

Community Networking @



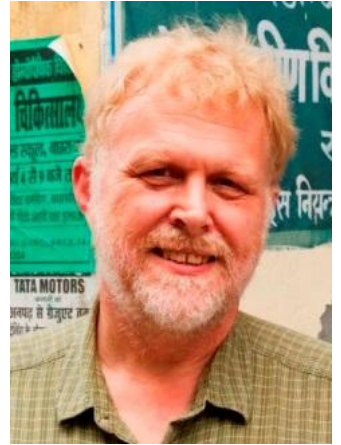
Kurtis Heimerl

kheimerl@cs.washington.edu



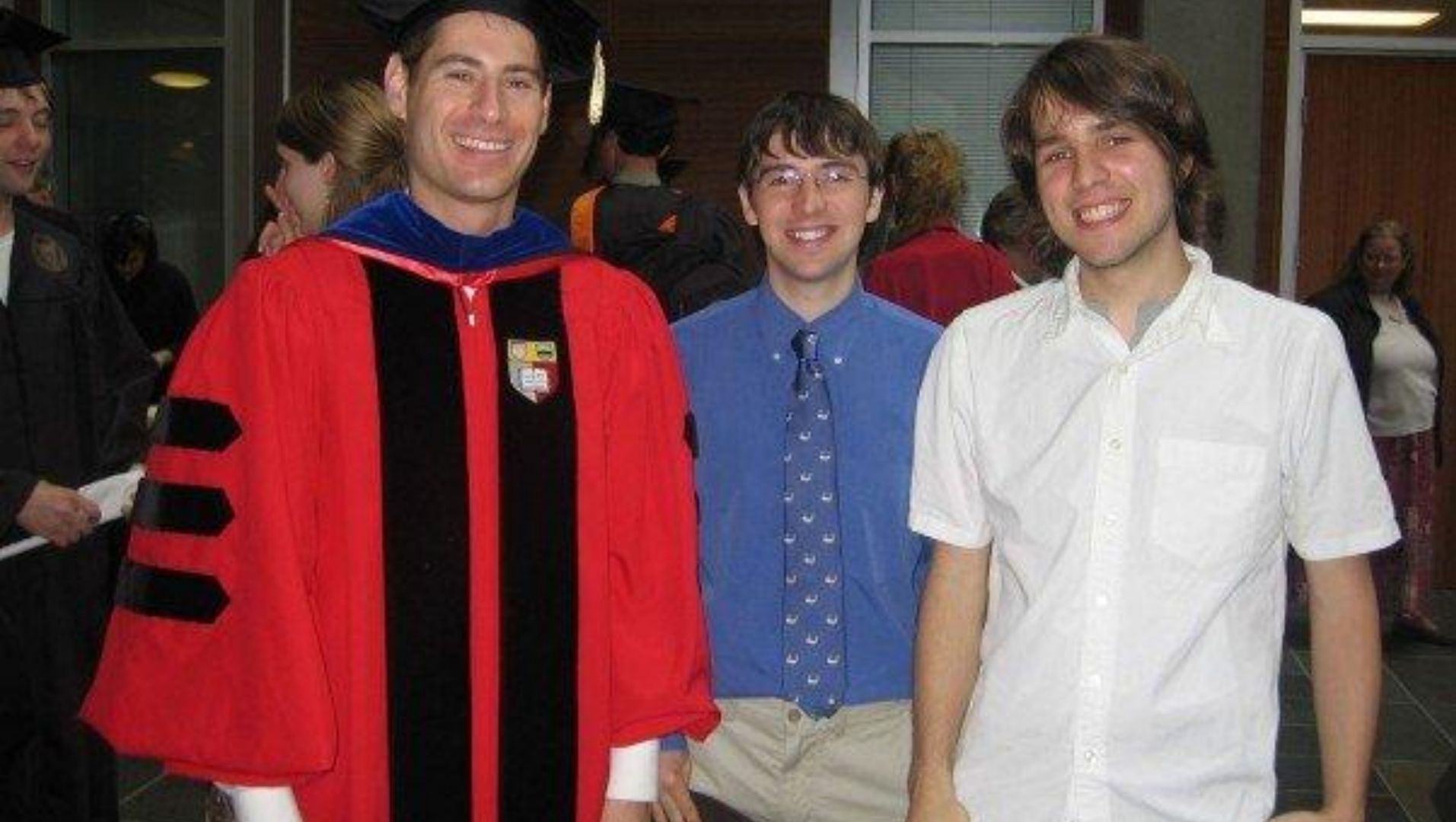
ICTD Lab @ W

- <http://ictd.cs.washington.edu>
- Established research group focusing on technology and poverty (ICTD)
- Professor Richard Anderson
 - ~6 Students
 - Focus on health and financial services
- Professor Kurtis Heimerl (<https://kurti.sh>)
 - ~4 Students
 - Focused on Internet access and conservation











Brief Intro to Community Networking

- Networks built, owned, and operated by citizens and users in a participatory and open manner
- Many examples throughout the world:
 - Guifi.net > 35,000 nodes
 - Freifunk, Altermundi, NYC Mesh, etc
- Largely built on 802.11 “mesh” protocols
 - Operate primarily in unlicensed spectrum (with some licensed backhaul)
 - Technology is understood by “networking professionals”



Background on Community Cellular

- Built off of software implementations of cellular protocols - OpenBTS, Osmocom, OAI
- Example deployments:
 - Rhizomatica - Oaxaca, Mexico
 - AirWave Missions - Papua, Indonesia
- Long-term Evolution (LTE/4G)
 - CommunityLTE (CoLTE) deployed in Indonesia and Oaxaca. More deployments planned.
- “Traditional” rural-focused installations
 - Limited backhaul
 - Local Services











BE THE PHONE COMPANY.

No more waiting for coverage: now you can build cellular networks yourself.

[Learn More](#)





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26

3

10

Status

Photo

Facebook



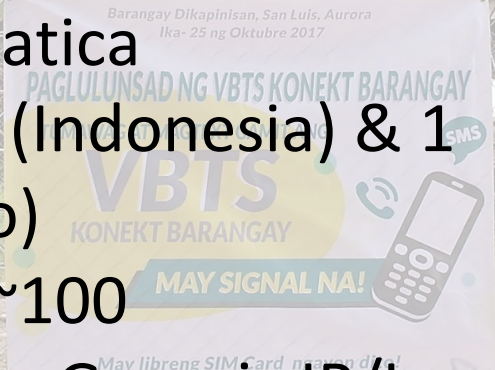
VBTS/CoCoMoNets

- Technology: GSM
- Partners: University of the Philippines/Globe Telecom/LGUs
- Sites: 17
- Users: ~3000
- Services: Voice/SMS



CoLTE

- Technology: LTE
- Partners: Ob Anggen /
Airwaves Missions /
Rhizomatica
- Sites: 1 (Indonesia) & 1
(Mexico)
- Users: ~100
- Services: Generic IP/Local
Media



Scaling Community Cellular Networks with CCM

Shaddi
Hasan



Mary Claire
Barela



Matthew
Johnson



Eric
Brewer

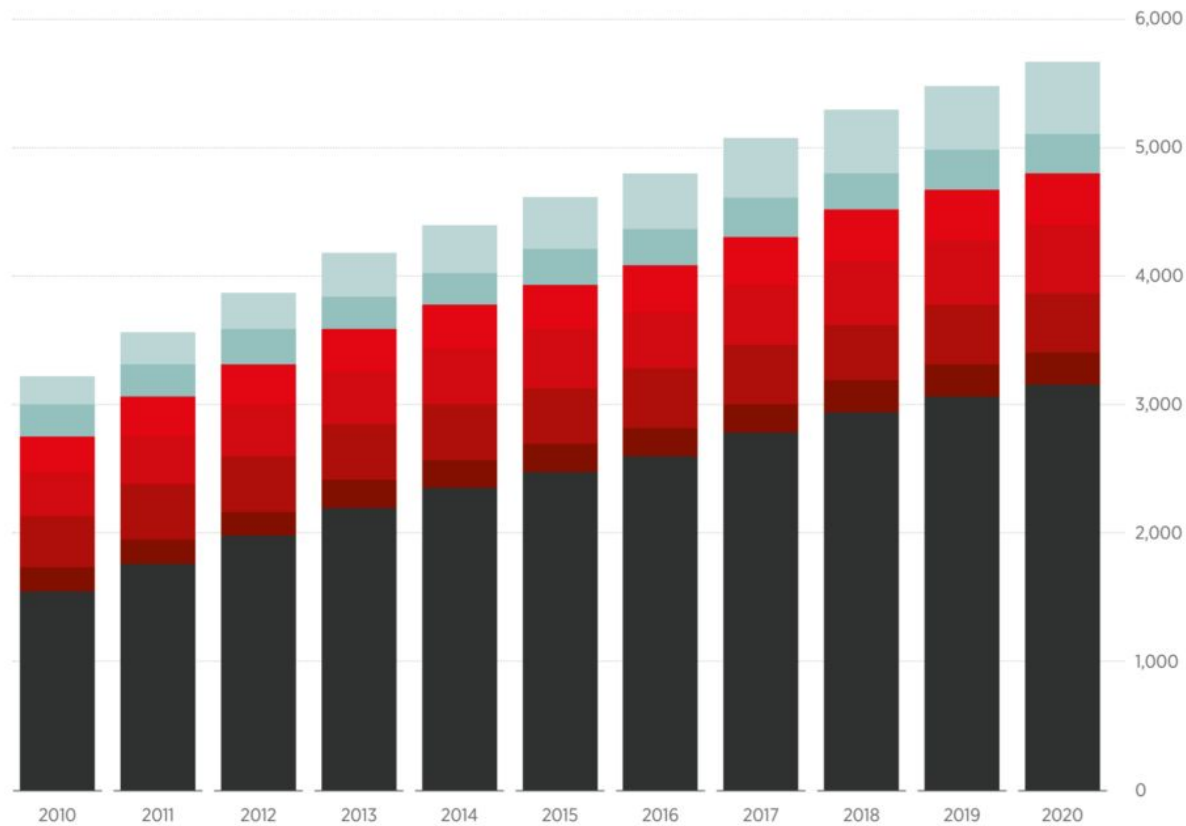


Kurtis
Heimerl



Unique subscribers by region

(Millions)



“In most countries, even in Africa, mobile operators have already rolled out 2G and 3G network coverage as far as possible within the envelope of a commercially sustainable business model.”

1.7 billion

People outside mobile broadband coverage

400 million

People outside **any** mobile coverage

Community Cellular Networks

Built **by and for** their users

Run **cooperatively**

Optimized for **local needs**

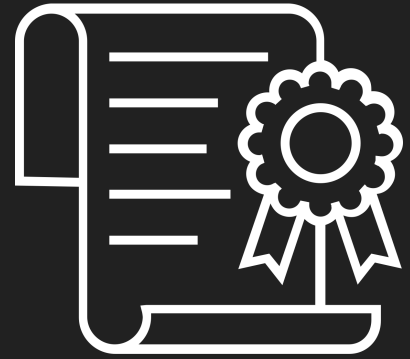
Leveraging **local resources**

Providing **local services**

Sustainable in rural areas



Rhizomatica (Mexico)



Scale

of telcos

+

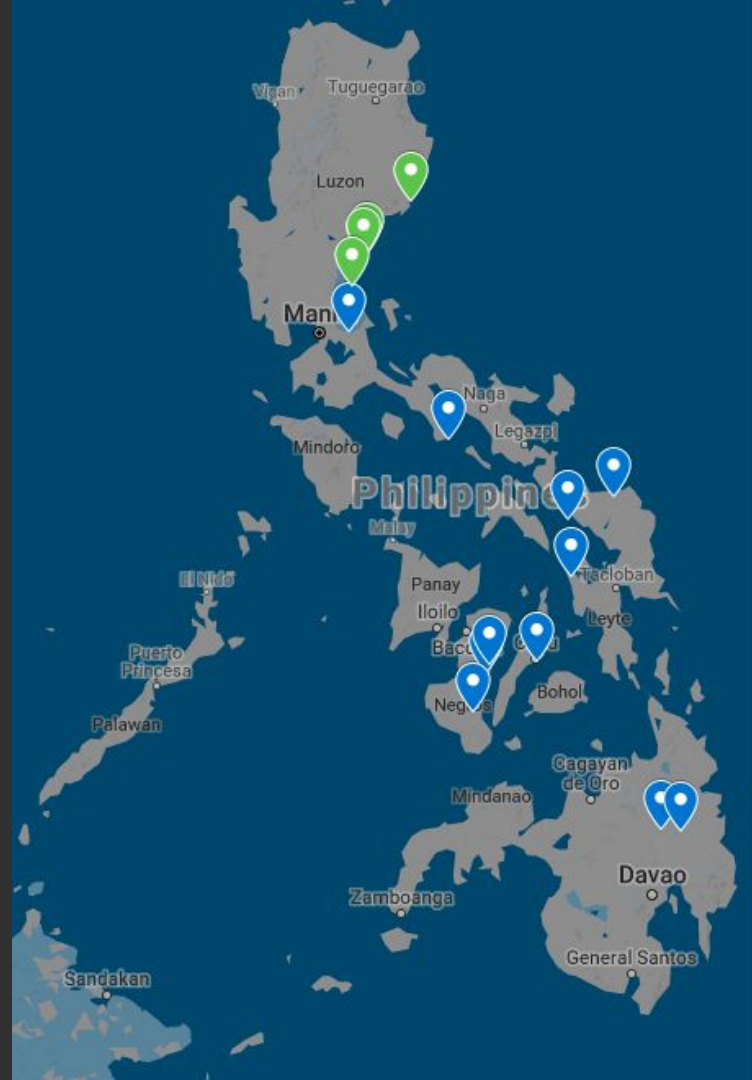
Reach

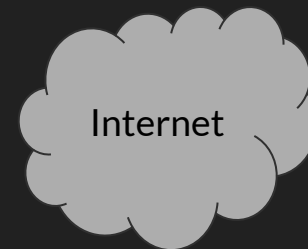
of community networks

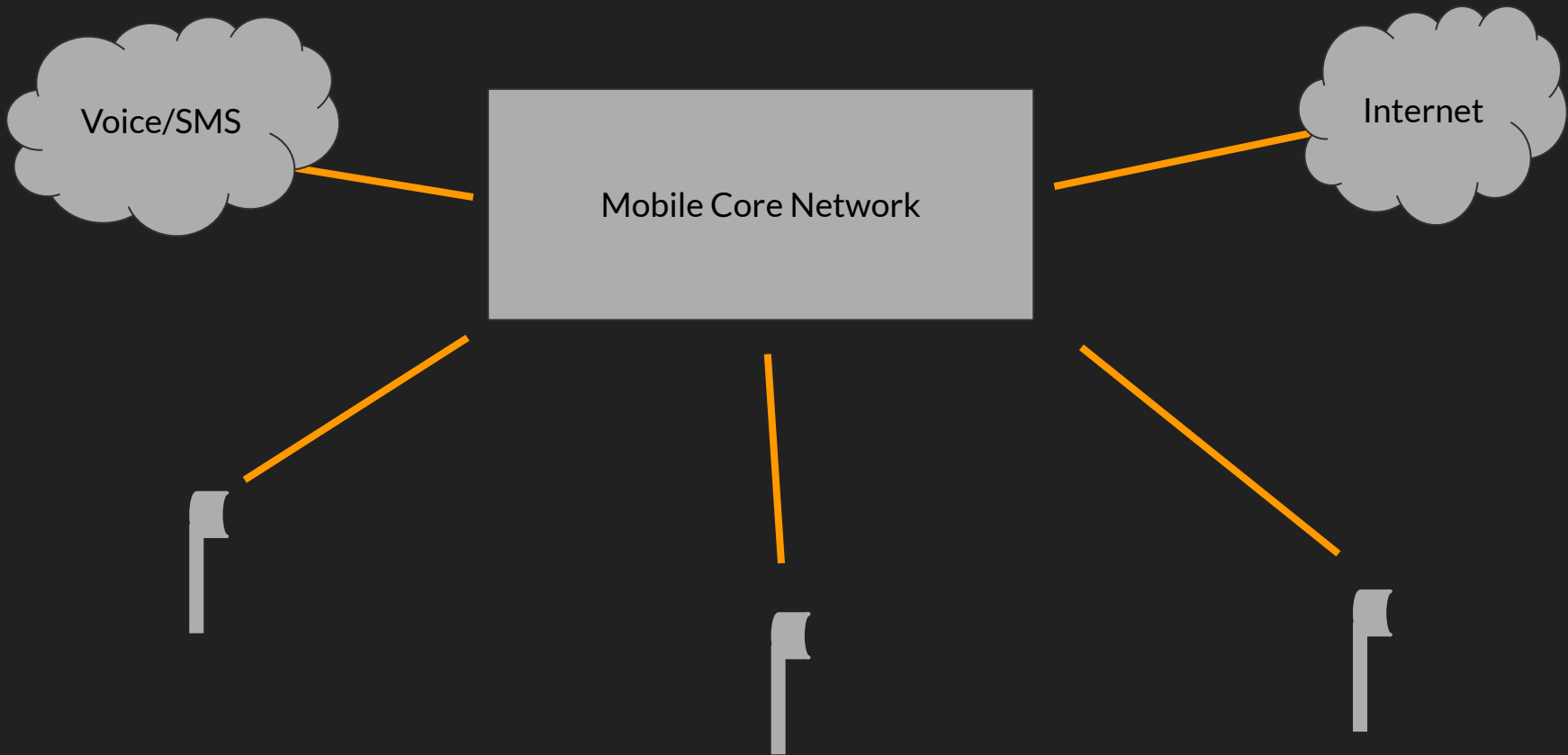
CommunityCellularManager

github.com/co-cell/ccm

3 years
17 sites
2.8K people
Telco partner





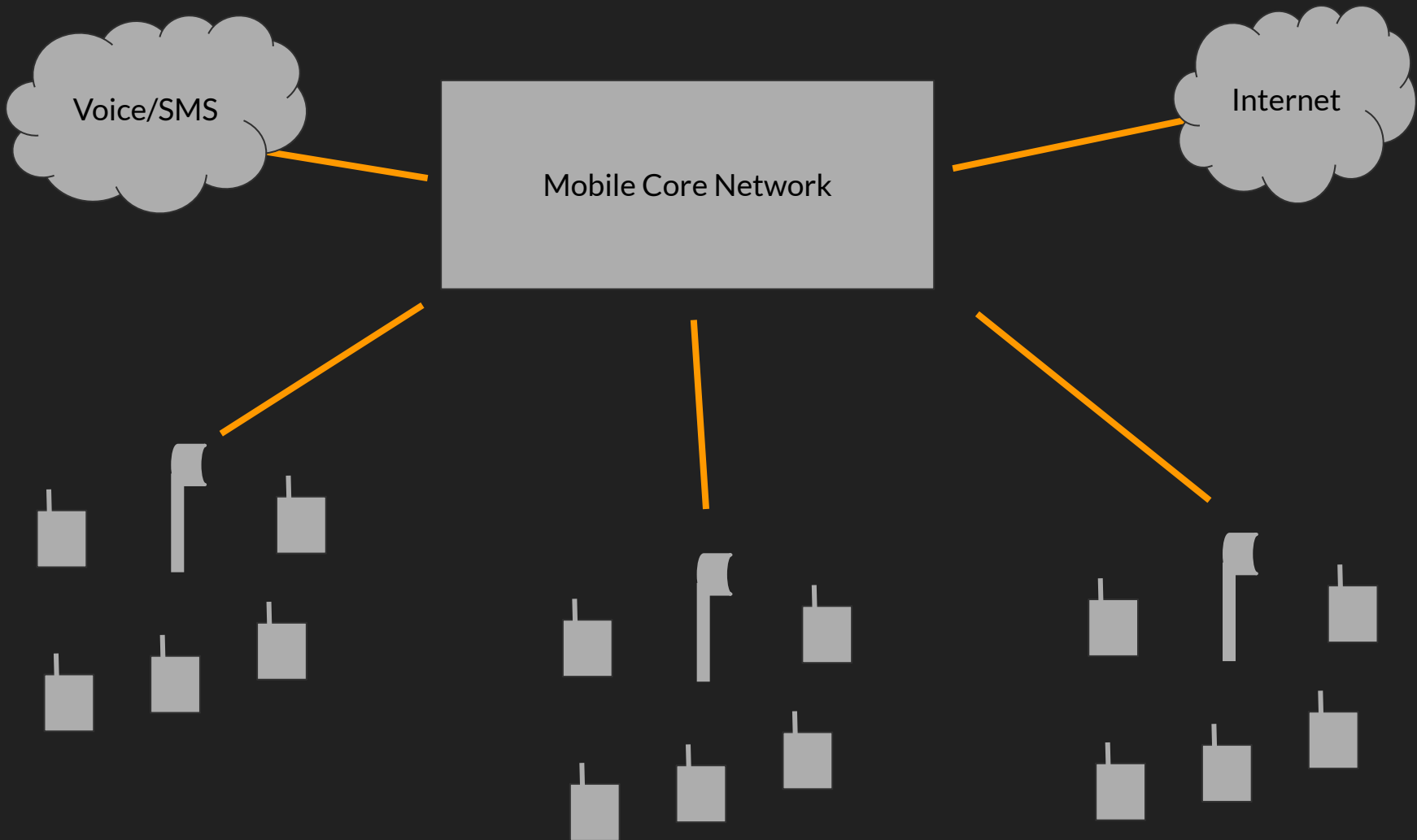


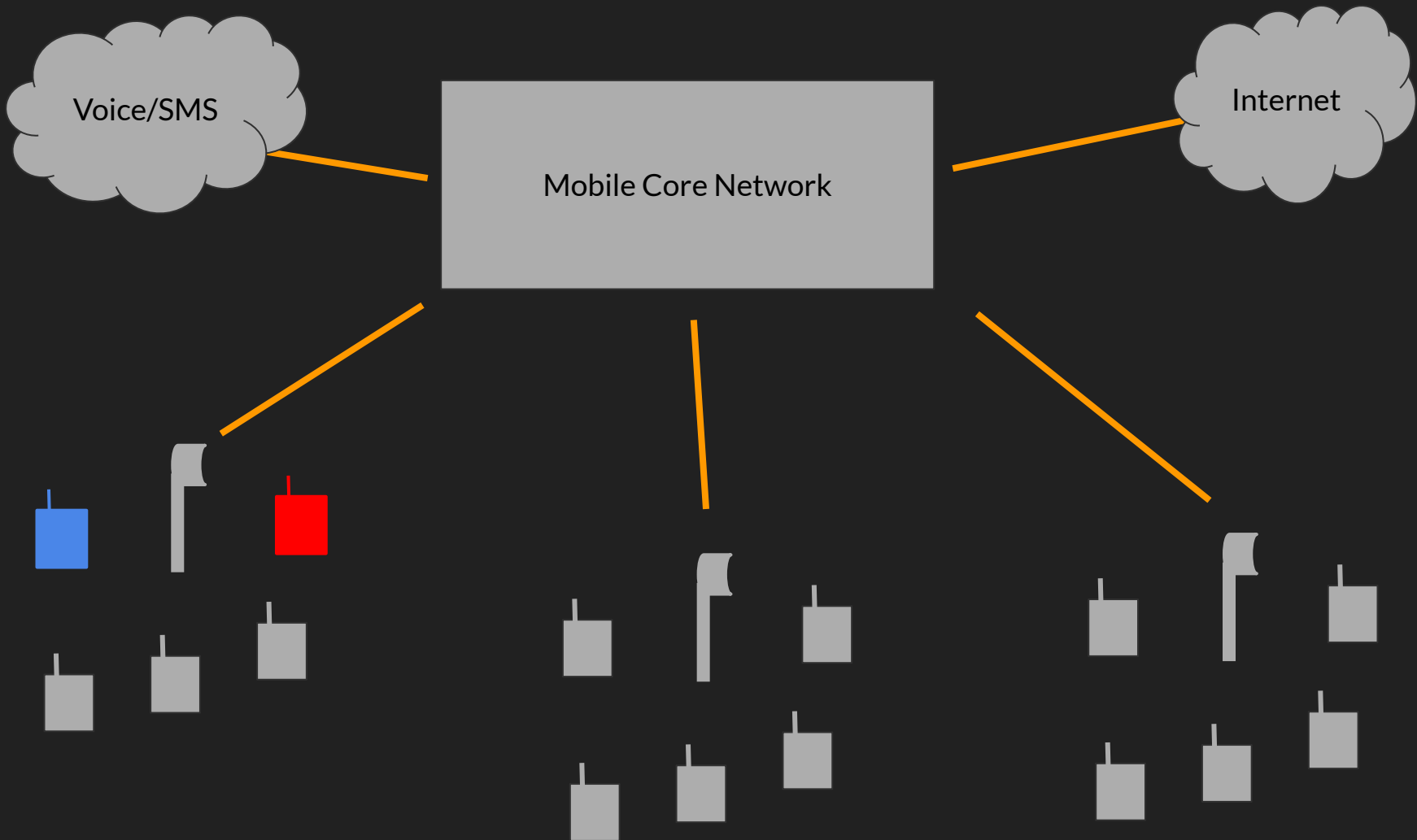
Voice/SMS

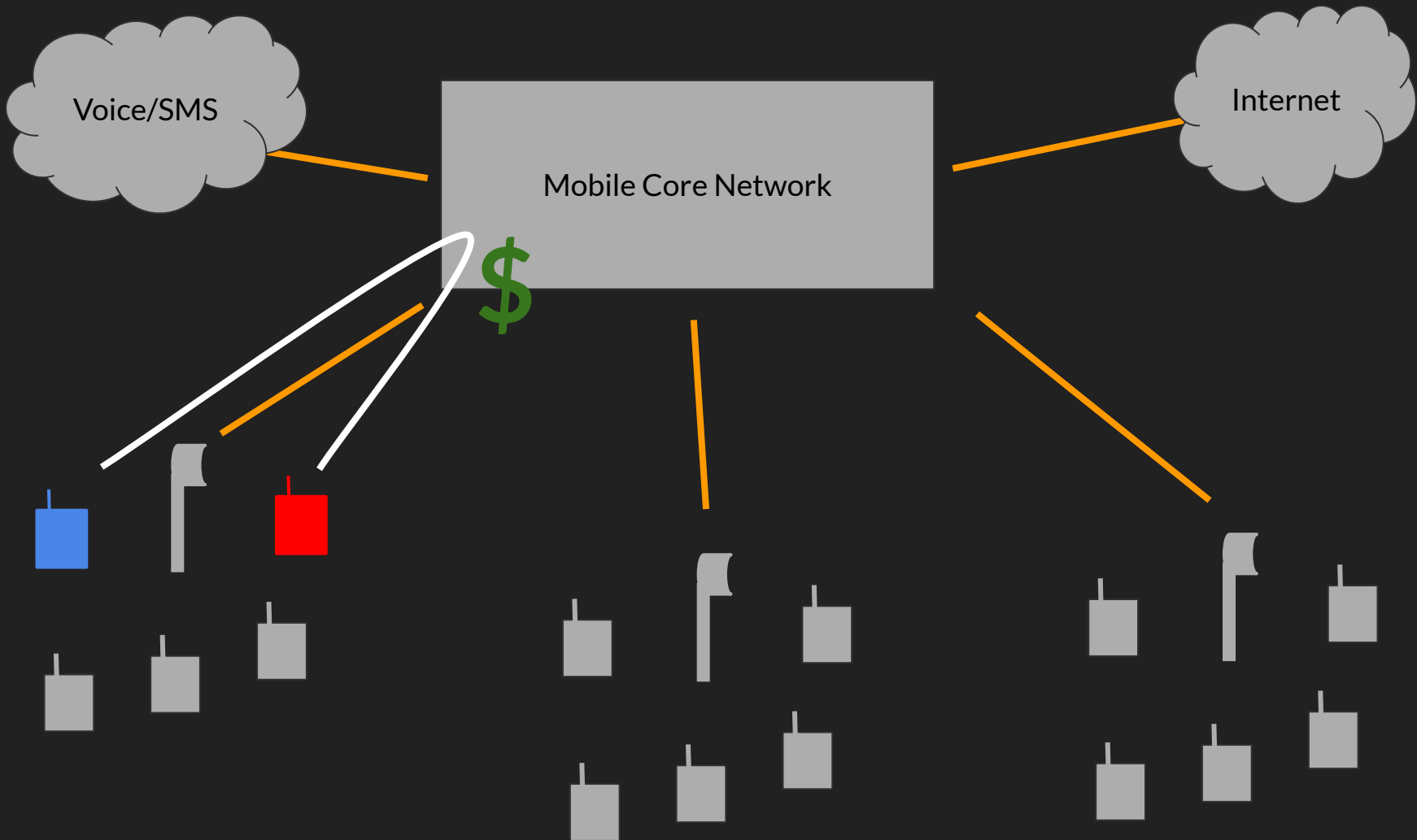
Mobile Core Network

Internet









1. No flexibility across sites



1. No **flexibility** across sites
2. Doesn't **degrade gracefully**



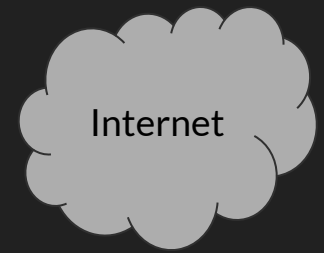
- 
- The diagram illustrates a Mobile Core Network architecture. At the top center is a grey rectangular box labeled "Mobile Core Network". To its left is a grey cloud labeled "Voice/SM". To its right is another grey cloud labeled "Internet". Below the "Mobile Core Network" box is a large, semi-transparent green dollar sign "\$". At the bottom of the diagram is a grid of small grey icons representing mobile devices, with one icon highlighted in red. Lines connect the "Voice/SM" cloud, the "Mobile Core Network" box, the "Internet" cloud, and the red mobile device icon to the three list items.
1. No **flexibility** across sites
 2. Doesn't **degrade gracefully**
 3. Modifying mobile core is **expensive**

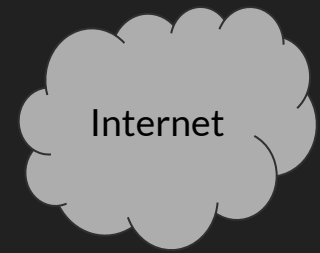
- 
- A network diagram with a central grey box labeled "Mobile Core Network". To its left is a grey cloud labeled "Voice/SM". To its right is a grey cloud labeled "Internet". Lines connect the central box to both clouds. A large green dollar sign is overlaid on the diagram.
1. No **flexibility** across sites
 2. Doesn't **degrade gracefully**
 3. Modifying mobile core is **expensive**

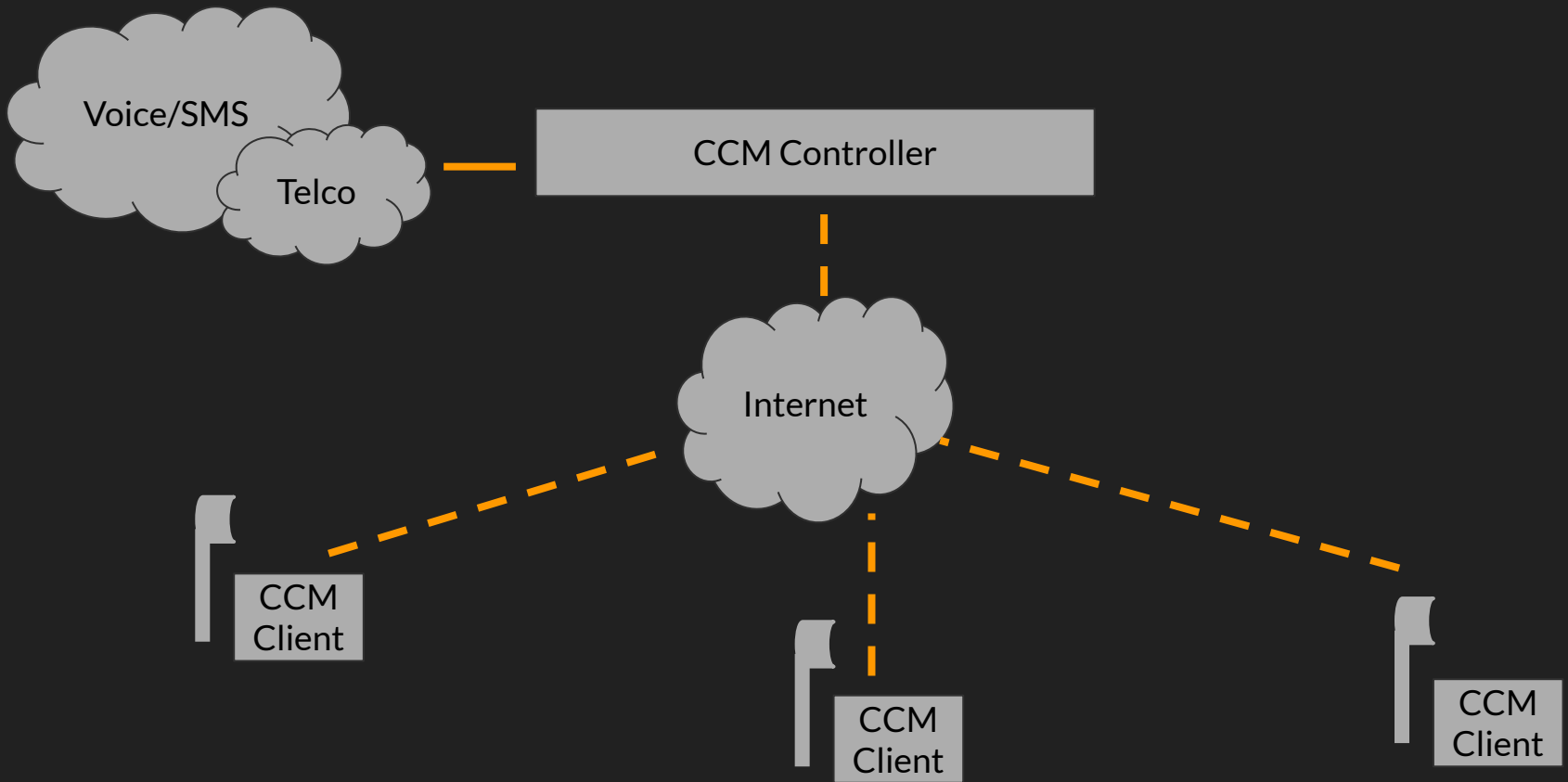
Centralize Management
Decentralize Network Services

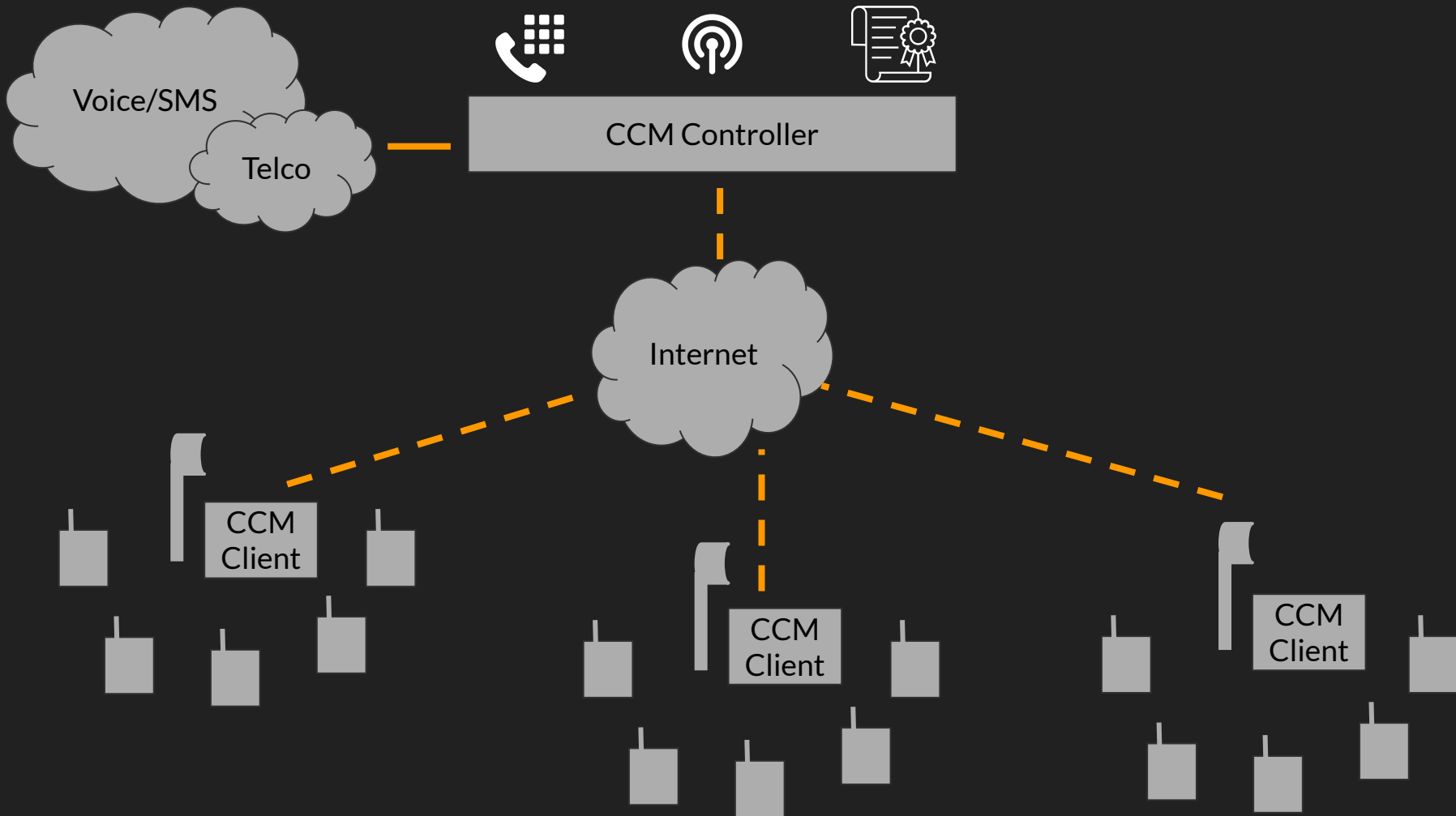
CCM is 2G only.

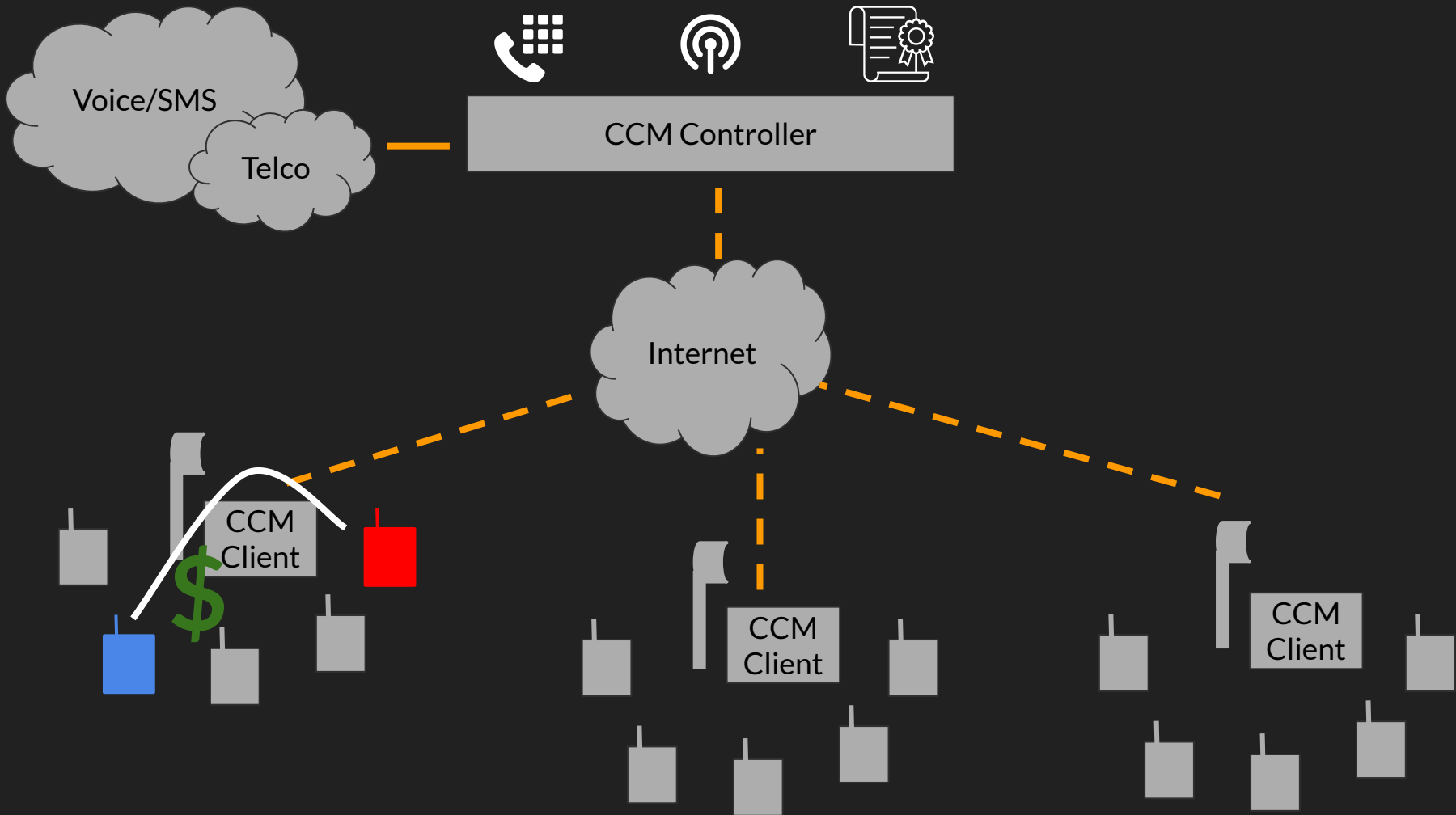
40% of devices only support 2G.*
LTE/5G is not [yet] relevant in our context.

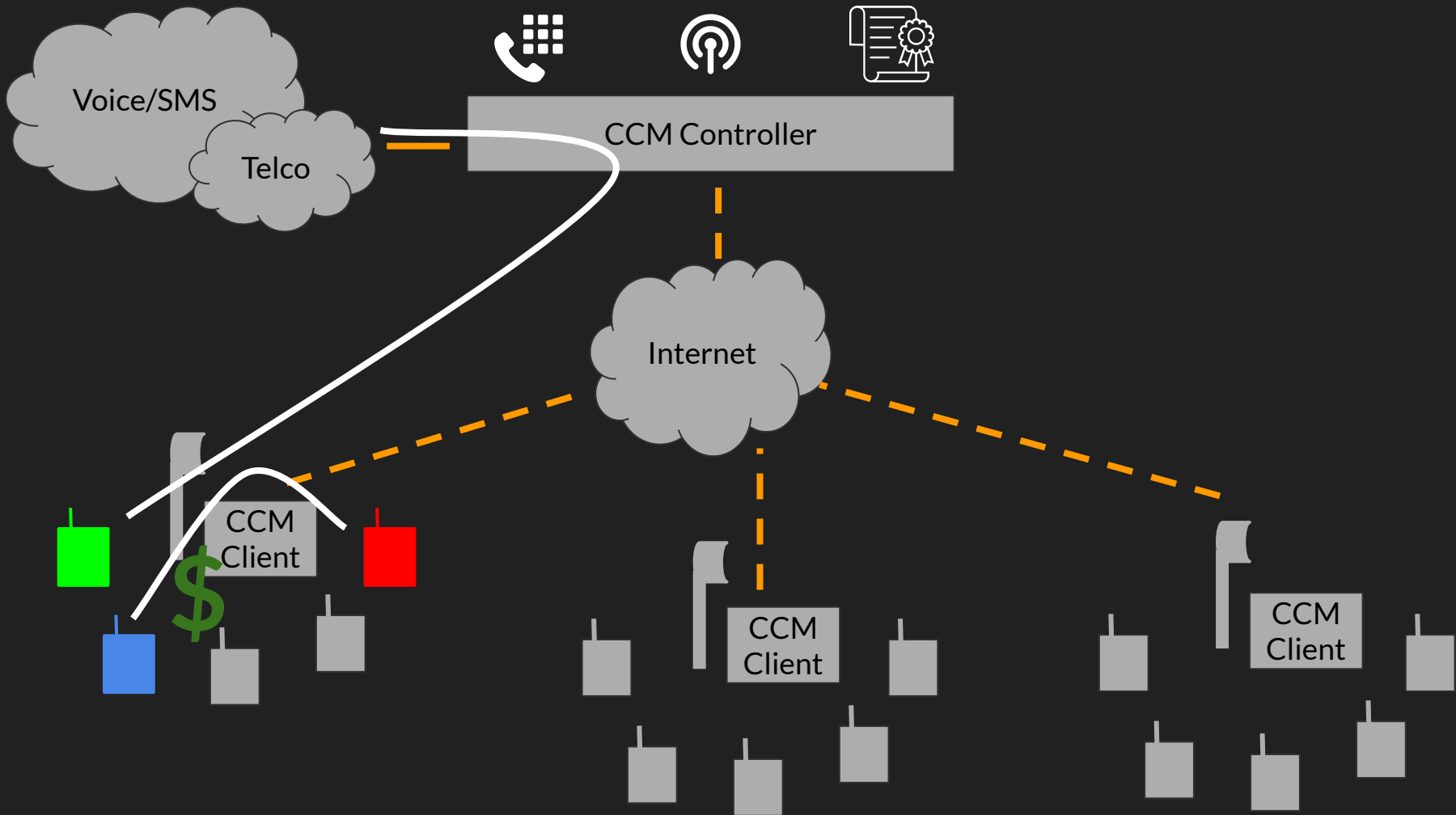


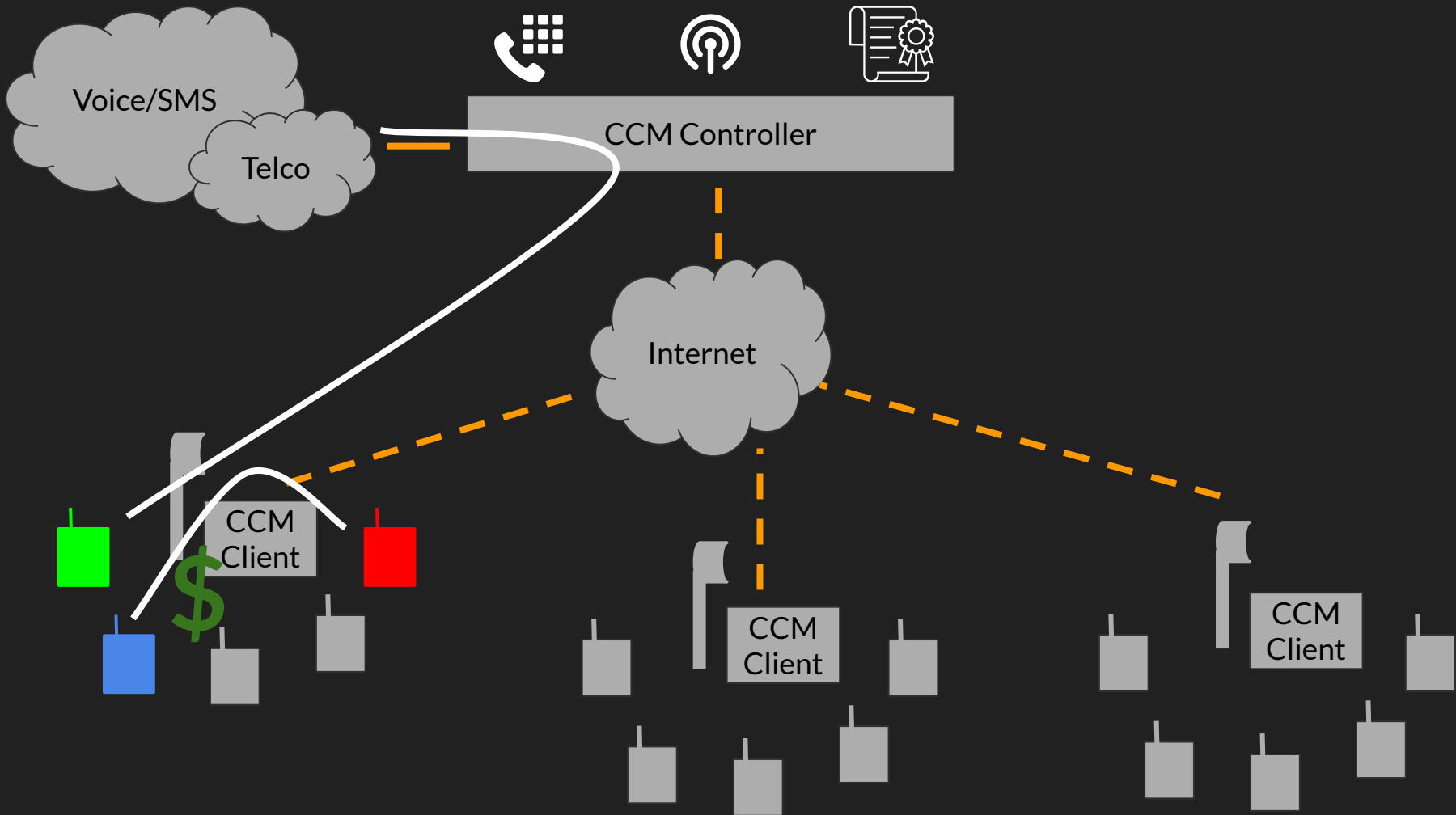


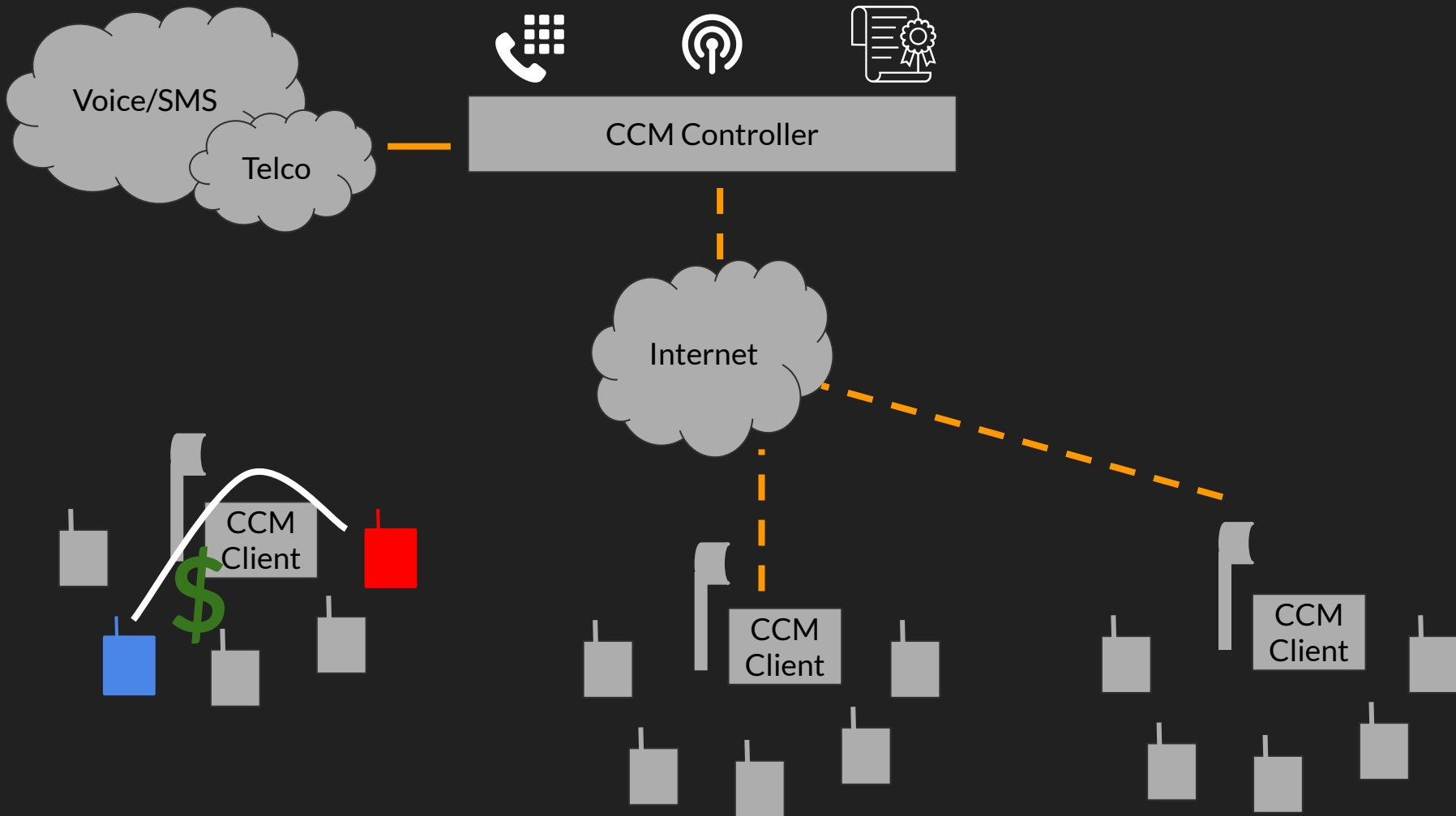


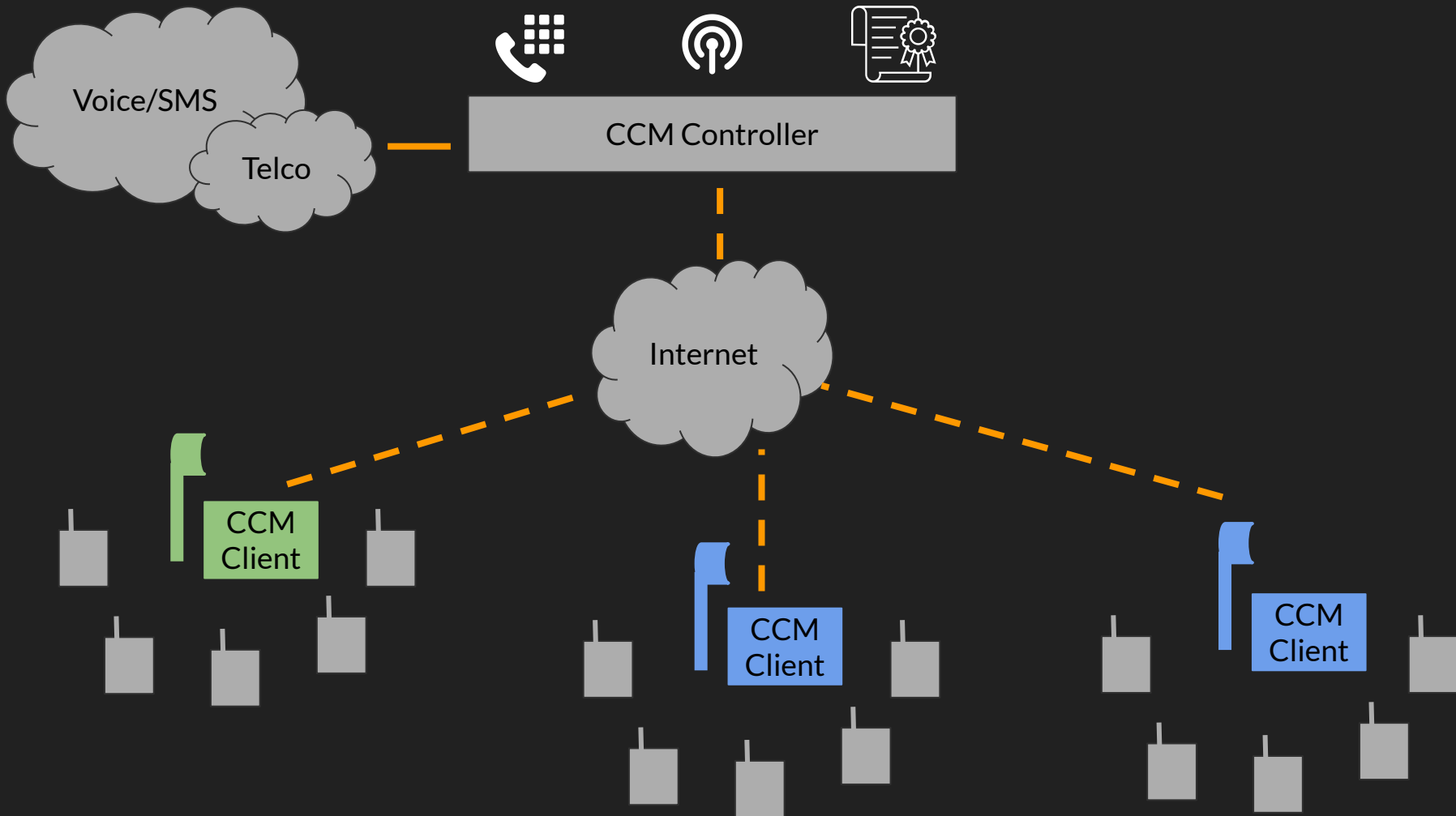




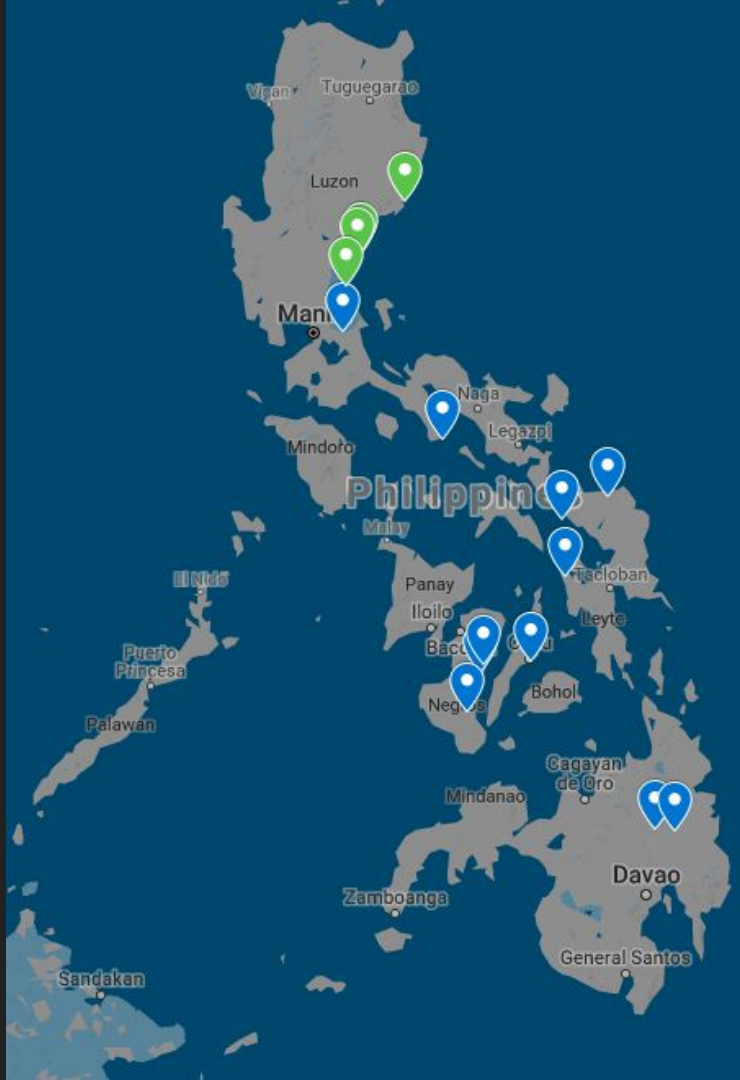








Deployment and Evaluation



UP Sites ●

Sabang-Limbok

Dikapinisan

Dibut

Diatorin

Bacong-Market

Dianao

Globe Sites ●

Tanay

Talisay

Binobohan

Ginulagan

Balogo

Casalaan

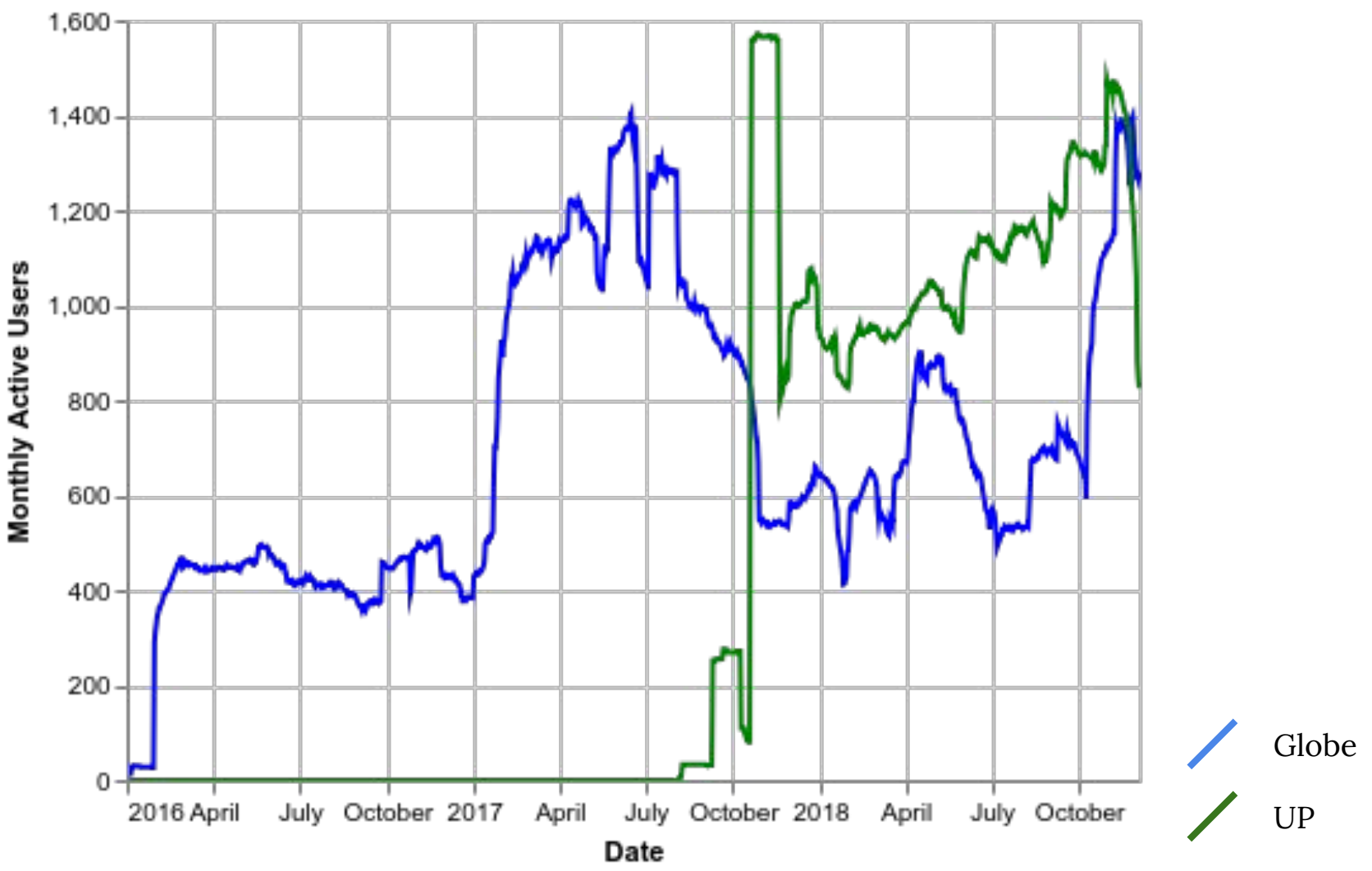
Banat-i

Mayaposi

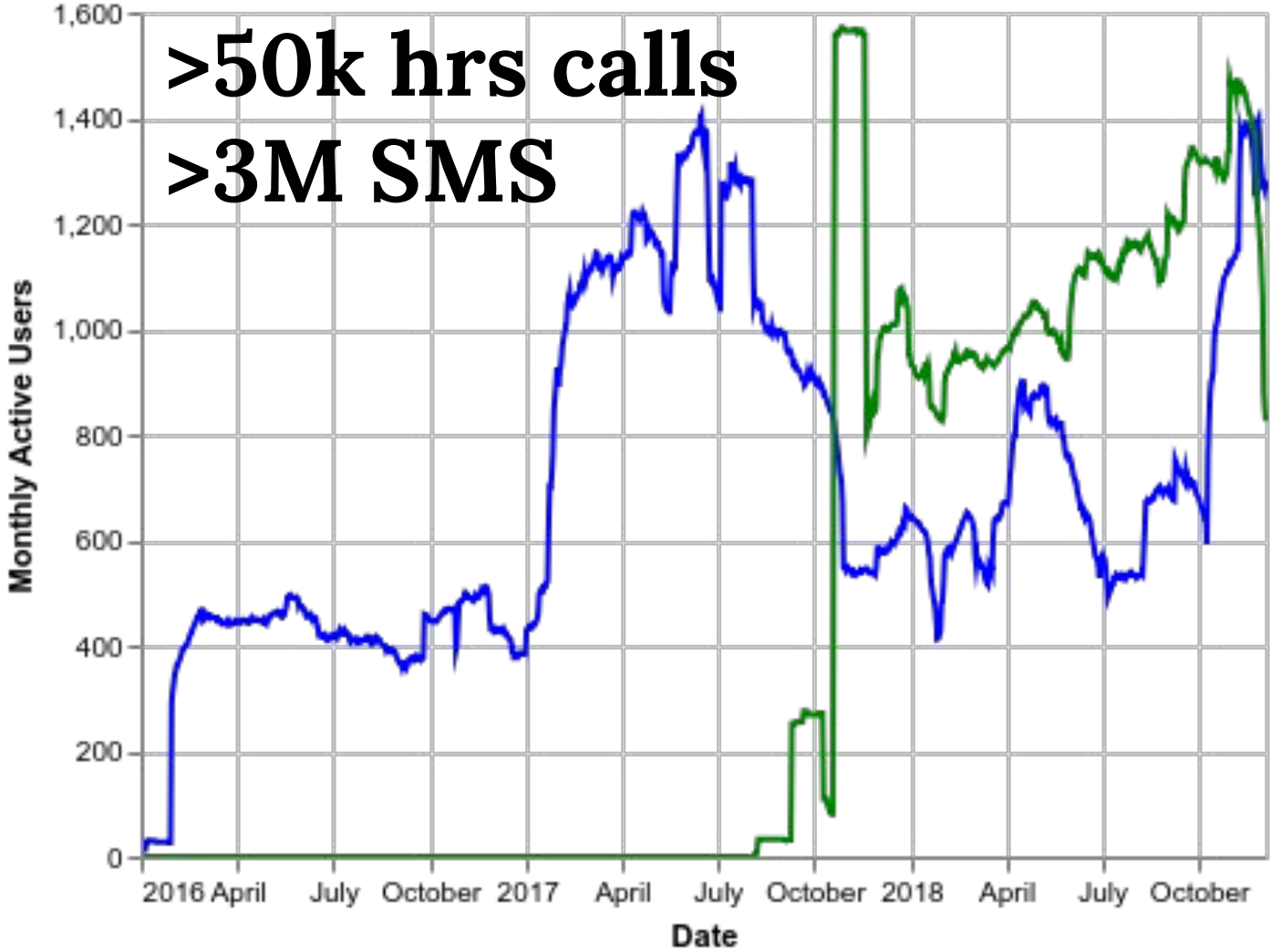
Golden Valley

San Mariano

Binucayan

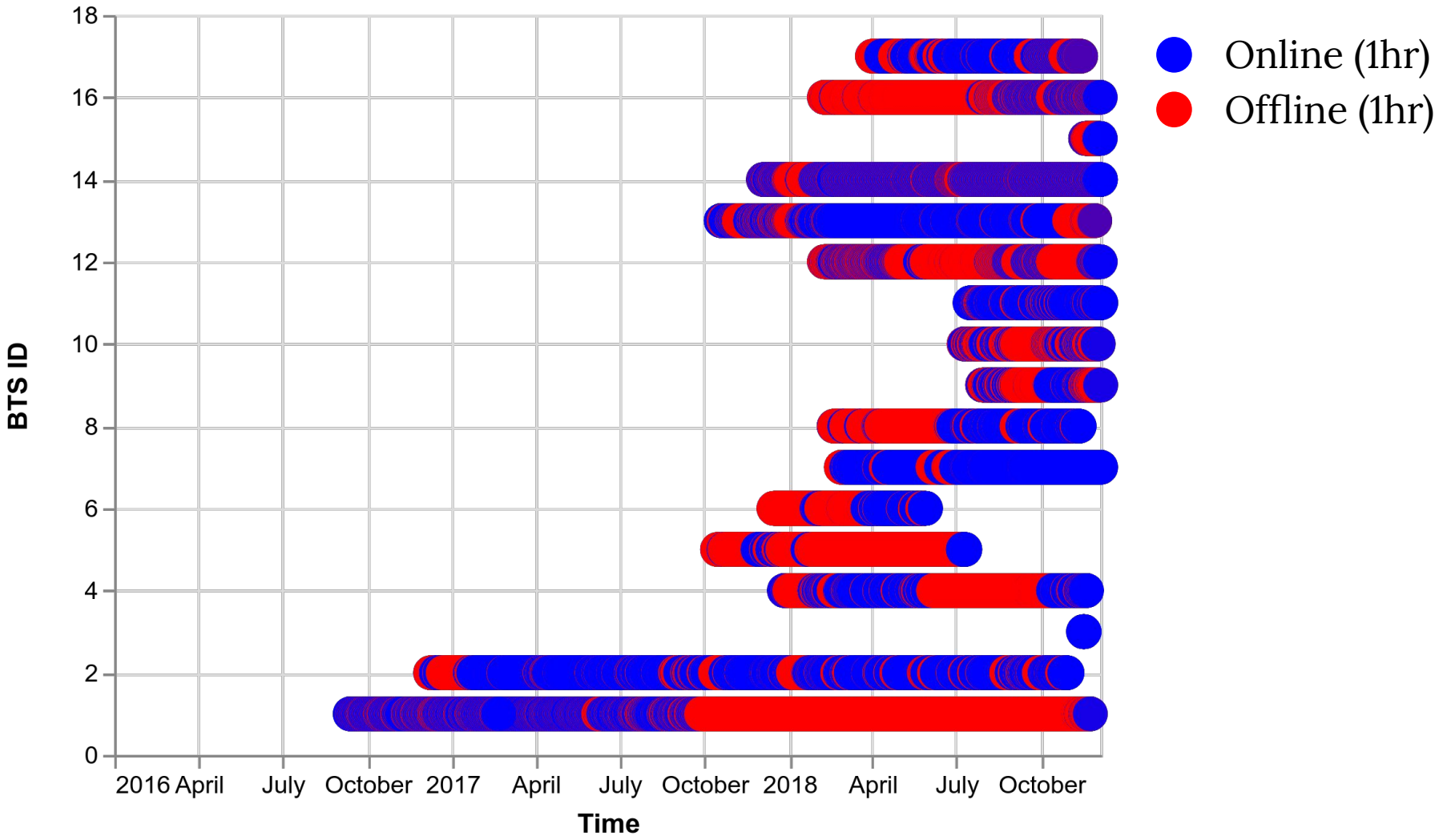


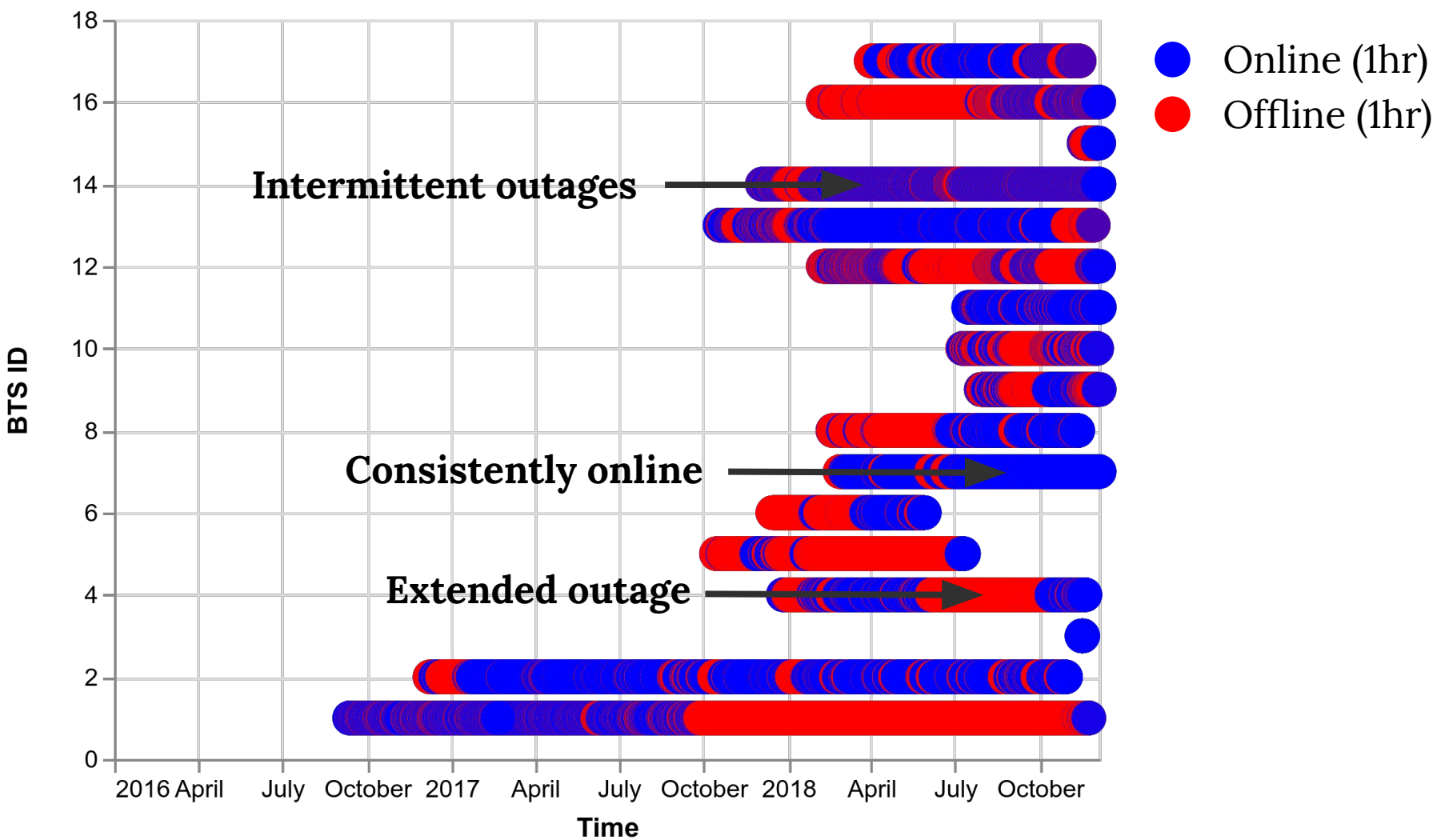
>50k hrs calls
>3M SMS



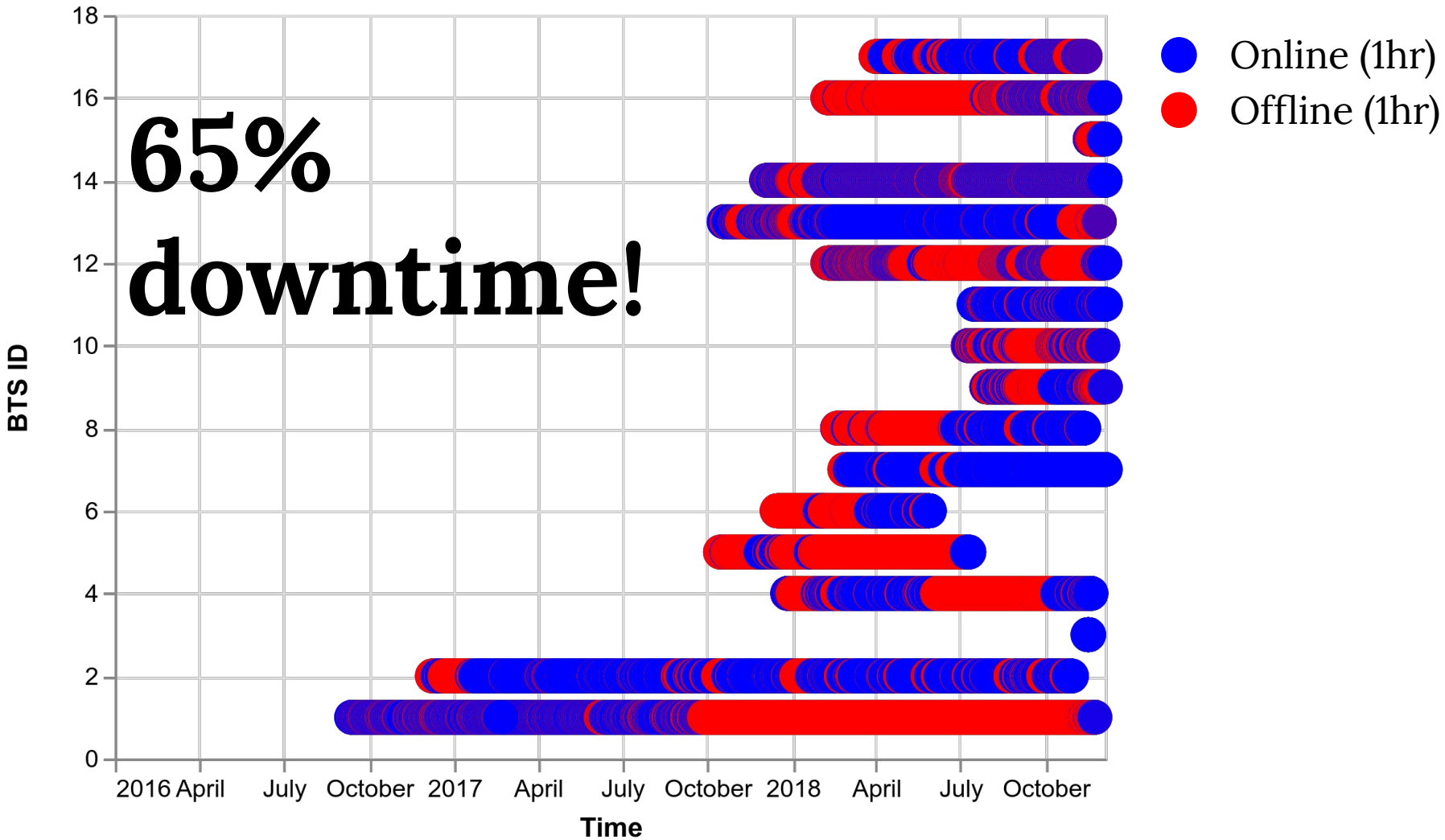
— Globe
— UP







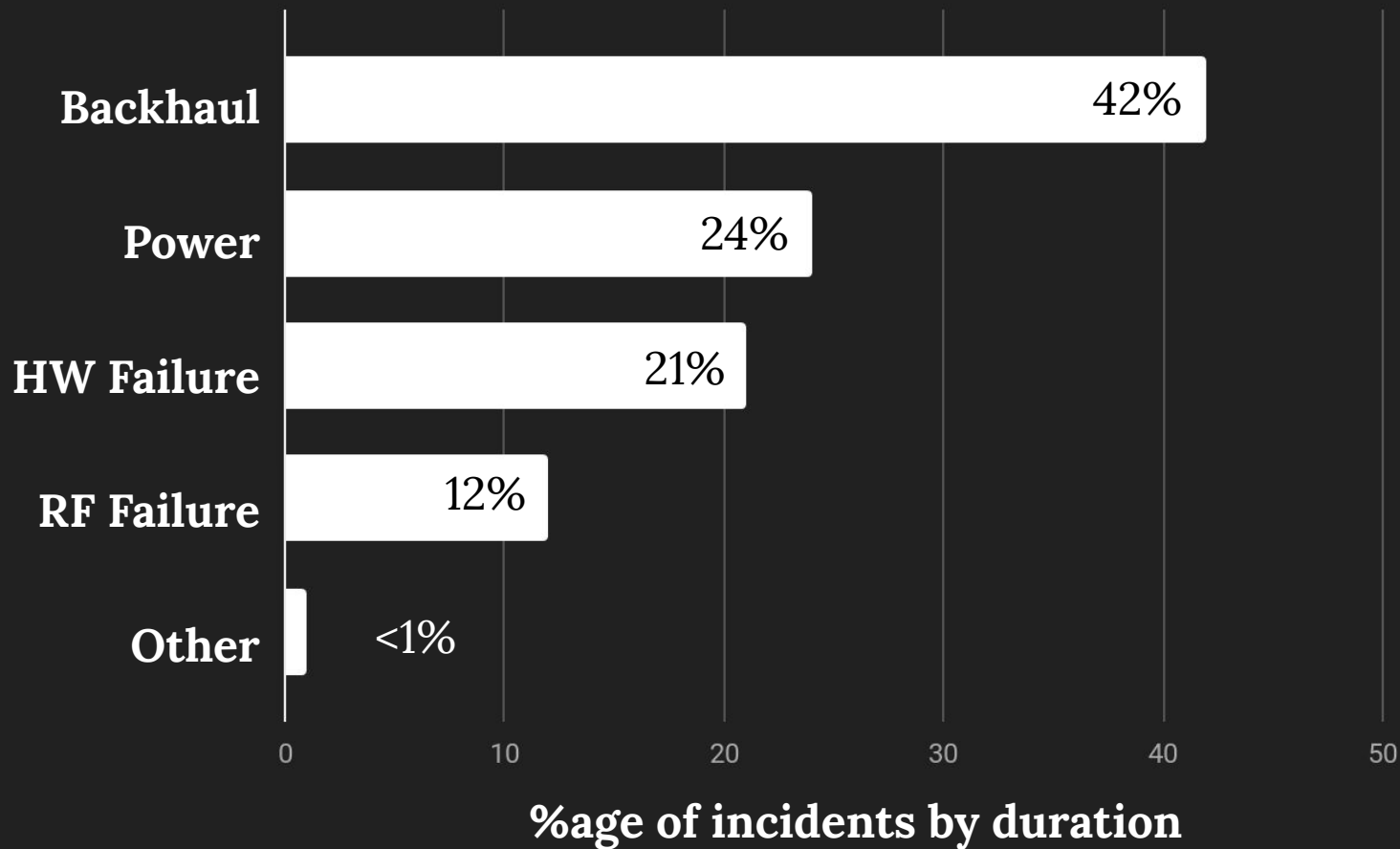
65%
downtime!



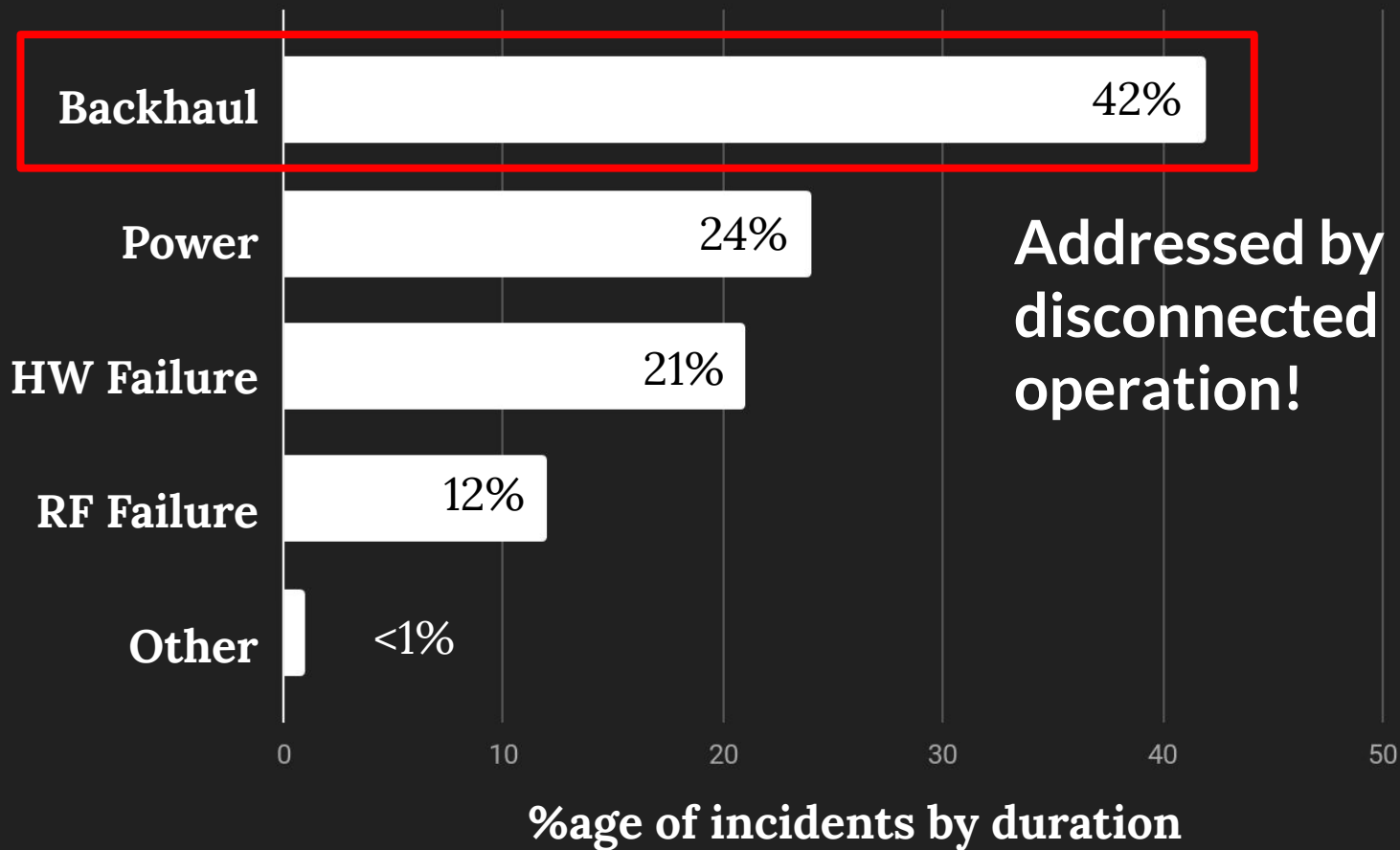
Outage causes in UP sites

Cause	Example
Backhaul	VSAT outage due to weather
Power	Discharged batteries
Site hardware	Overheating
Site RF	Damaged RF cables
Other	Software bug

Outage causes in UP sites



Outage causes in UP sites



+19%

local calls + SMS

+16%

credit transfers (sales)

Local Services

UP Sites

- “Repair manual” SMS app
- Promotional billing
- SMS outage hotline



CommunityCellularManager

1. Provides **autonomy** for community cellular networks
2. Degrades **gracefully** in the face of failures
3. Enables **cooperation** between community cellular networks and telcos
4. Supports the **largest** community cellular network deployment to date

Current Status

Current Status

- September 2019 Globe pulled the spectrum license
 - They were unable to operate the software themselves but also unwilling to farm it out to external firms.
 - Hardware sourcing issues: Vendor overpromised
- “Sustainable” sites converted to 802.11 Wifi
 - Unsustainable sites largely correlated with existing coverage
 - Wifi backhauled using VSATs deployed during project.
 - Many users left out; feature phones no longer supported.
 - Provides general Internet access

Open Challenges:



Last-mile Service Delivery

The remoteness of our sites resulted in a number of setbacks in creating a feasible trade and distribution process.

- The sites are far away from formal financial institutions like banks and remittance centers; travel time and difficulty to reach the sites also pose ongoing dangers to local communities.

Technical Limitations of Large Telecoms

MNOs operating at massive scale are not well suited to using iterative or rapid design processes.

- It was agreed that the coop would receive 80% of the revenue share, which would be used to cover operating costs of the site beyond the project duration. This contract took almost another two years to get approved.
- Unfortunately, the delays broke the projected operational model as it was assumed that the cooperative would be able to tap the revenue for their operational expenses, or for additional capital for e-load distribution.

Personnel Retention

Personnel retention has remained a challenge as better opportunities beyond their village limits the long-term participation of delegated personnel.

- We looked into the reasons behind L1 absence and found the following: (a) insufficient compensation and (b) unappreciation of the network's value.
- When the original personnel at one site left for work in Baler, an untrained resident with a basic background in electrical principles received cursory instructions from the former personnel and took up his functions.

Trust and Community Relations

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What next?

LTE changes
everything.

LTE changes
~~everything~~ many things.





Wireless ISP deploying fixed broadband with LTE.

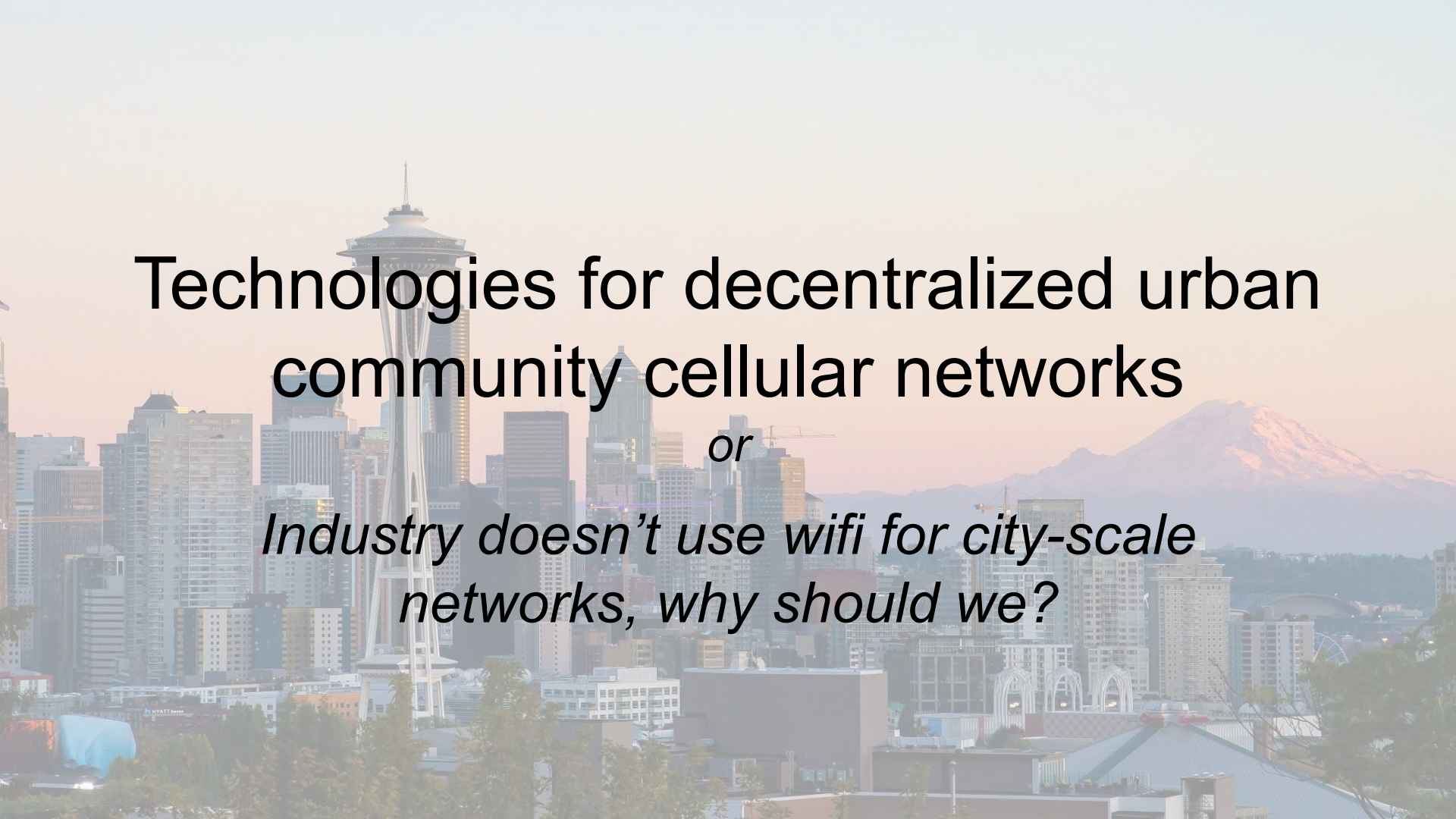
Peru, 2017

**Community network
deploying LTE.**
Indonesia, 2019



Open source LTE

- **Magma** (Facebook)
github.com/facebookincubator/magma
- **CoLTE** (U. Washington)
github.com/uw-ictd/colte
- **OpenAir-CN** (OpenAirInterface Alliance)
github.com/OPENAIRINTERFACE/openair-cn
- **NextEPC**
github.com/acetcom/nextepc

A panoramic view of the Seattle skyline at dusk or dawn. The Space Needle is the central focus, surrounded by various skyscrapers and buildings. In the background, snow-capped mountains are visible under a soft, hazy sky. The overall tone is warm and slightly desaturated.

Technologies for decentralized urban community cellular networks

or

*Industry doesn't use wifi for city-scale
networks, why should we?*

An aerial photograph of a residential community, possibly a housing project or a planned development. The scene is dominated by a large, multi-story building with a prominent red roof, situated in the middle ground. This building is surrounded by numerous smaller, single-story houses and trailers, many of which are arranged in neat rows. The houses have various colors, including white, light blue, and brown. In the background, a large, calm body of water, likely a lake or a wide river, stretches across the horizon. The sky is overcast and grey, and the overall atmosphere is somewhat somber and quiet. The text "Question: Is community cellular appropriate for *cities* as well?" is overlaid in the center of the image in a bold, black, sans-serif font.

Question: Is community cellular
appropriate for *cities* as well?

Example: City-scale Wifi

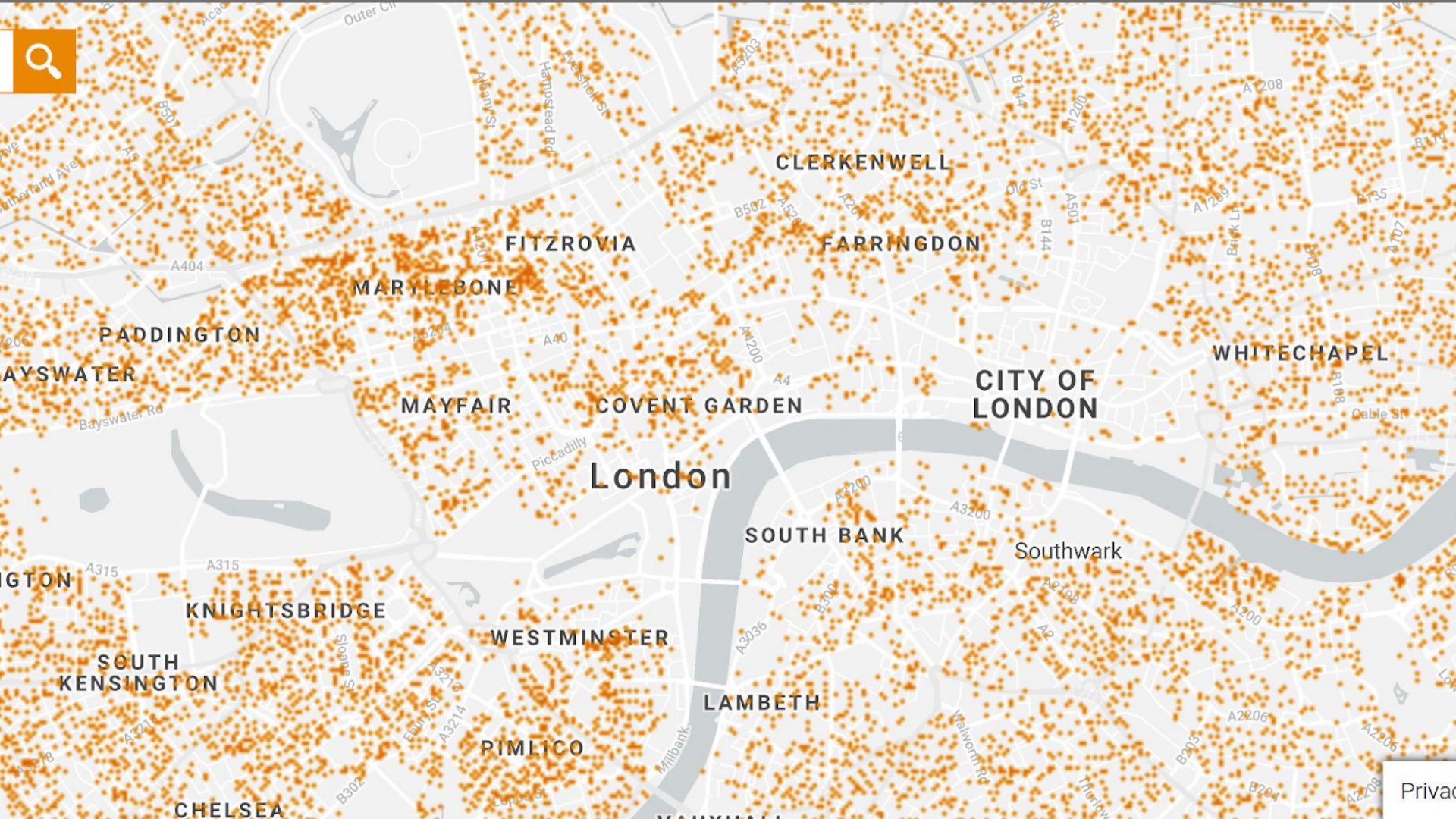


Join our global WiFi network by buying access
or partnering with us.



Use our cutting-edge solutions to deliver WiFi
services in a secure, scalable, and uniquely
flexible way.





London

CLERKENWELL

FARRINGDON

FITZROVIA

MARYLEBONE

PADDINGTON

WHITECHAPEL

CITY OF LONDON

MAYFAIR

COVENT GARDEN

SOUTH BANK

Southwark

KNIGHTSBRIDGE

WESTMINSTER

LAMBETH

SOUTH KENSINGTON

PIMLICO

CHELSEA

Private

Why is city-scale wifi so hard?

Why is city-scale wifi so hard?

1. Wifi is bad at city-scale

- Transmit power (and thus coverage range) is inherently low
 - Operates at spectrum poorly suited for propagation
- Generally power-hungry

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- Mobility defines city-scale: need to connect to multiple APs
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- Limited coverage area provides little opportunity for effective handover

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- Mobility defines city-scale: need to connect to multiple APs
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3. Wifi is bad at spectrum coordination

- Network too dense? Spectrum congestion
- Network too sparse? Can't do handover

Example: City-scale Cellular

For the home

For business and public sector

For global business

Type keyword here to search



About BT

Investors

News & media

Digital impact & sustainability

Innovation

Careers



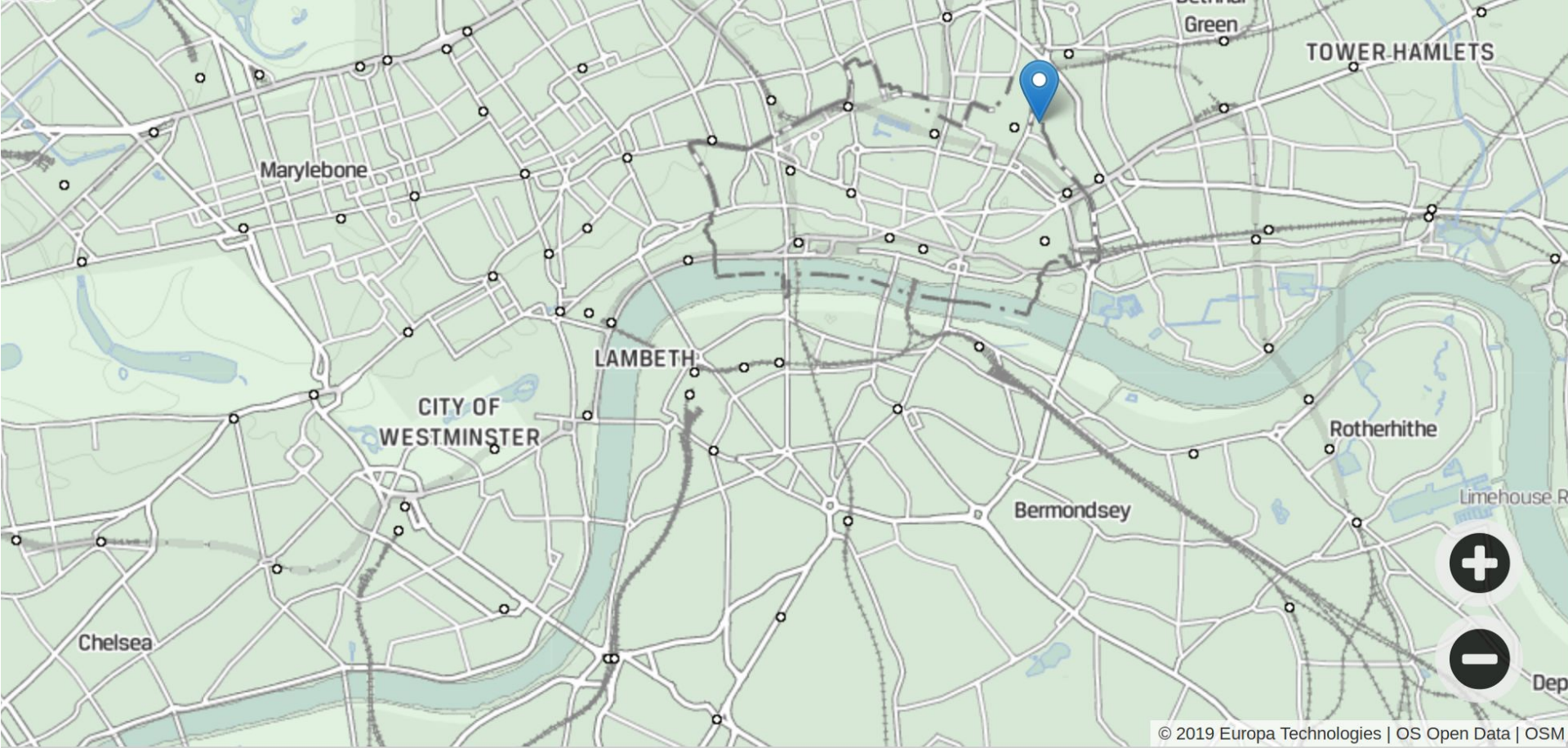
We use
commu
make a

Fi

2019 Annual report

Latest results

Share price: **187.02p** -1.96p (-1.04%)
2019



Likely to have good coverage

You may experience some problems

Reliable signal unlikely

You should not expect to receive a signal

Why is city-scale cellular so common?

Why is city-scale cellular so common?

Lots of business reasons

We'll skip those for now

Why is city-scale cellular so common?

1. Cellular is good at wide-area
 - Often kilometers of coverage

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- LTE includes p2p mobility primitives

3. Cellular is good at spectrum coordination

- This is the whole point of “cellular”
- Variety of spectrum technologies such as self organizing networks (SONs)

Why is city-scale cellular so common?

1. Cellular is good at wide-area
 - Often kilometers of coverage
2. Cellular is good at mobility
 - C
 - L
3. Cellular is good at low-cost
 - T
 - V

What's stopping **us** from building these networks?

Issues with Community Cellular

1. **Spectrum - Cellular uses licensed spectrum.**

Issues with Community Cellular

1. **Spectrum - Cellular uses licensed spectrum.**

- a. Yes but they've started creeping in on other unlicensed bands
- b. Citizen's Broadband Radio Service (CBRS) is a dual licensed regime going live in April
- c. LTE-U and LTE-LAA are both protocols for operating cellular gear in Wifi bands

Issues with Community Cellular

- 1. Spectrum - Cellular uses licensed spectrum.**
- 2. Hardware - Cellular hardware is super expensive and only telecoms can afford it at scale.**

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- 1. Spectrum - Cellular uses licensed spectrum.**
- 2. Hardware - Cellular hardware is super expensive and only telecoms can afford it at scale.**
 - a. Not since LTE. A reasonable LTE access point (eNB) costs ~\$2500USD, about half of a 2G radio.
 - b. This will continue to shrink as more manufacturers enter the NR space as they're "small cells"

Issues with Community Cellular

- 1. Spectrum - Cellular uses licensed spectrum.**
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- 3. Interconnect - Telecoms don't play ball.**

Issues with Community Cellular

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- 3. Interconnect - Telecoms don't play ball.**
 - Still true, but as LTE is entirely IP-based, that's fine. We can peer at the IXP.
 - OTT services (e.g., WhatsApp, Messenger, etc) are dominant anyhow!

Issues with Community Cellular

- 1. Spectrum - Cellular uses licensed spectrum.**
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- 4. Operations - Cellular equipment is hard to use and not designed for "little guys" to run.**

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- 1. Spectrum - Cellular uses licensed spectrum.**
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 - This has shifted dramatically. One point is the Wireless ISP market, with many operating LTE networks from BaiCells or TelRad. So the hackers can do it.
 - “Private LTE” is rapidly gaining traction. These are small companies or building running their own.
 - “Carrier Aggregation” is another important shift. Building owners will install their own network and allow their users to “roam” onto *multiple* MNOs for a cut.

Issues with Community Cellular

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3. **Interconnect - Telecoms don't play ball.**
4. **Operations - Cellular equipment is hard to use and not designed for “little guys” to run.**

There is a great opportunity for urban
community cellular networks

A semi-transparent photograph of a university campus. In the foreground on the left is a large, dark grey sculpture of the letter 'W' on a stone base. To the right is a tall, light-colored stone tower with a pointed top and a small window. The background is filled with lush green trees and a paved area. A sign with the word 'BURK' is visible on the right. The text 'What's the plan?' is overlaid in the center.

What's the plan?

Technology agenda - Federated LTE/NR

- Use distributed ledger to allow for shared federated backbone
- Create a way for new network nodes (wide area transmitters) to dynamic join a single nation-scale telecom
- Need to distribute the following essential core network functions:
 - Authentication
 - Billing
 - Mobility
 - Network spectrum coordination (SON)
 - Sensed spectrum coordination (DSA)

Deployment agenda - Community LTE in Seattle

- Deploying first urban cooperative cellular network in the fall of 2019
- Two networks federated together:
 - Campus (north) network
 - Hospital (south) network
- Eventually high points will be used to provide backhaul
 - Instead of transmitting
- You can join too!
 - We have SIMs to share!

