Networks Beyond the Reach of Networks: What Roles Can 5G Play?

Henning Schulzrinne

Columbia University
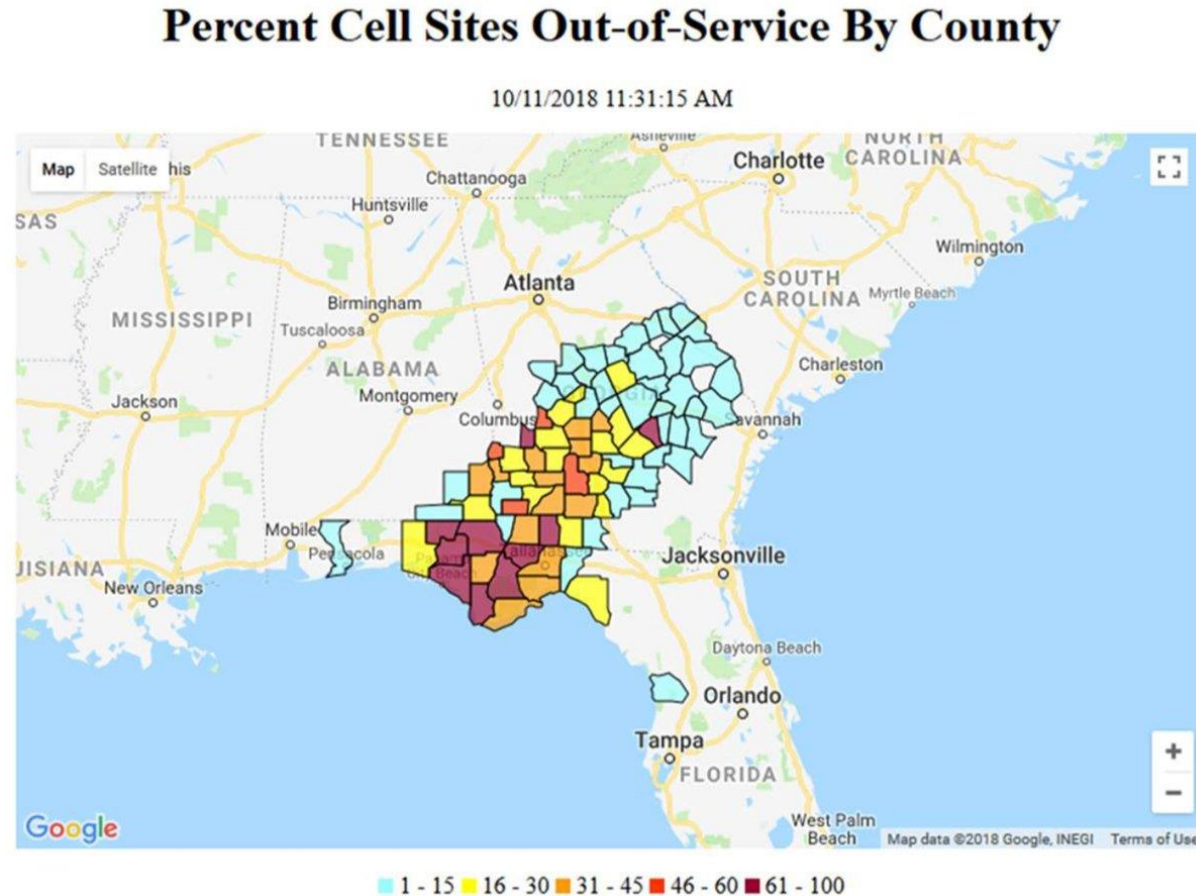
October 23, 2018

Design principles & lessons

- Keep applications independent of lower layers
  - in particular, PHY
  - = fundamental design principle of the Internet, even if 50 years old…
- Allow island deployments that can merge to backbone when available
  - may only be intermittent – but information needs may also be less urgent
- Rely on commercial equipment where possible
  - ruggedized, but same specs
  - allows integration of non-traditional responders (Cajun Navy)
- Simplify authorization
  - mediated trust
- Require no specialized resources
  - no special spectrum licenses
  - no carrier technicians or vehicles
  - minimal training (IT technician level)

Cell networks may not be available

- "She explained that in some cases even after service is restored, it quickly goes out again. New fiber cuts arise as recovery workers begin clearing roads and removing debris from residential properties, and as electric poles get replaced.

  - "Our fiber crews are working around the clock to make repairs," Schultz said Monday. "While they are making good progress, we are still experiencing new fiber cuts as soon as repairs are made."

Percent Cell Sites Out-of-Service By County

10/11/2018 11:31:15 AM

1 - 15 16 - 30 31 - 45 46 - 60 61 - 100

Fires, too

Oct. 10, 2017, 1:51 p.m.

By DAKOTA SMITH and JOY RESMOVITS

Damaged cell towers create communication problems in Northern California fire zone

...sidents reported problems with getting alerts about fires, an issue ...by fire damage to cellphone towers, a county spokeswoman said
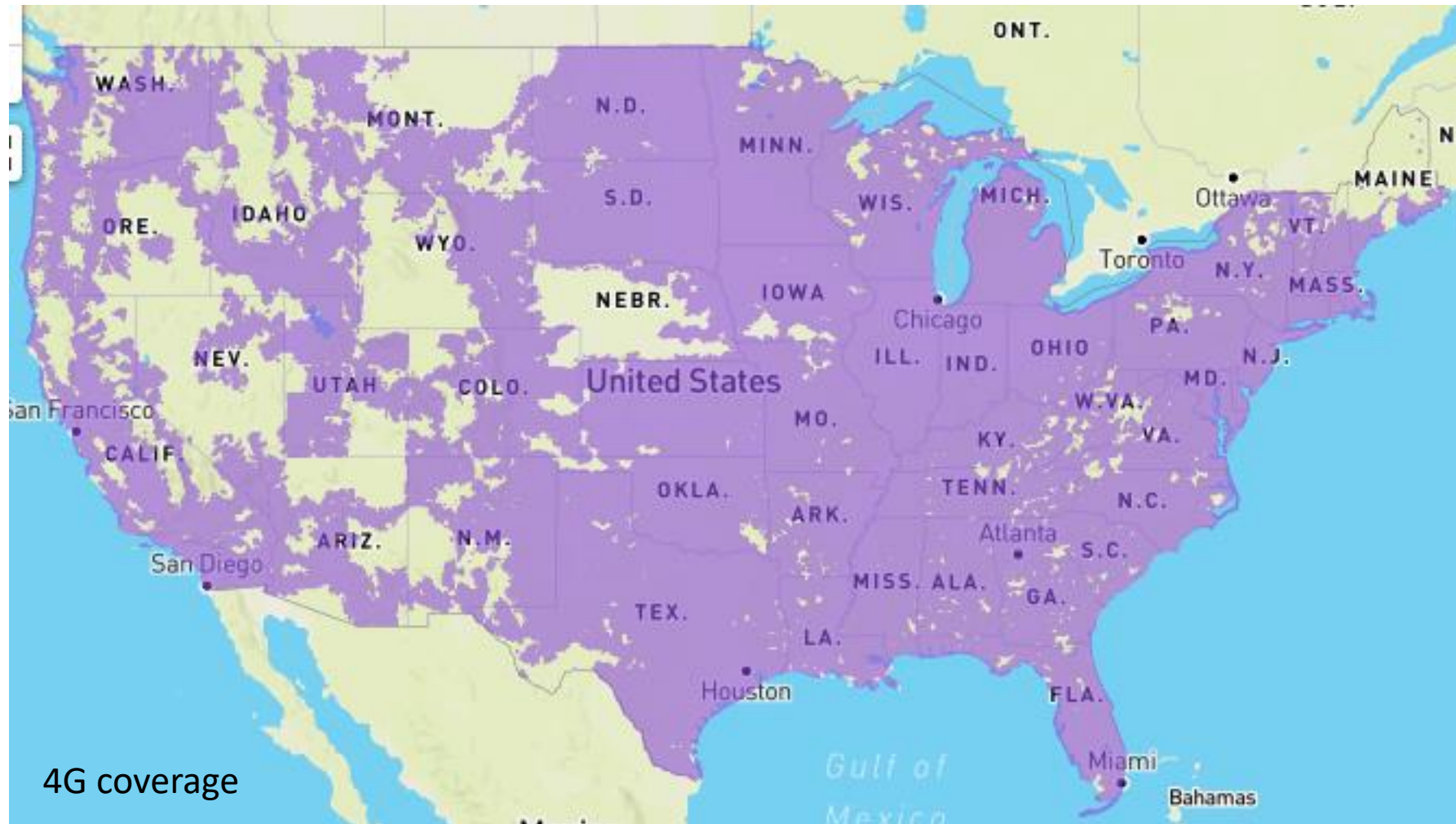
"We are well aware that there are challenges," said Napa County Public Information Officer Kristi Jourdan. "It's been a challenge to get information to folks at times using Nixle. I know some folks have had problems receiving text messages."

Nixle is a popular alert system used by public safety agencies and schools.

In a news conference Tuesday, Mark Ghilarducci, director of the California Governor's Office of Emergency Services, acknowledged that many evacuees are struggling to access alerts or get in touch with each other.

He said that across Northern California, 77 cell sites were destroyed or damaged, and that the state is creating mobile communications units to help.
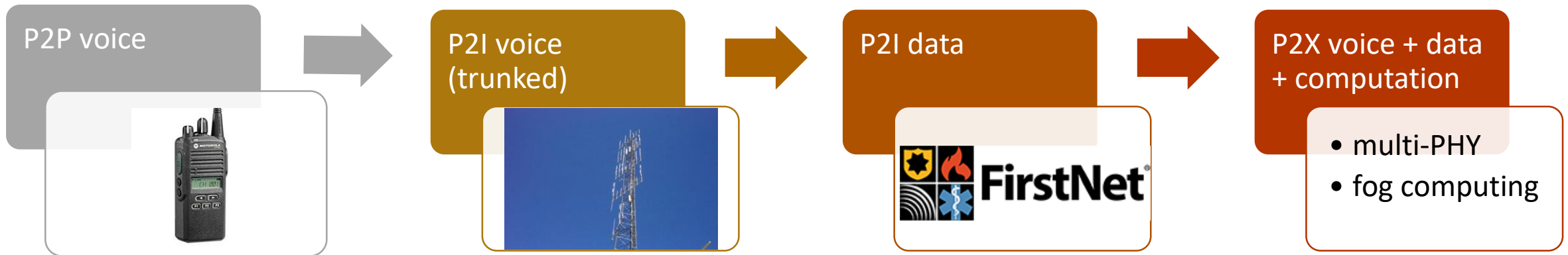
The inverse fire map

4G coverage

"Whatever it takes" communication

Progression

P2P voice

→

P2I voice (trunked)

→

P2I data

→

P2X voice + data + computation

- multi-PHY
- fog computing
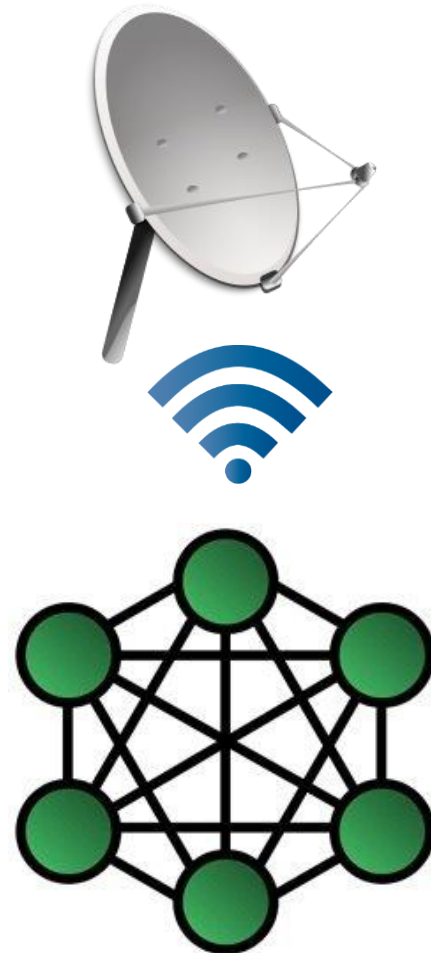
Example: DARPA PHOENIX nodes

DARPA RADICS: support blackstart for electric utilities

DECT

802.11af
(TVWS)

high-bandwidth
VHF

- mesh network (OLSR)
- self-configuring – just turn on
- network-technology agnostic (not just 4G)
- local services (VoIP, messaging, edge cloud)
- with diagnostics and traffic isolation

SDR: P.25
over VHF + Codec2 + data

Internet Protocol radio communication

Distance	Technology	Bandwidth	Example radio
< 1 mi	24 GHz	< 1 Gb/s	Ubiquiti AirFiber
< 10 mi	802.11 5 GHz	< 300 Mb/s	Ubiquiti RP5AC
< 25 mi	802.11af (TVWS)	< 24 Mb/s	Carlson Wireless
< 50 mi	VHF	640 kb/s in 50 kHz (FD) 40-160 kb/s in 12.5 kHz	MiMOMax Tornado
< 1000 mi	HF	kilobits	

tethered
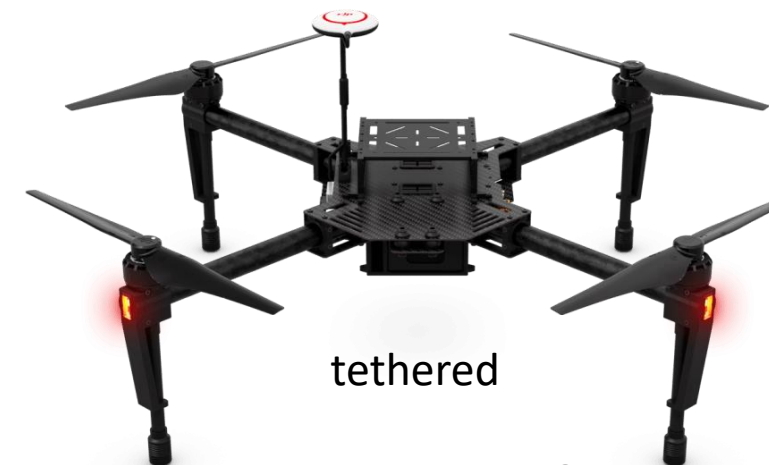
Need local computation

- Mobile devices don't have the battery or continuity

- Remote cloud is too unreliable

- $\rightarrow$ good application of fog computing

- Applications:
  - local VoIP and text service
  - message store-and-forward
  - IoT data gathering and aggregation
  - local GIS system
  - video processing
  - higher-level data compression
  - informational and transactional resources for public (e.g., check-in)

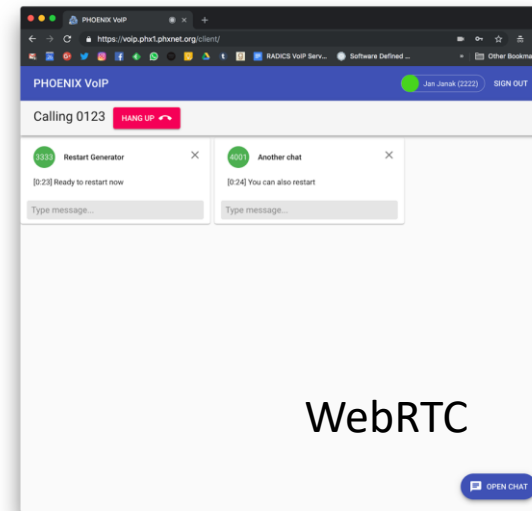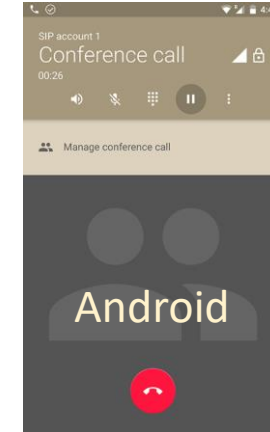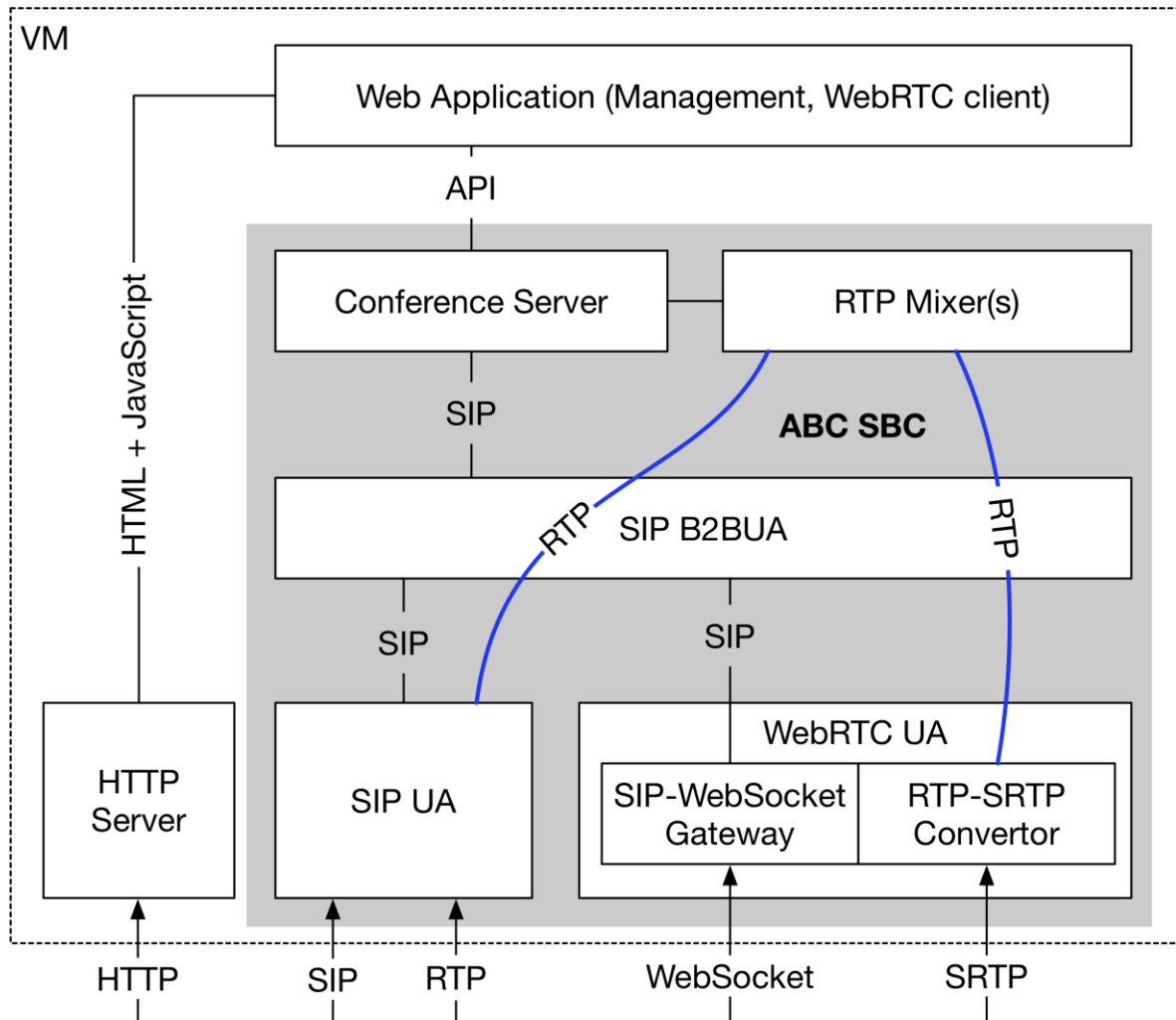# Integrating information flows

tailored sitreps
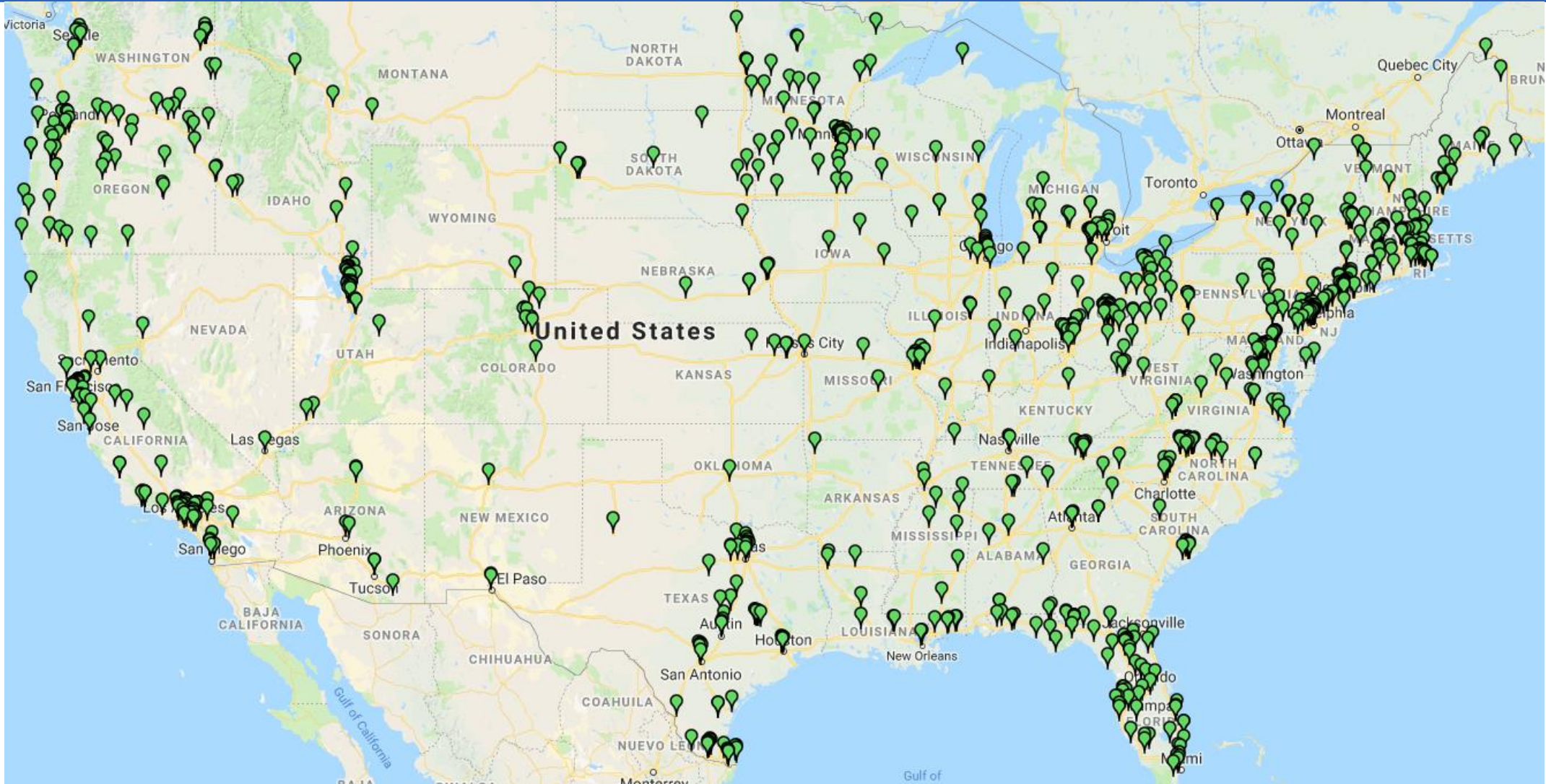
Example: distributed VoIP implementation
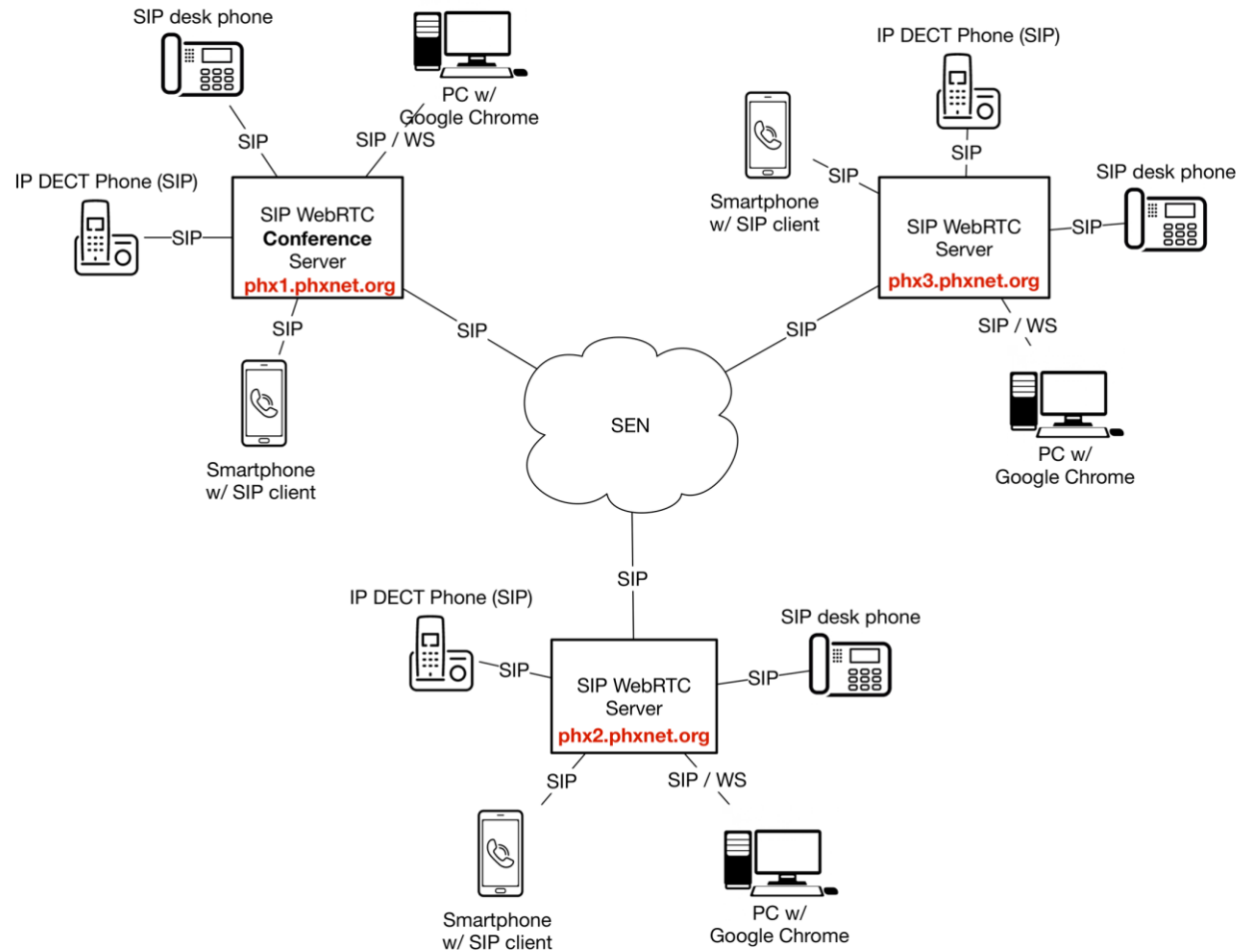
Every node can function by itself
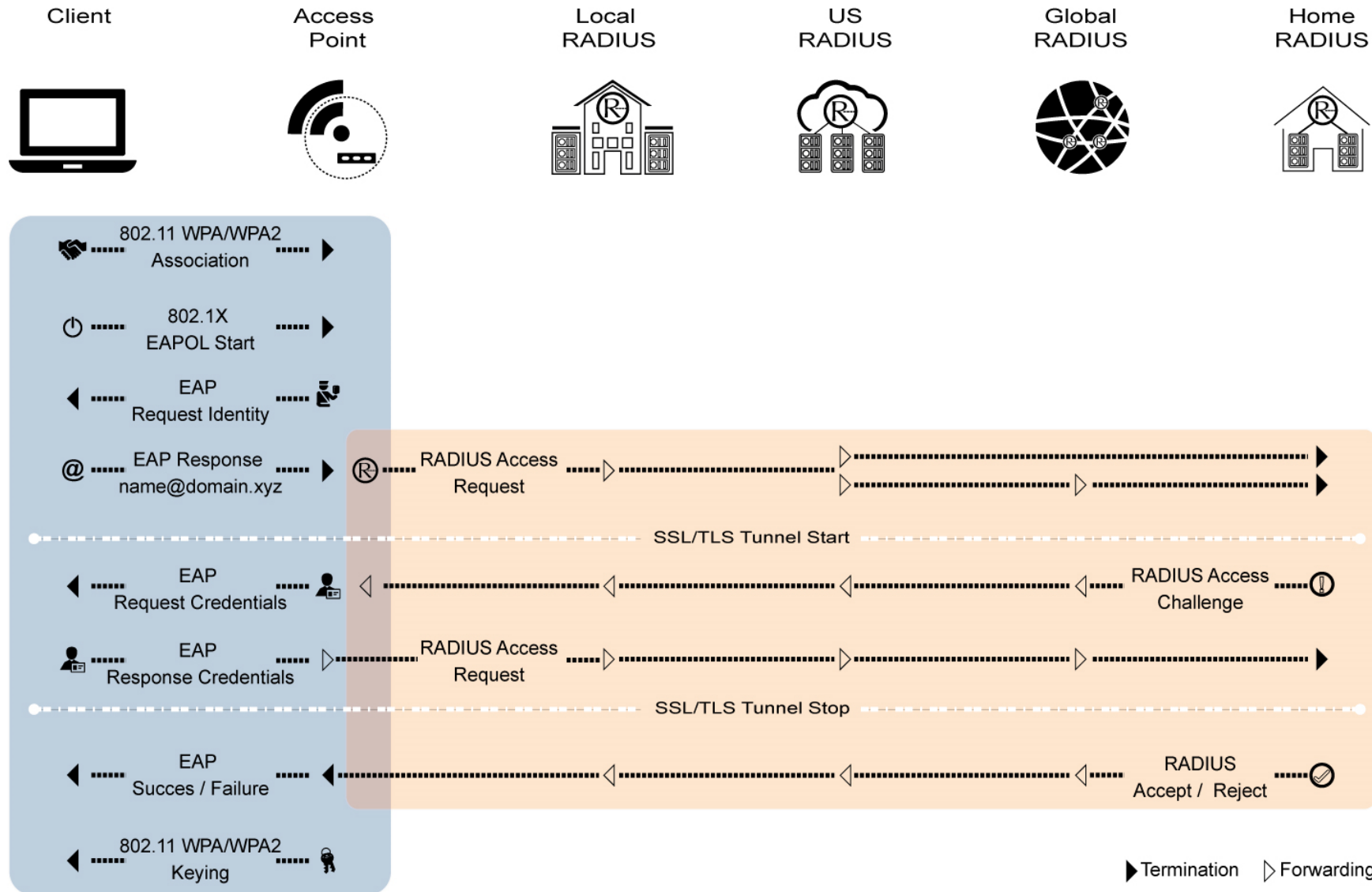Local capability, "global" dial plan

Node example – complete SIP VoIP

Federated identity: eduroam – US campuses

Federated identity: eduroam - mechanism

For public safety, plan for surprises

Generation	Expectation	Surprise	Cost per GB
0G (landline)	voice	fax & modem	
1G	corporate limousine	eavesdropping	
2G	better voice quality ("digital!")	SMS	$1000
3G	WAP	web	$100
4G	IMS	YouTube, WhatsApp, notifications	$10
5G	IoT (low latency)	?	$1?

- underestimated cost and WiFi-equivalence as drivers
- are the even generations the successful ones?

Conclusion

- Lessons of 1G through 4G (+ the Internet): avoid coupling services and network

- Consider hybrid networks as alternative
  - allow for incremental service and technology upgrades
  - helpful: open-source 4G & 5G implementations for local "cellular" service

- Convincing use case for fog computing
  - even if dubious elsewhere