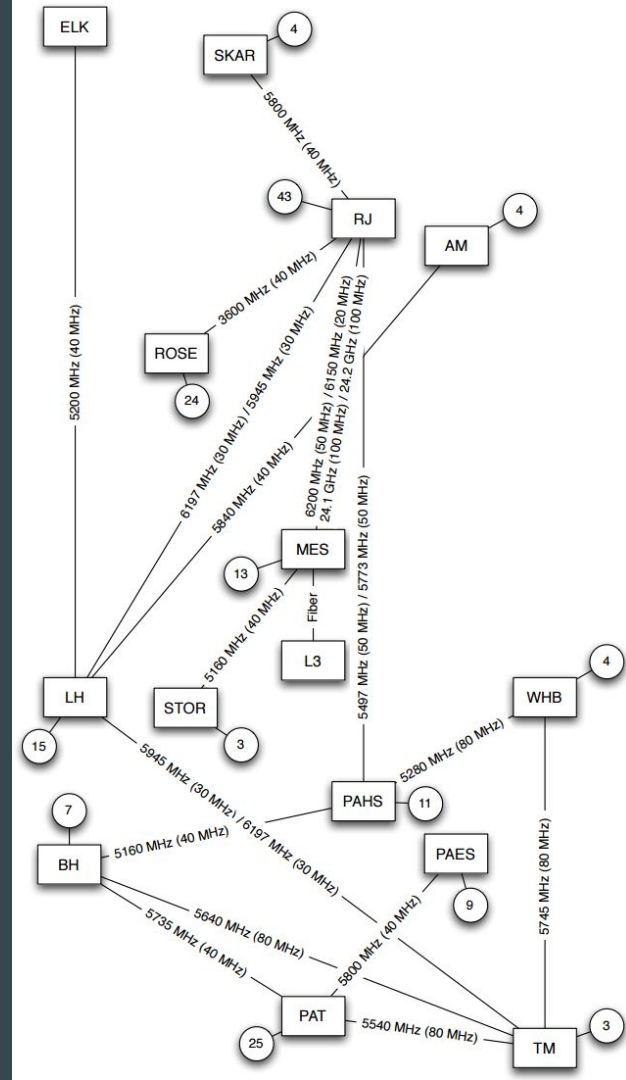
# Celerate: An SDN controller for WISPs



<https://github.com/Celerate/celerate-controller>

# Intelligent Routing?

- Goal: automatic re-routing of traffic after faults and for performance optimization
- First six months: did not have multiple paths!
- Afterwards:
  - STP good enough for handling link failures
  - Bottleneck at the CPE, so no performance benefit in core



# SDN-based billing?

- Idea: Implement billing/metering/shutoff via SDN controller and OVS rules
- In practice:
  - Manually throttling traffic on CPE using existing software
  - **No automatic shutoff: billing issues are complicated**

# Subscriber Mapping

staging.furtherreach.net:3000/subscriber

CelerateSubscribersNodesHardwareSitesDiscoveryBilling Export DownloadEmails Admin

global

342

Search subscribers

Add Search Field

Add New User

See Connected

See New Leads

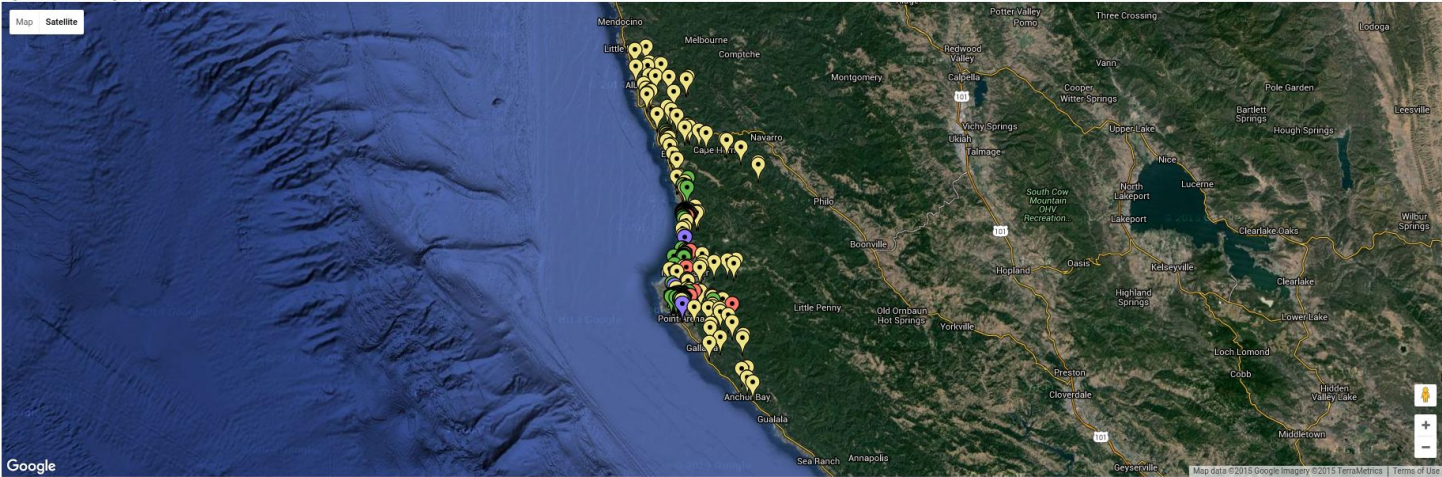
See No Coverage

Show Map






Recenter Map

Right click to see lat/long at specific location

MapSatellite



Map data ©2015 Google Imagery ©2015 TerraMetrics | Terms of Use

	Full Name	Status	Street Address	City	Plan	Signup Date	Activation Date	Email	
	 James Hayes	not interested	120 Port Road	Point Arena		08-10-14		thejimhayes@hotmail.com	
	Greg Jirak	not interested	27101 South Highway 1	Point Arena		08-14-14		gajirak@mcn.org	



# Integrated Billing

staging.furtherreach.net:3002/c8351f609db501c0d78b97b8f049a9cf890536b

Further Reach

## Further Reach Customer Dashboard

### Your Plan

Ultra

Account ID: cdc96a758  
Monthly Price: \$130  
Details: Min: 10Mbps Typical: 30Mbps  
Type: Residential

Manage Autopay

Off On

Autopay Info  
Email: randommaemail@email.com  
Card: Visa ending in 4242

### Contact Information

random user A New User

Name: random user A New User  
Email: randommaemail@email.com  
Address: .

## Bill

### Monthly Charge

Period	Plan	Amount
11/01/2015 - 11/30/2015	Ultra	\$130.00
<b>Monthly Total:</b>		\$130.00

### Installation

Description	Amount	Rate	Total
Standard Installation (includes antenna, access point, Ethernet cable, 3 hour labor)	1		\$150
<b>Installation Total:</b>			\$150.00

Pay full installation - \$150.00

Pay full installation - \$150.00

Pay installment - (6 payments of \$25.00 each)

**Total: \$280.00**

[Make a Payment](#)

# Node Database

[Celebrate](#) [Subscribers](#) [Nodes](#) [Hardware](#) [Sites](#) [Discovery](#) [Billing Export Download](#) [Emails Adm](#)

## Subscriber Details

[Customer Dashboard](#) [Dashboard in 30 days](#) [Archive Subscriber](#) [Delete Subscriber](#) [Associated Site](#)

[Basic Info](#) [Scheduling](#) [Extra Contact Info](#) [Billing Info](#)

Has agreed to terms: ✓ Mon Nov 03 2014 20:02:14 GMT+0000 (UTC)

Standard Installation:

Paid for installation:

Extra Labor HOURS:

[Save](#)

Extra Equipment:  Price:  Tax (%):  [Add Equipment](#)

Discount Amount (\$):  Discount Label:  Discount Notes:  [Add Discount](#)

The Discount Label will show up on user's bill. Notes are internal documents.

Plan Activity

Previous Plan: hold New Plan: hold Date: Sat Feb 28 2015 00:10:39 GMT+0000 (UTC)

[OK](#)

Web: 800-333-3333 connected 14921 Navarro Mx Manchester limited 08-14-14 08-01-14 headpaud@comcast.net

# Node Database

staging.furtherreach.net:3000/node?id=f93567ad79544150c72021f7

CelerateSubscribersNodesHardwareSitesDiscoveryBilling Export DownloadEmails Admin

globalAdd Search Field

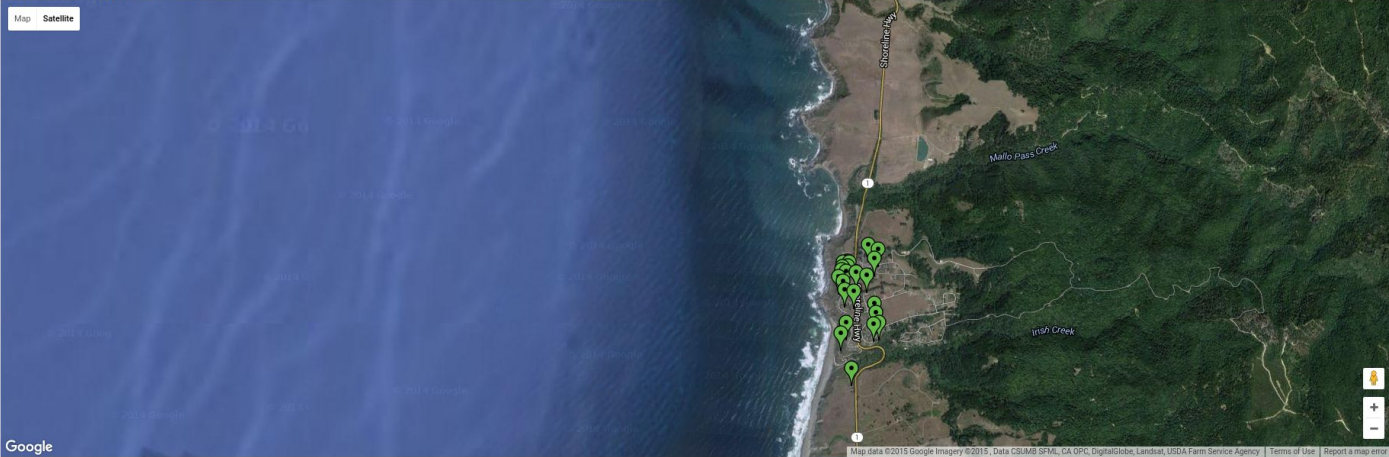
150Search nodes

☒ Show Map☐ Show All Links☐ Recenter Map

Add New Node

Right click to see lat/ing at specific location

MapSatellite



Map data ©2015 Google Imagery ©2015, Data CSUMB SFML, CA OPC, DigitalGlobe, Landsat, USDA Farm Service Agency | Terms of Use | Report a map error

	Name	Hardware	MAC	Management IP	
	10mile-af5u-lh	airfiber_5u-int	24:A4:3C:38:24:48		
	10mile-nbm5-bill	powerbeam_5ac_500	04:18:D6:4E:CD:F9		
	10mile-powerbeam5ac-hs	nanobeam_m5_400	04:18:D6:4E:CE:2F		

# Lesson: Build software to support business process

- Simple network means simple network management
- Existing network management systems work well enough
- Major gap: integration of non-network elements
  - Power systems
  - Inventory
  - CRM
  - Billing
  - Physical location of equipment
- Management and operational subsystems of Celerate were most important for day-to-day operation

# Building a WISP is a non-technical problem (mostly).

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