

# Scaling Community Cellular Networks with CCM

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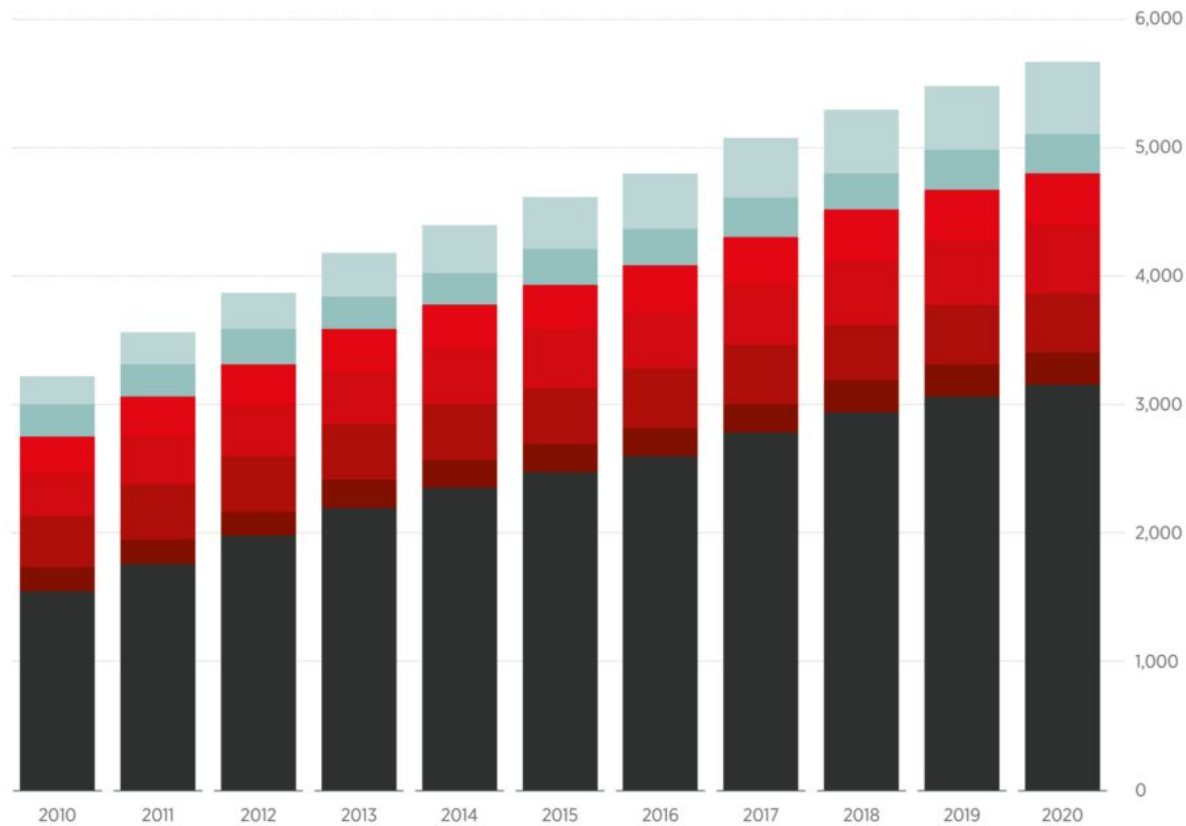


# Thanks!

CHED, PCARI, Facebook, USAID, NSF  
Omar Ramadan, Matt Ball,  
Steve Muir, Evgeiny Makeev,  
UP VBTS team,  
Globe Konekt team,  
...so many others!

# 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**

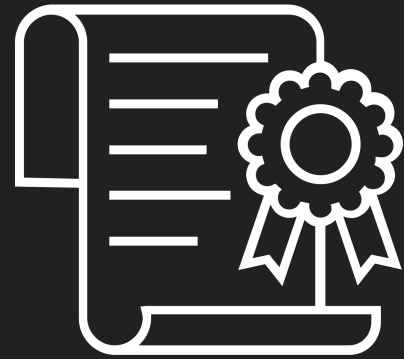
Leveraging **local resources**

Providing **local services**

**Sustainable** in rural areas



Rhizomatica (Mexico)





# Scale

of telcos

+

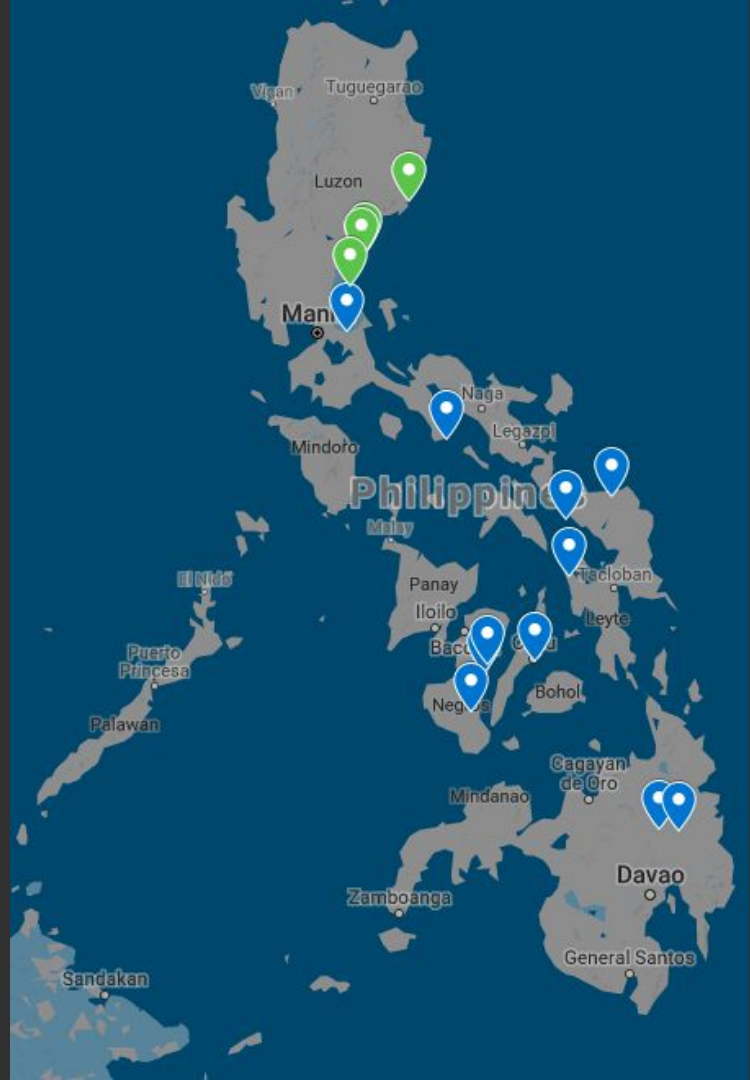
# Reach

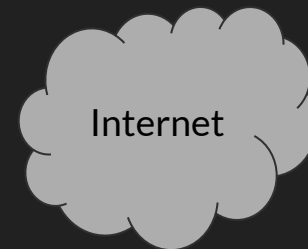
of community networks

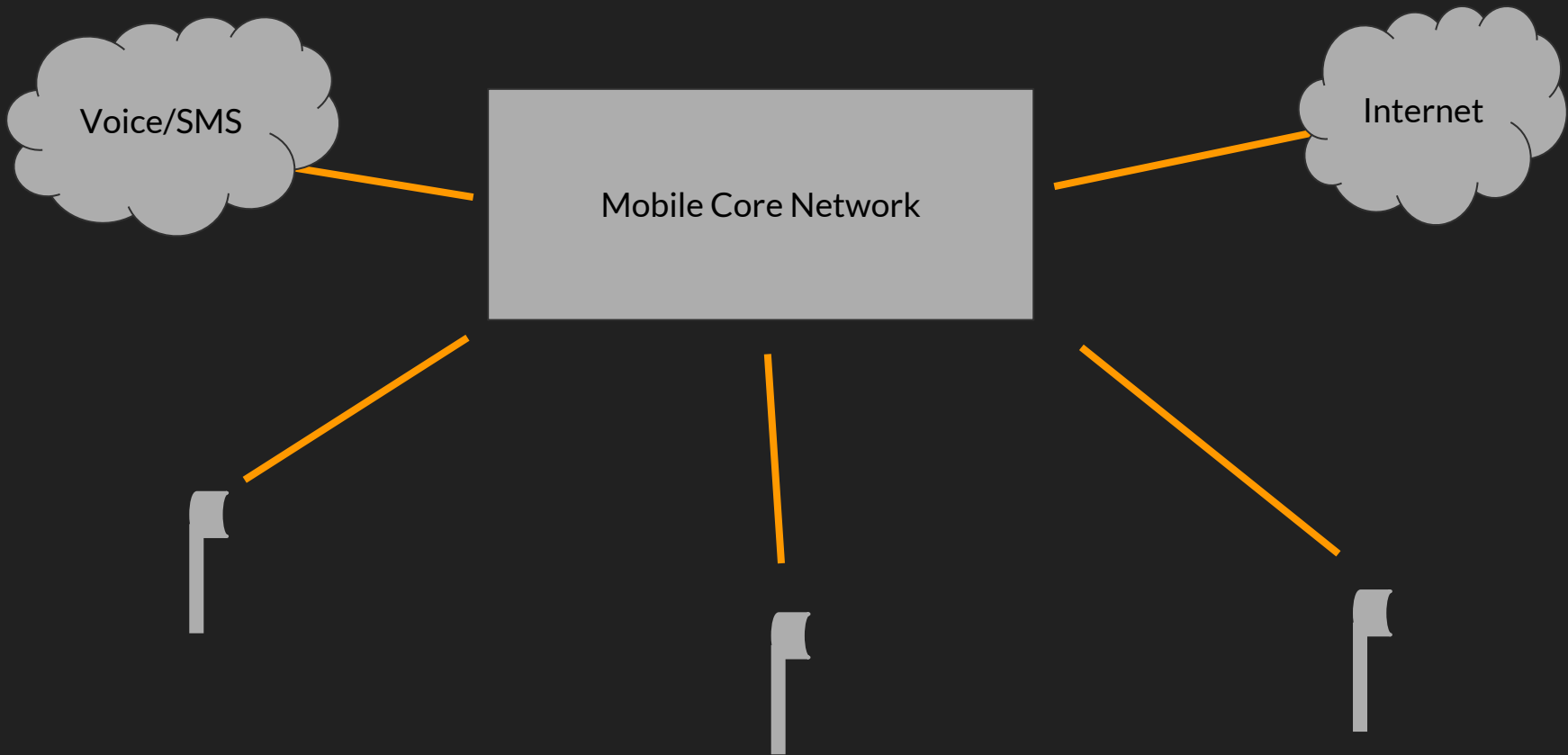
# CommunityCellularManager

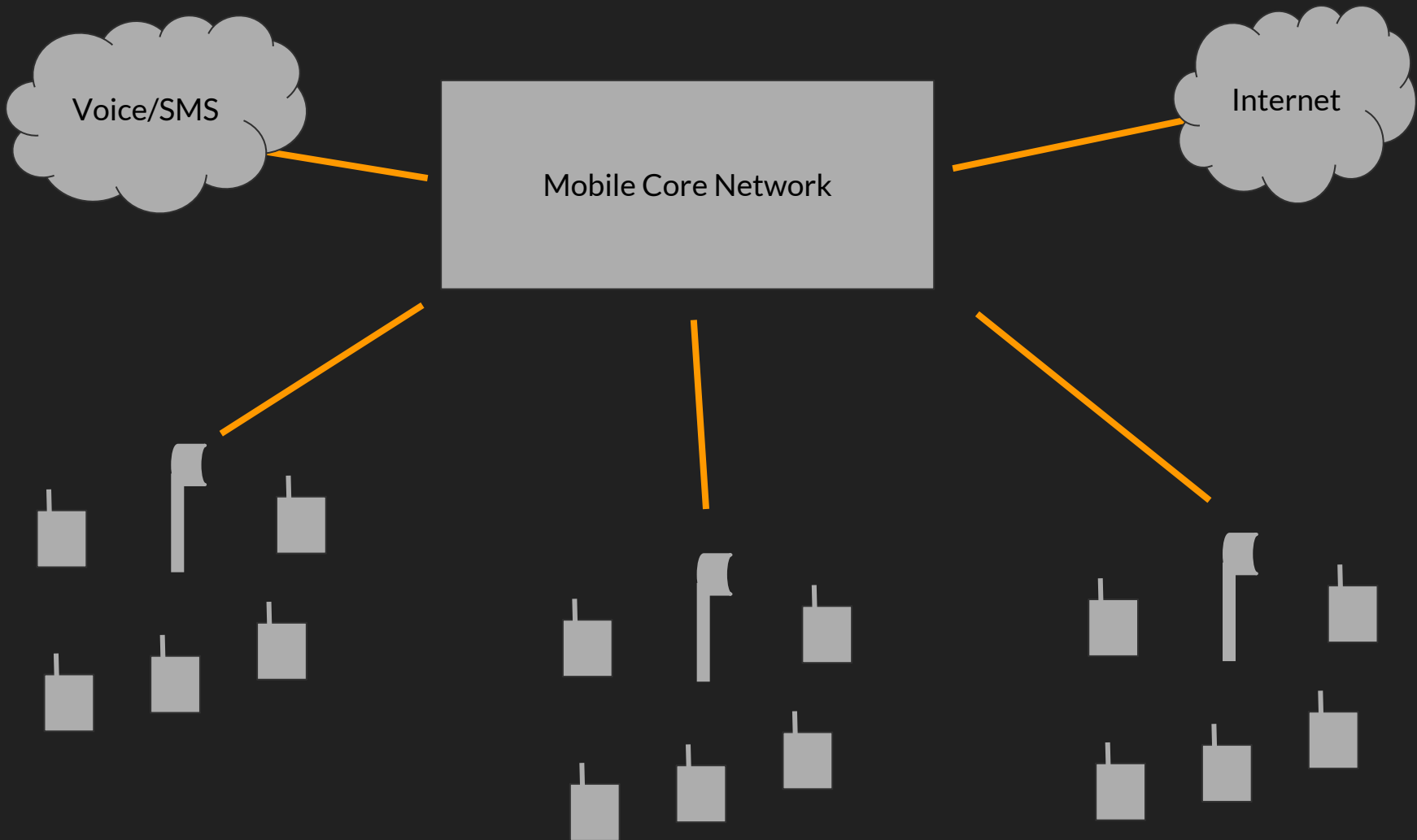
[github.com/co-cell/ccm](https://github.com/co-cell/ccm)

3 years  
17 sites  
2.8K people  
Telco partner





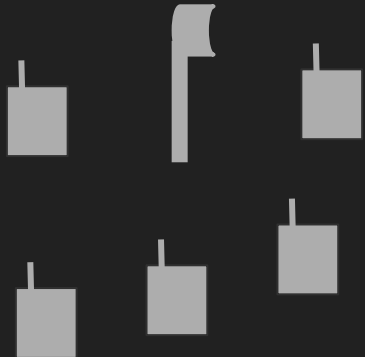


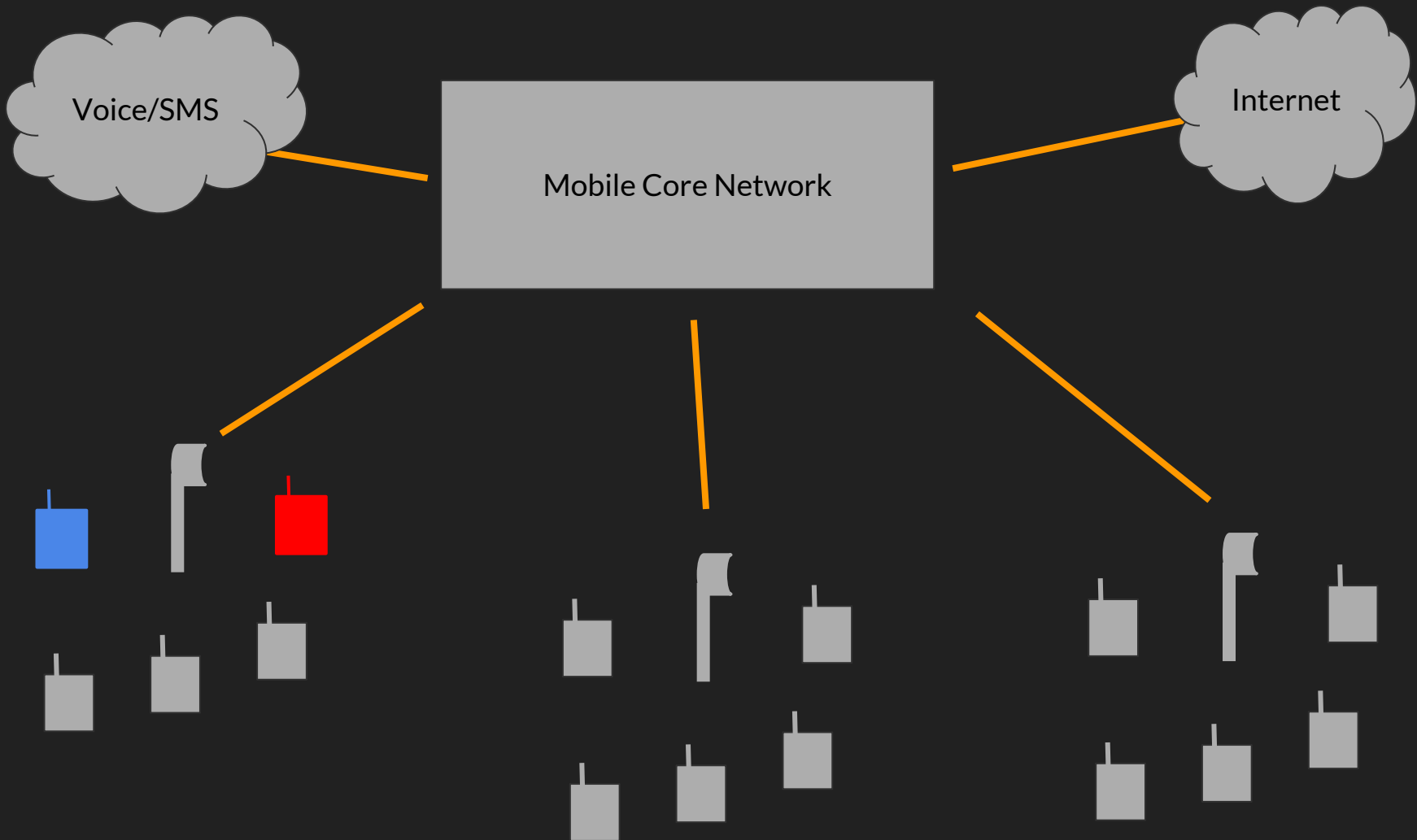


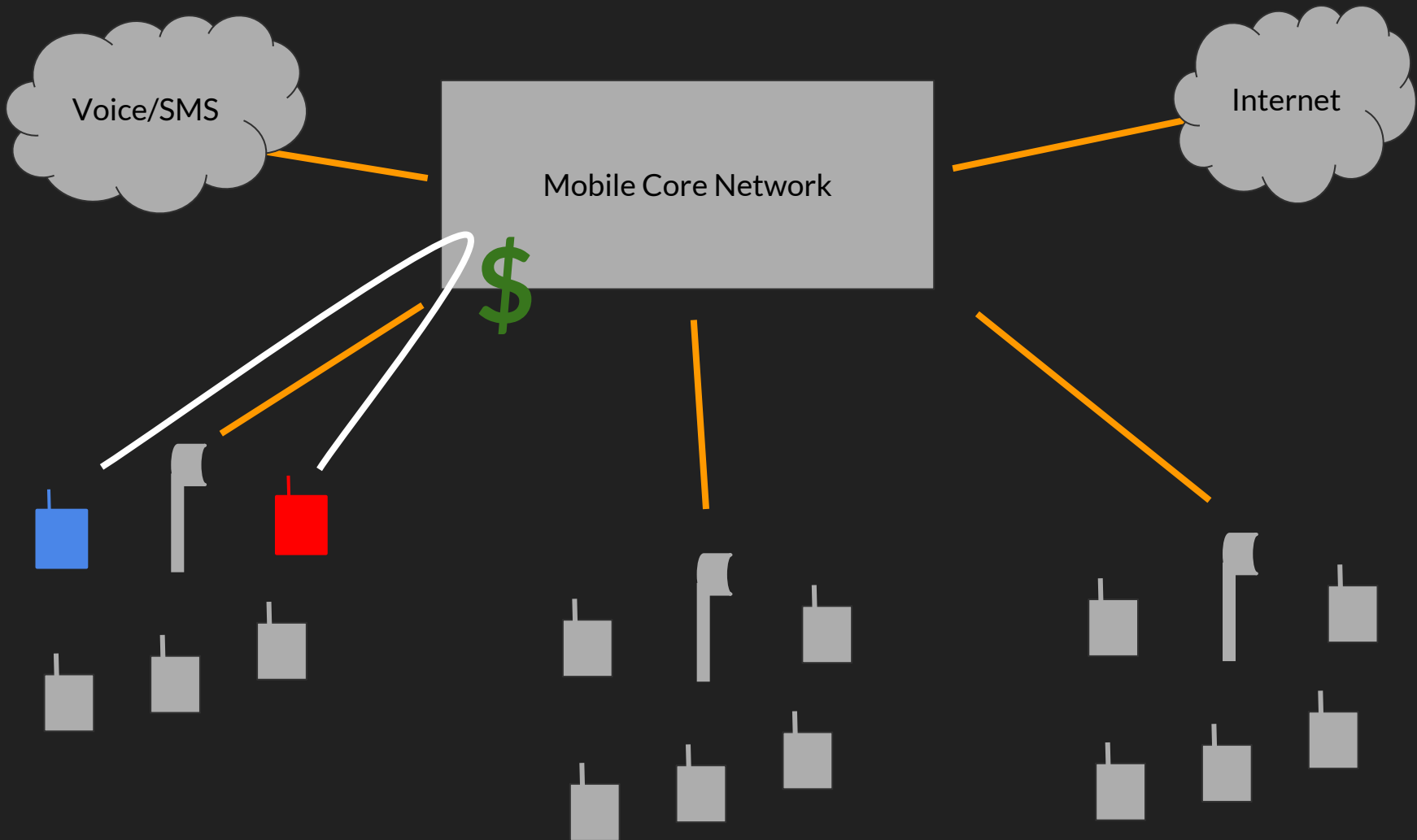
Voice/SMS

Internet

Mobile Core Network







Voice/SMS

Internet

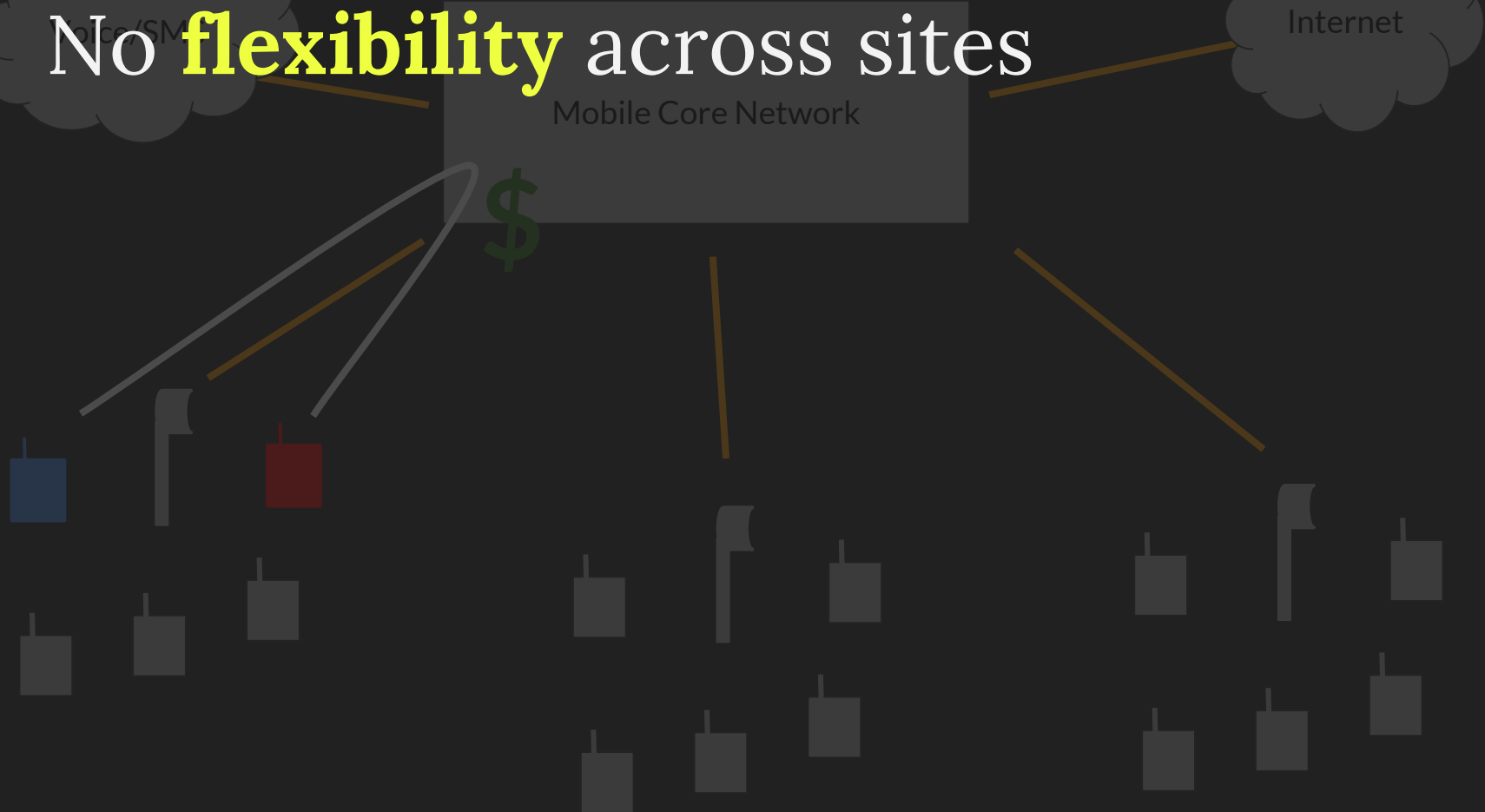
Mobile Core Network

\$





# 1. No **flexibility** across sites



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



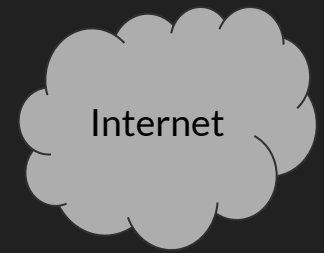
- 
- The diagram illustrates a Mobile Core Network. At the top center is a grey rectangular box labeled "Mobile Core Network". To its left is a grey cloud labeled "Voice/SM". To its right is another grey cloud labeled "Internet". Below the central box is a large, faint green dollar sign "\$". At the bottom of the diagram, there is a grid of small grey icons representing mobile devices, with one blue icon and one red icon on the left side. Lines connect the central box to the "Voice/SM" and "Internet" clouds, and to the grid of devices. The text "1. No flexibility across sites", "2. Doesn't degrade gracefully", and "3. Modifying mobile core is expensive" is overlaid on the diagram.
1. No **flexibility** across sites
  2. Doesn't **degrade gracefully**
  3. Modifying mobile core is **expensive**

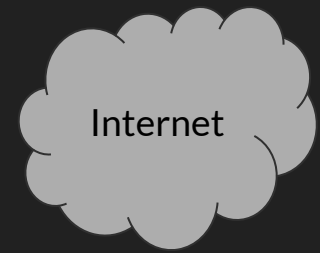
- 
- A network diagram with a central grey box labeled "Mobile Core Network". To its right is a grey cloud labeled "Internet". To its left is another grey cloud labeled "voice/SMS". Lines connect the central box to both clouds. The text "voice/SMS" is partially obscured by the first list item.
1. No **flexibility** across sites
  2. Doesn't **degrade gracefully**
  3. Modifying mobile core is **expensive**

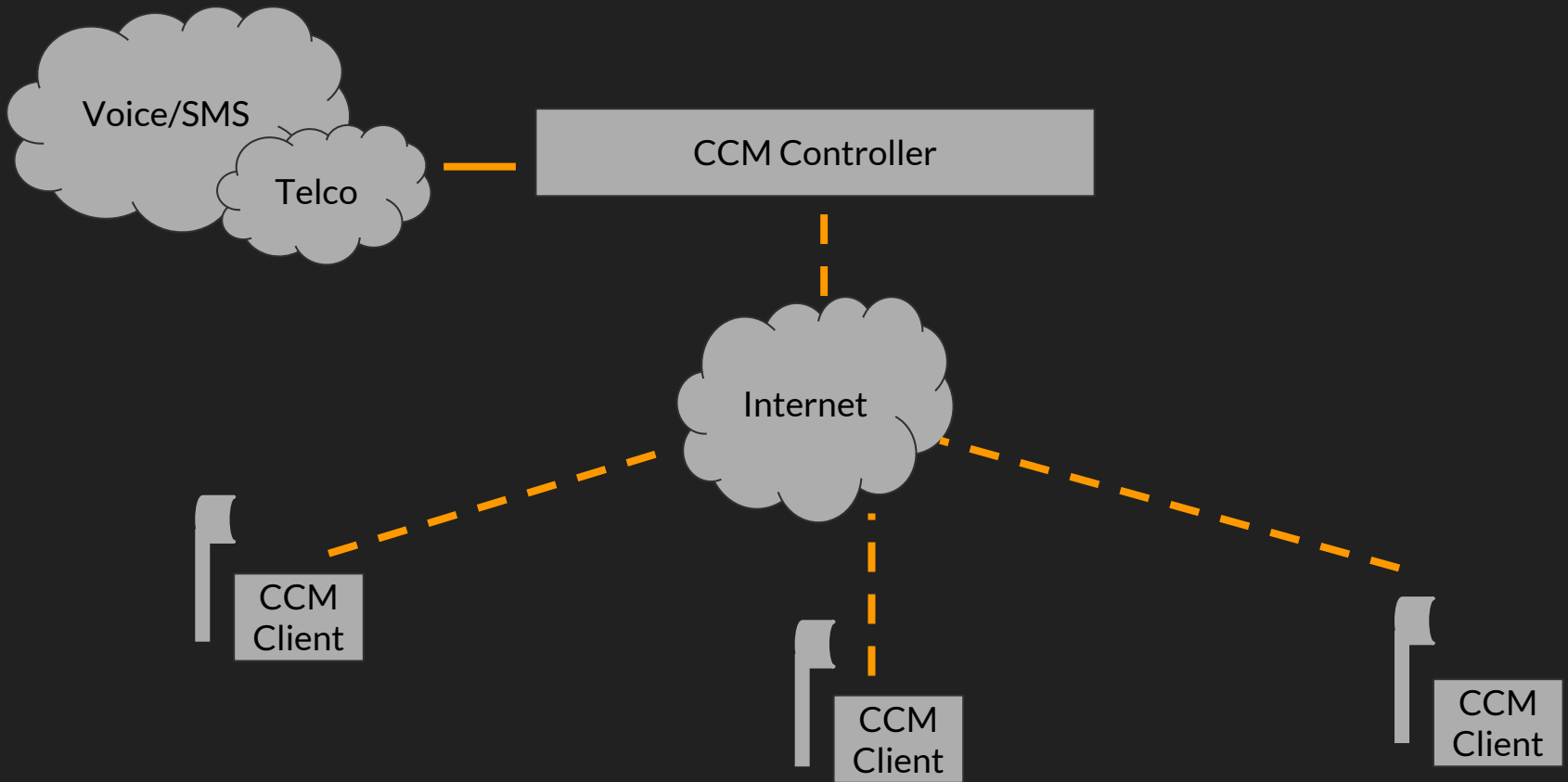
**Centralize Management**  
**Decentralize Network Services**

# CCM is 2G only.

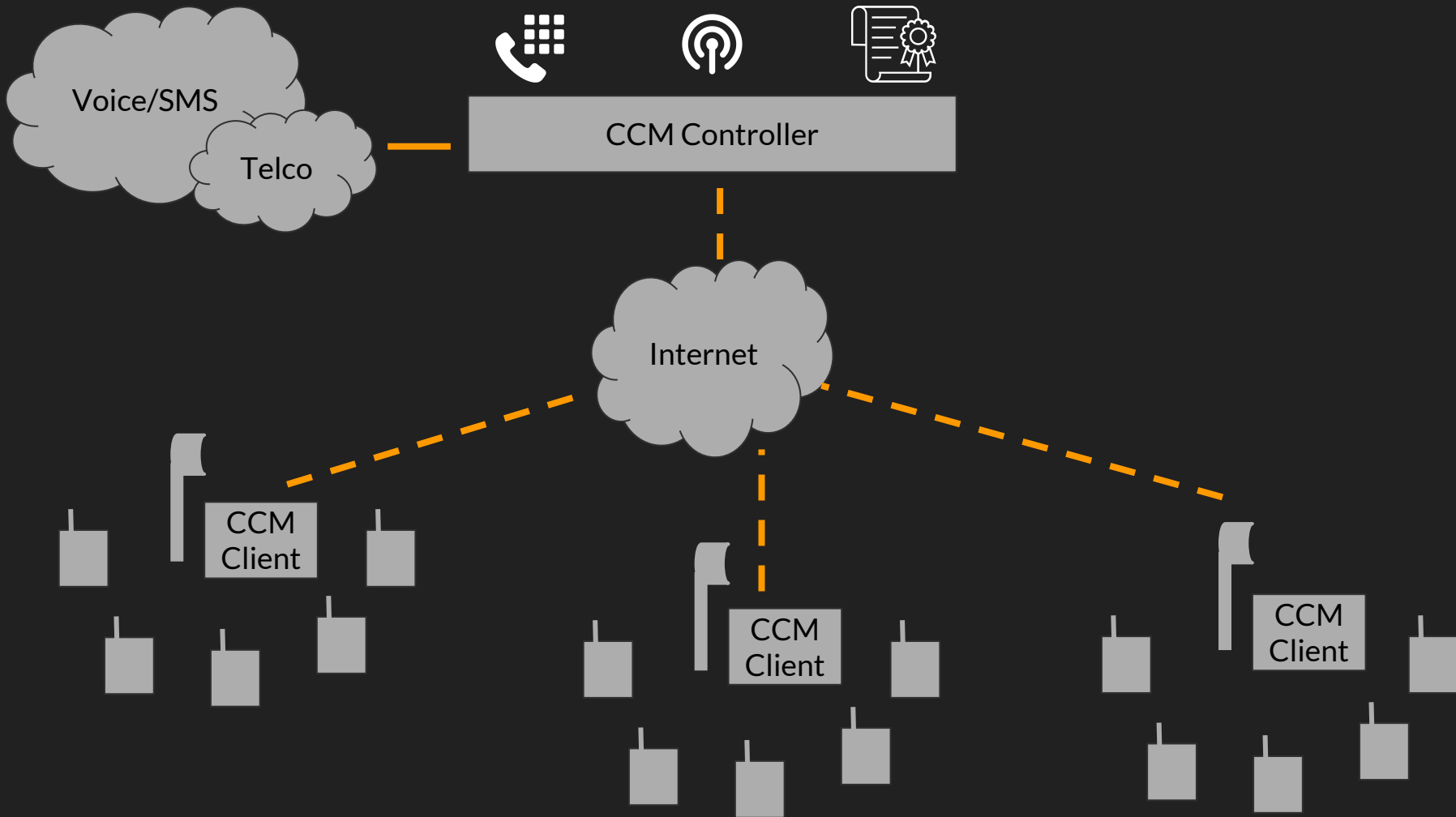
40% of devices only support 2G.\*  
LTE/5G is not [yet] relevant in our context.

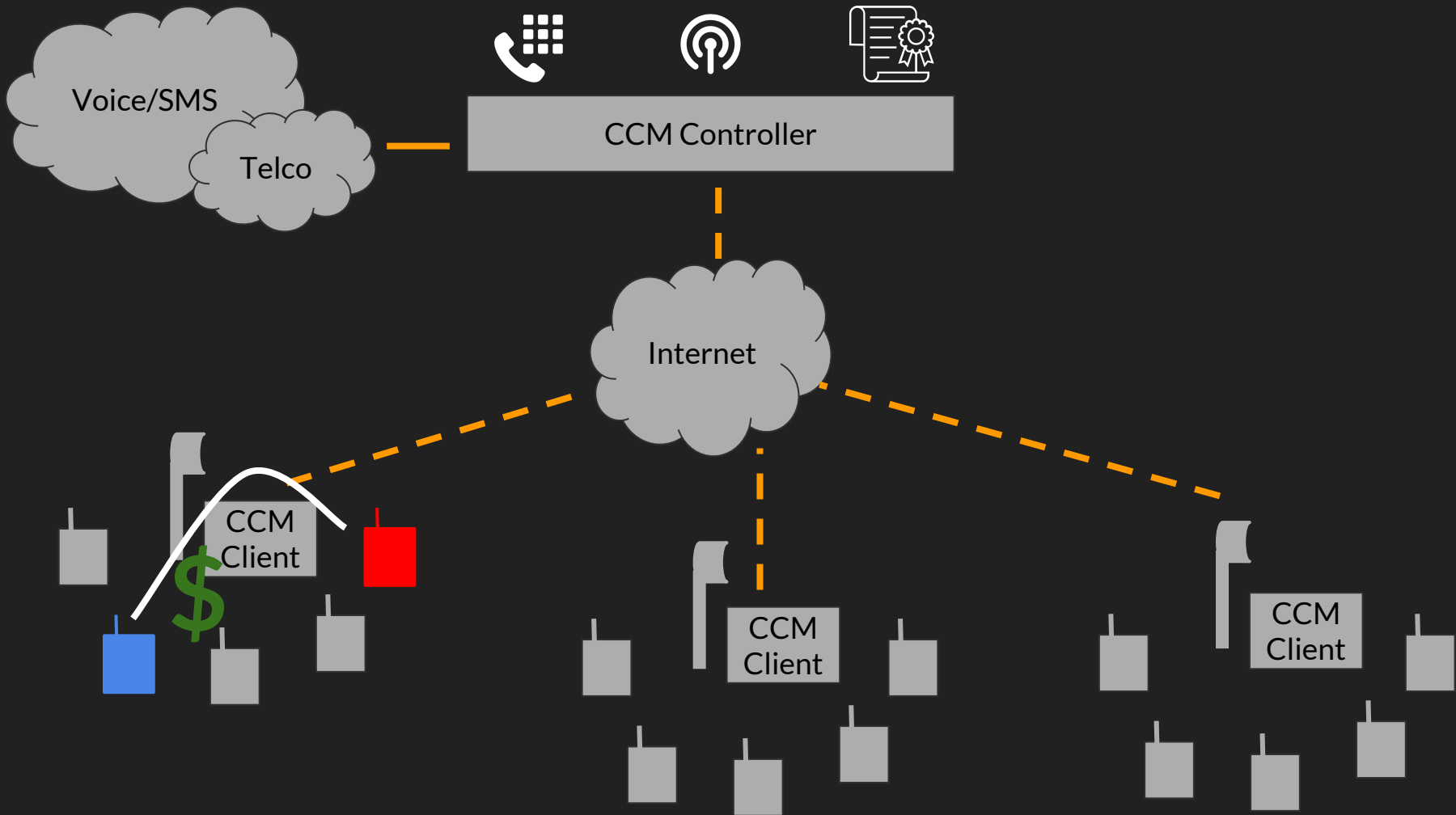


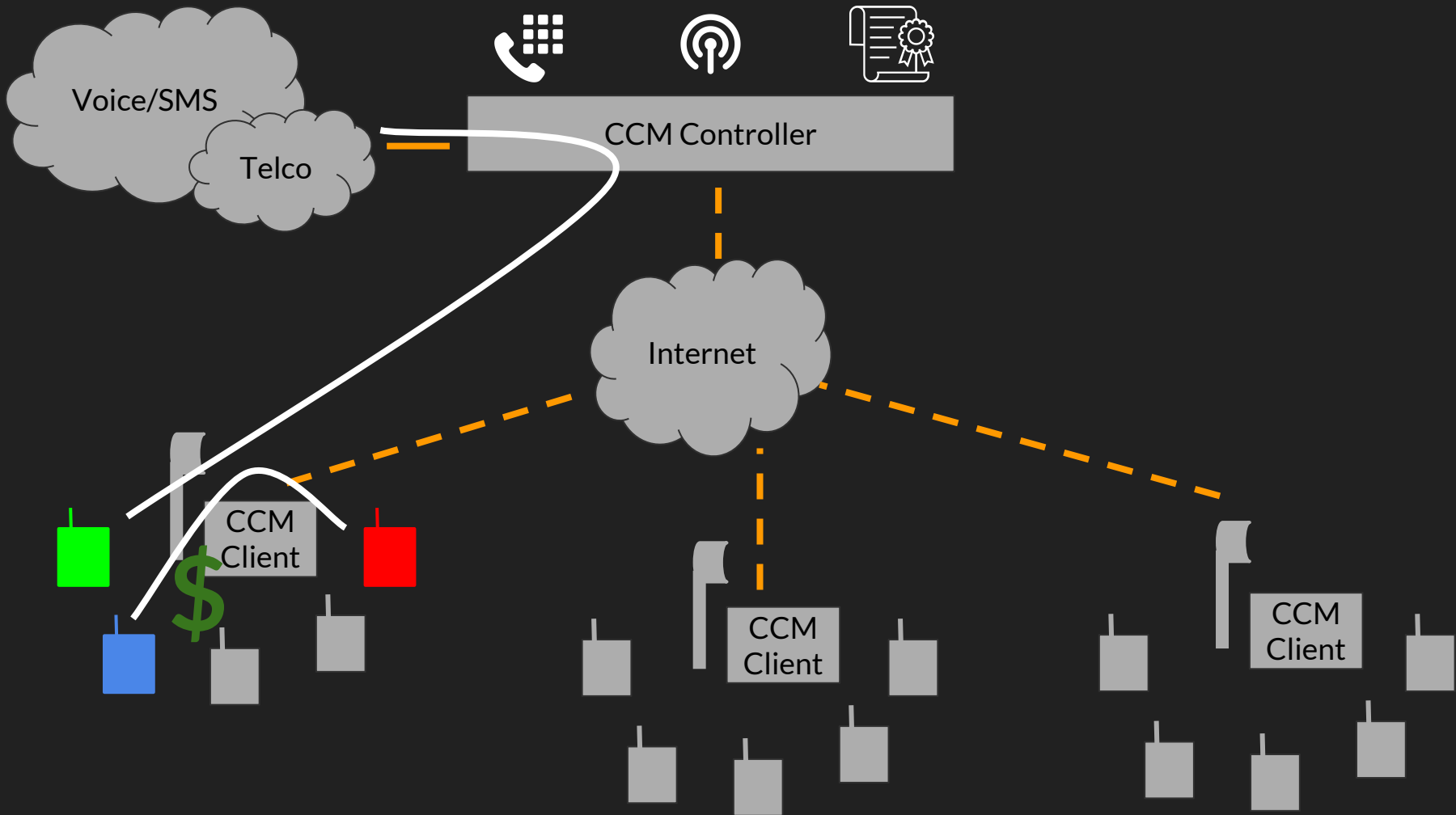


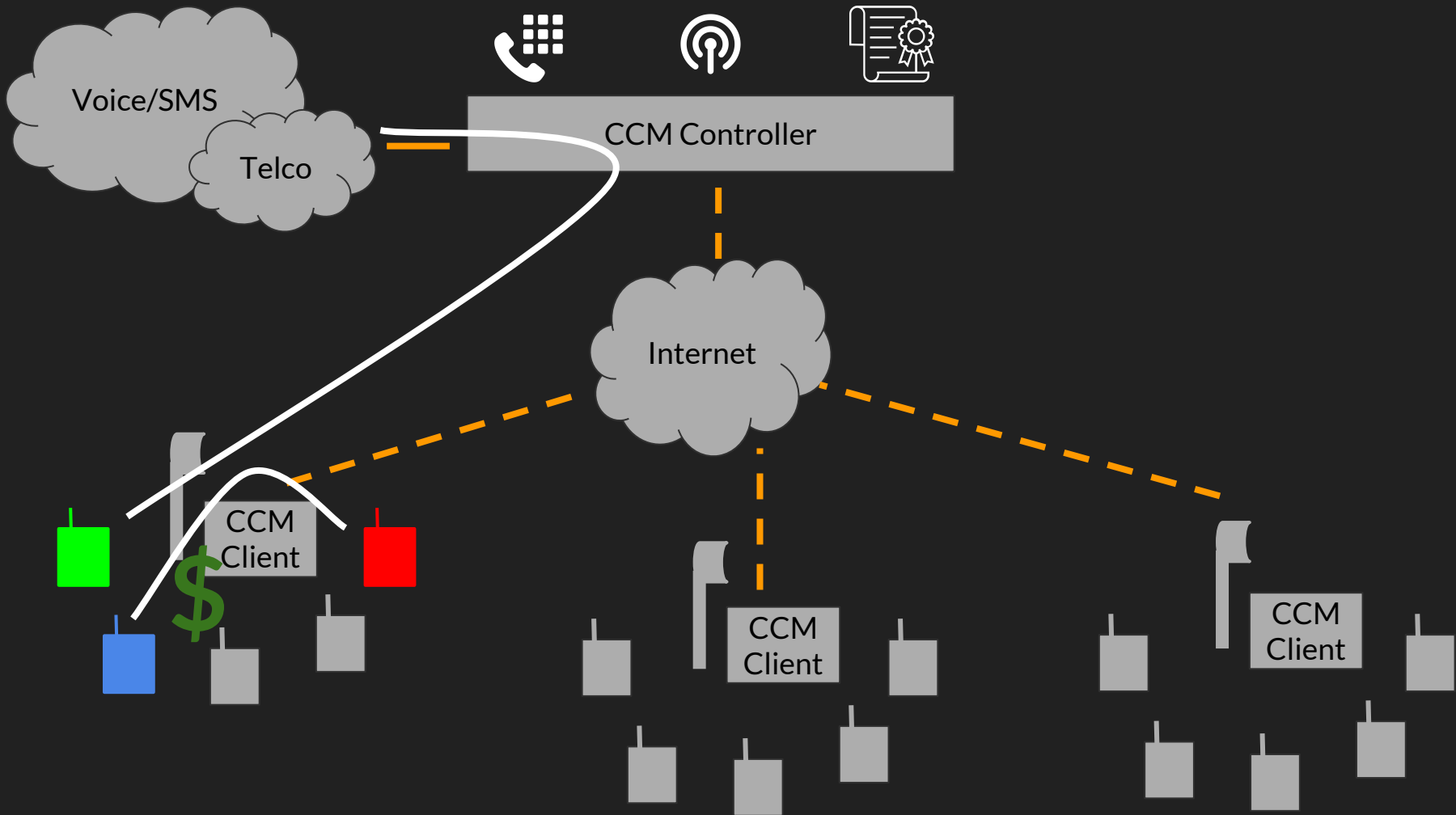


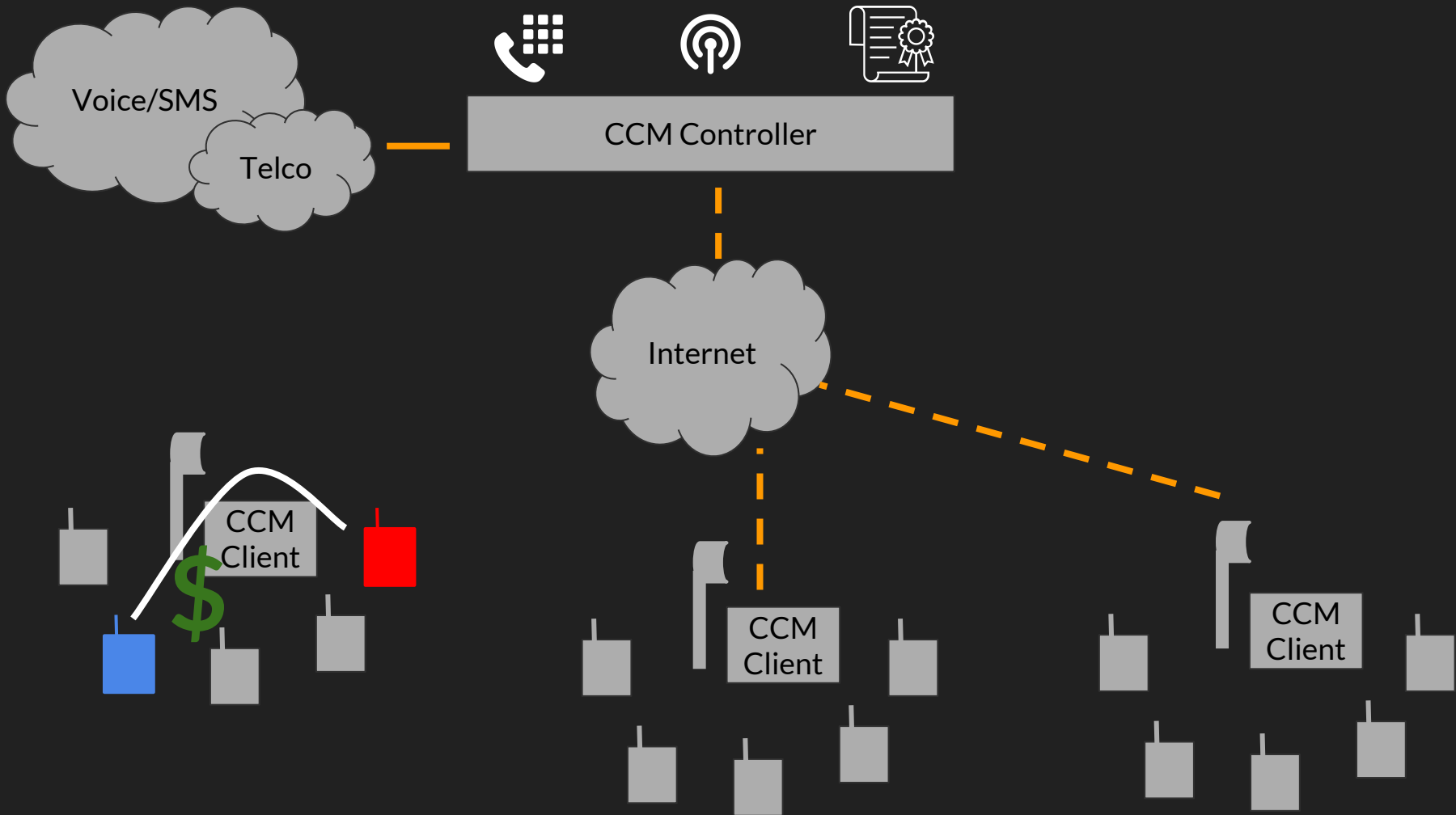


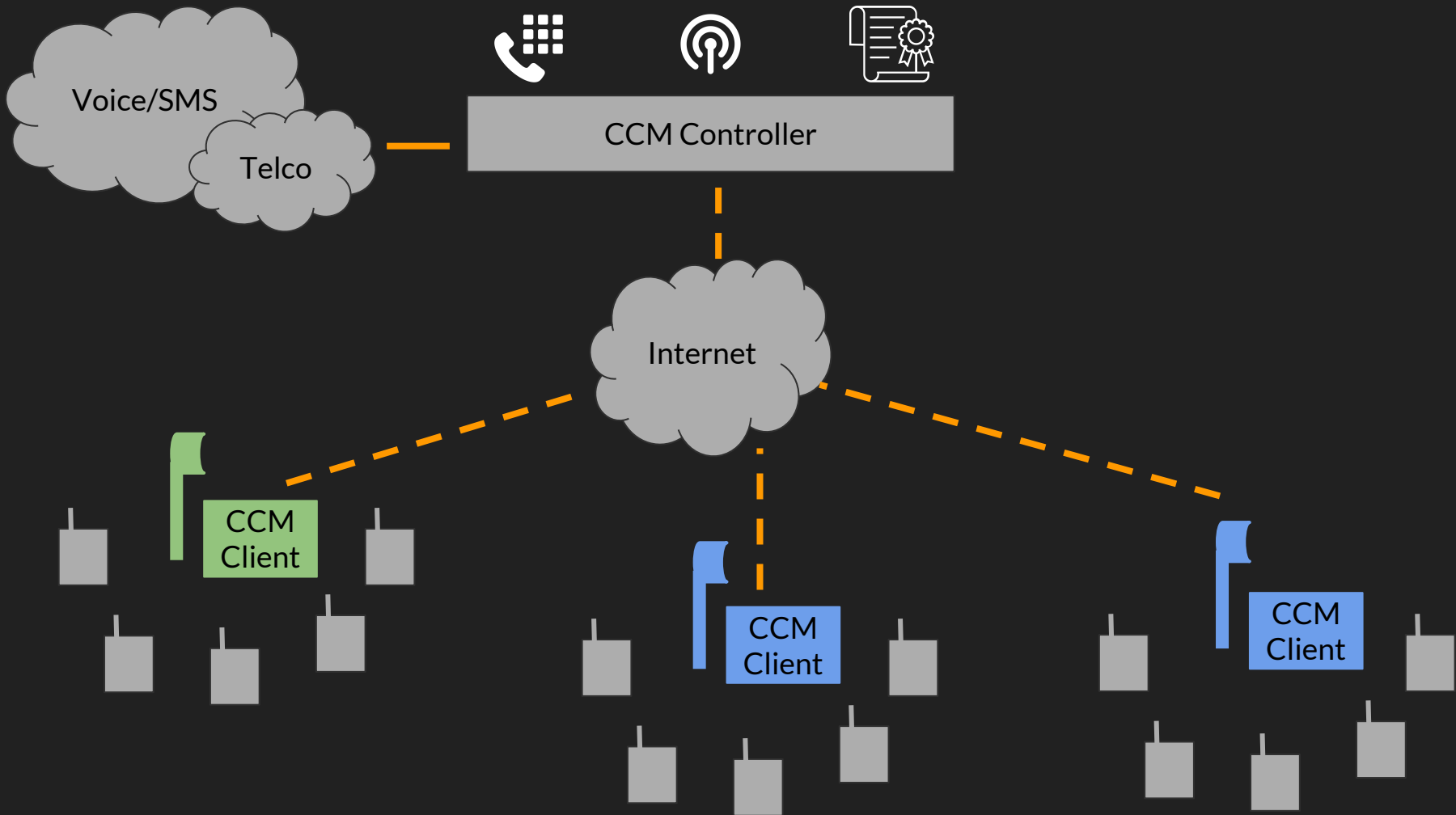












# Synchronizing state: Checkin

**Request** (*Client -> Controller*)

```
{
  'status': {
    'active_users': 24,
    'ran_load': 51,
    ...
  },
  'events': [
    [15, 'IMSI123', 'out_sms', ...],
    [16, 'IMSI345', 'transfer', ...],
  ],
  'modified_subs': [...],
  'ctx': {...}
}
```

**Response** (*Controller -> Client*)

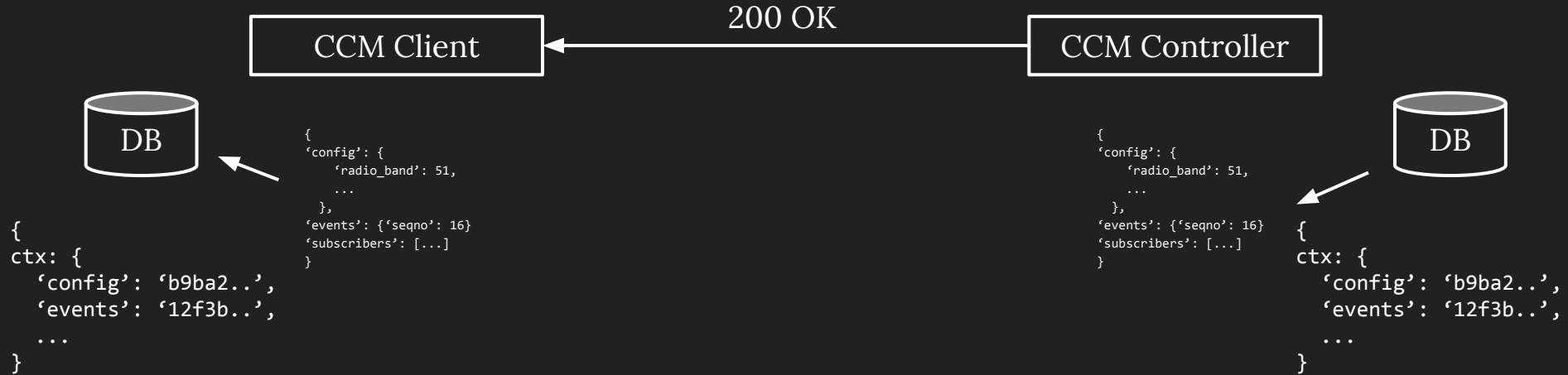
```
{
  'config': {
    'radio_band': 51,
    ...
  },
  'events': {'seqno': 16}
  'subscribers': [...]
}
```

# Synchronizing state: Checkin

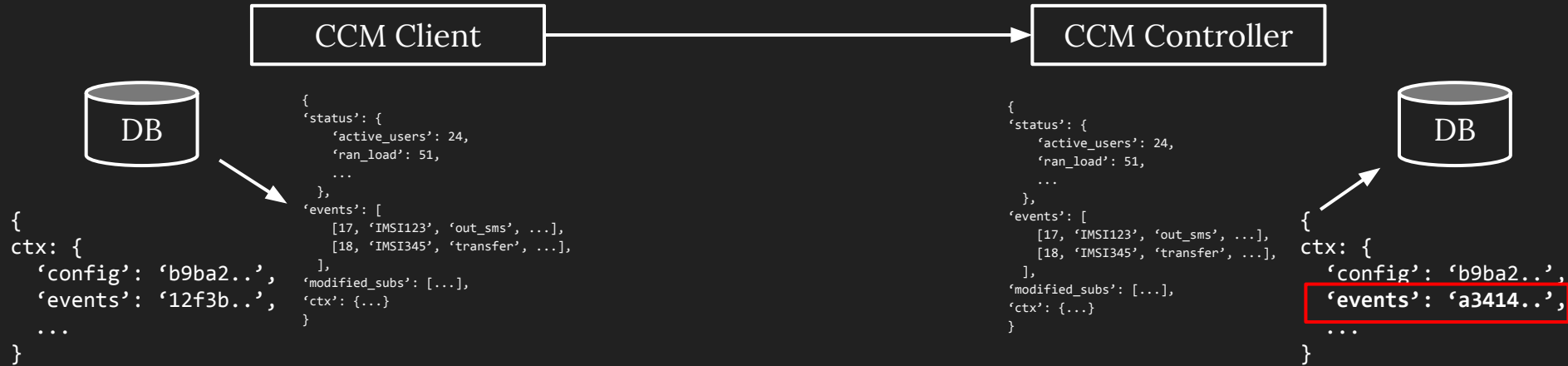




# Synchronizing state: Checkin



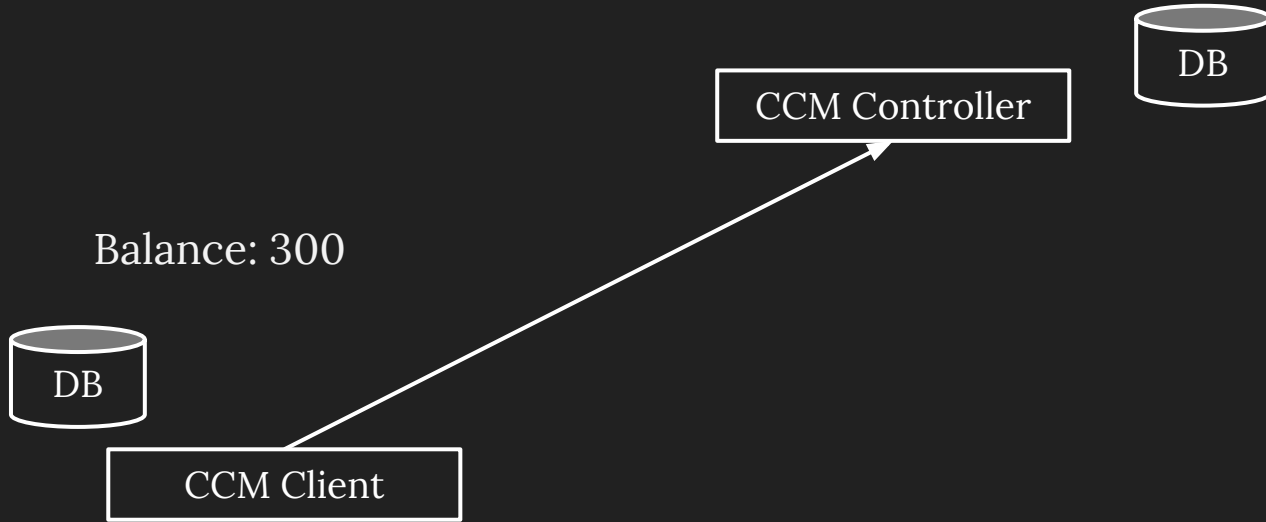
# Synchronizing state: Checkin



# Synchronizing state: Checkin



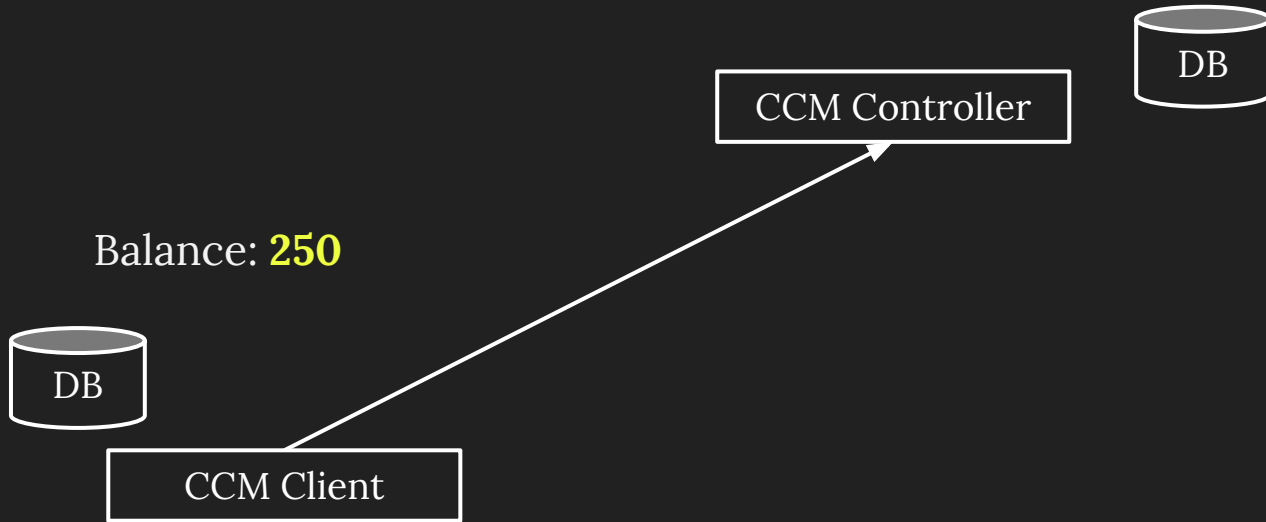
# Synchronizing state: Billing



IMSI123:

```
{'bts1': {'+' : 500, '-' : 200}  
}
```

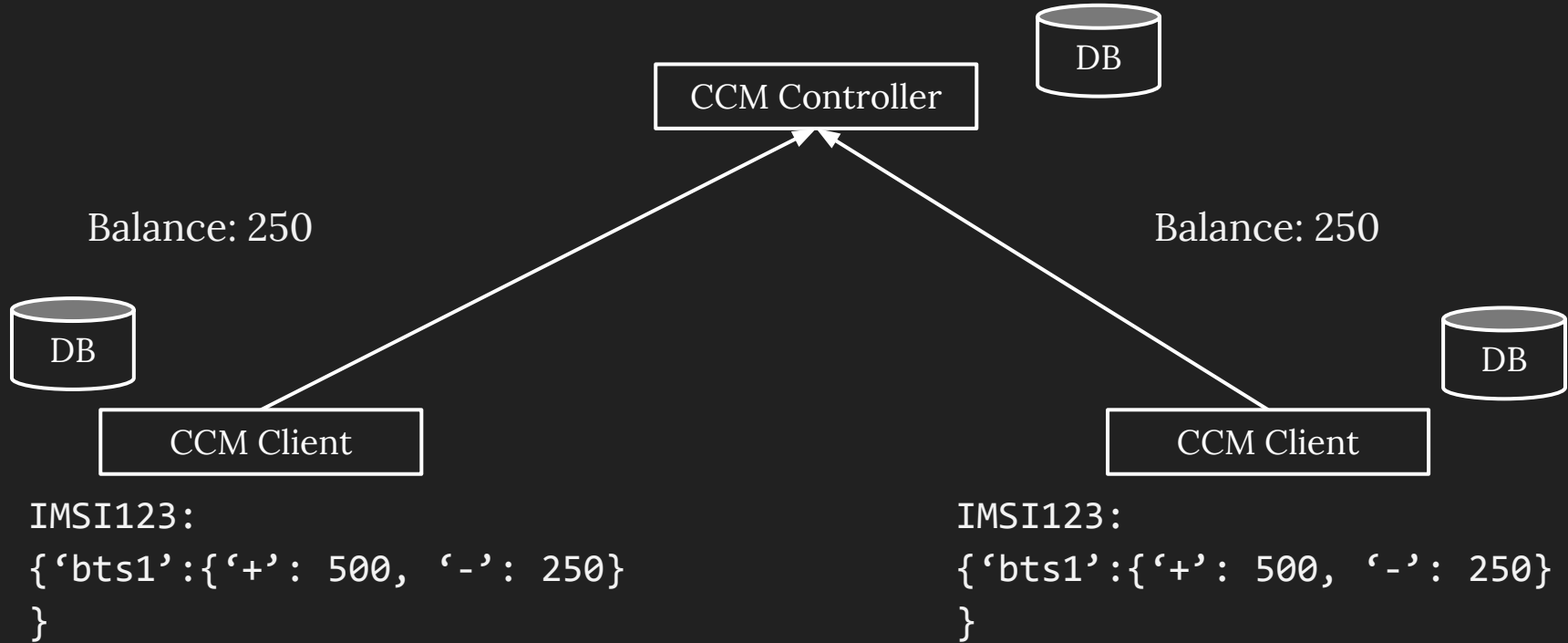
# Synchronizing state: Billing



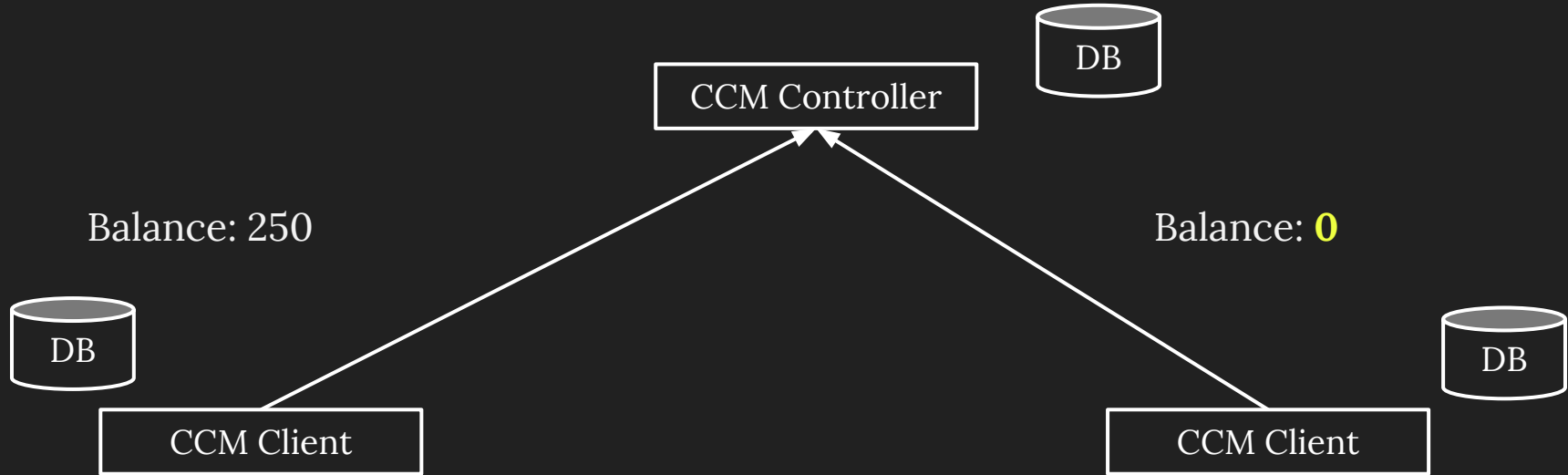
IMSI123:

```
{ 'bts1': { '+': 500, '-': 250 } }
```

# Synchronizing state: Billing



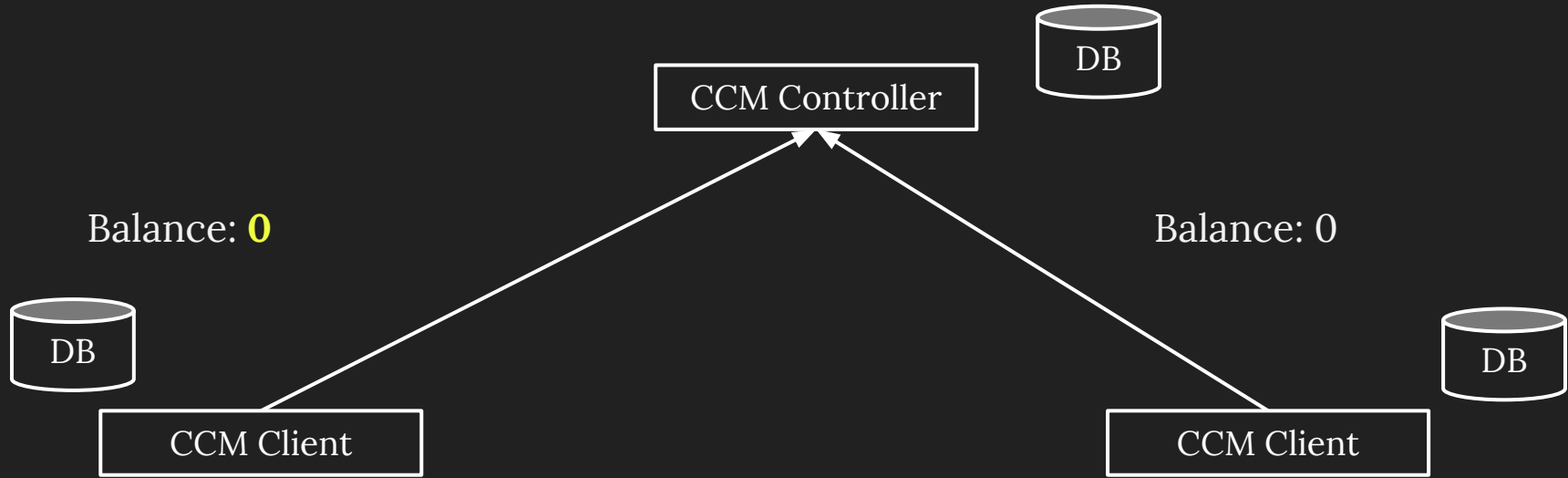
# Synchronizing state: Billing



IMSI123:  
{ 'bts1': { '+': 500, '-': 250 }  
}

IMSI123:  
{ 'bts1': { '+': 500, '-': 250 }  
 'bts2': { '+': 0, '-': 250 }  
}

# Synchronizing state: Billing



Balance: **0**

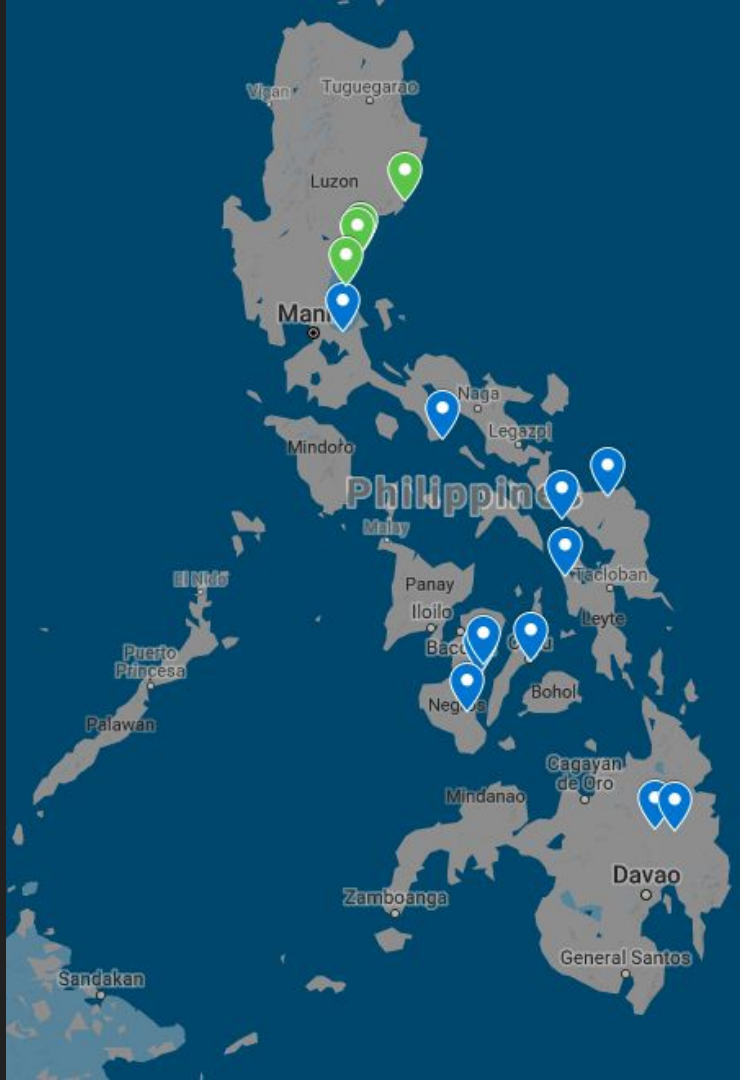
Balance: 0

```
IMSI123:  
{'bts1': {'+': 500, '-': 250}  
  'bts2': {'+': 0, '-': 250}  
}
```

```
IMSI123:  
{'bts1': {'+': 500, '-': 250}  
  'bts2': {'+': 0, '-': 250}  
}
```



# Deployment and Evaluation

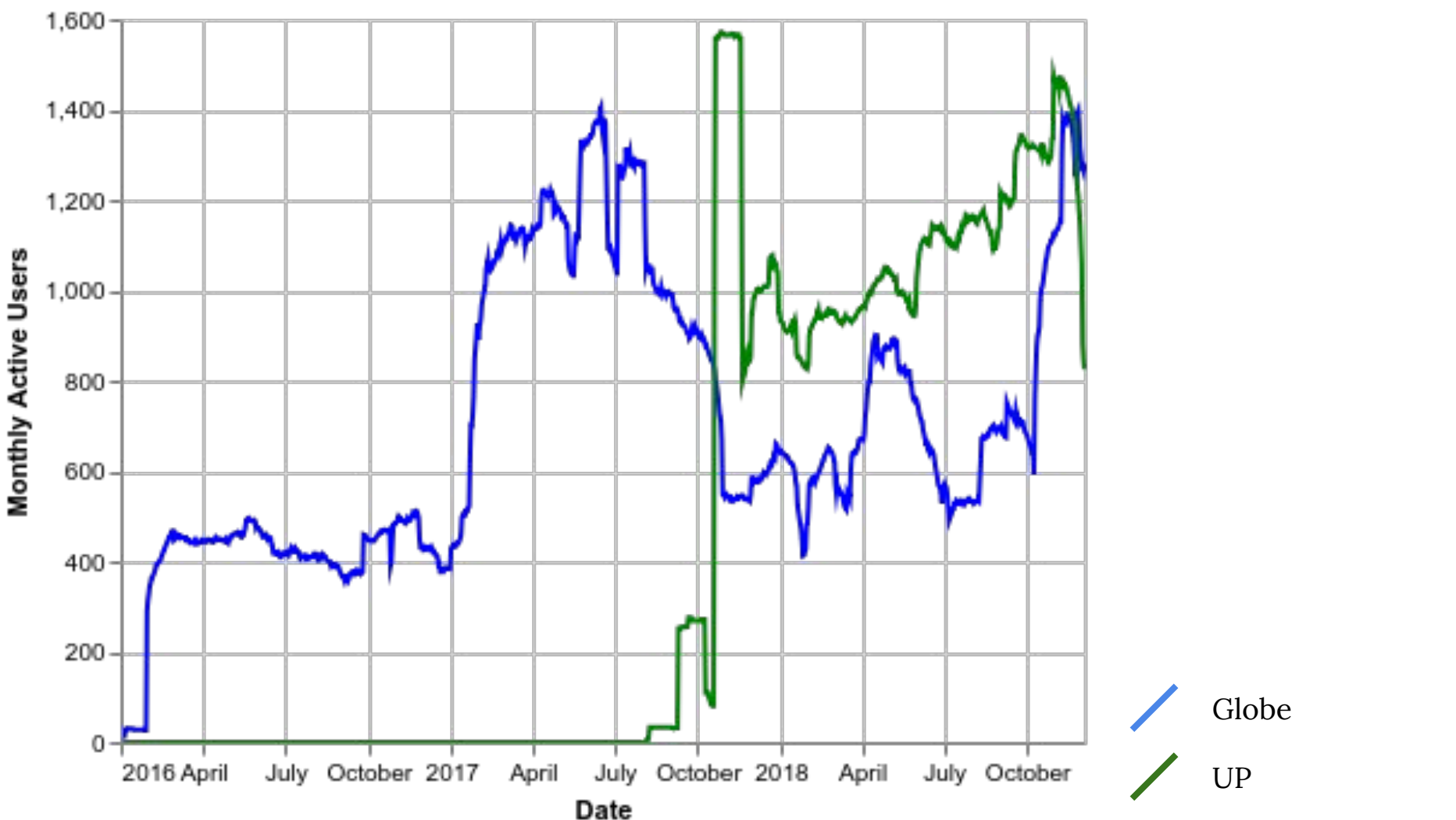


**UP Sites** ●

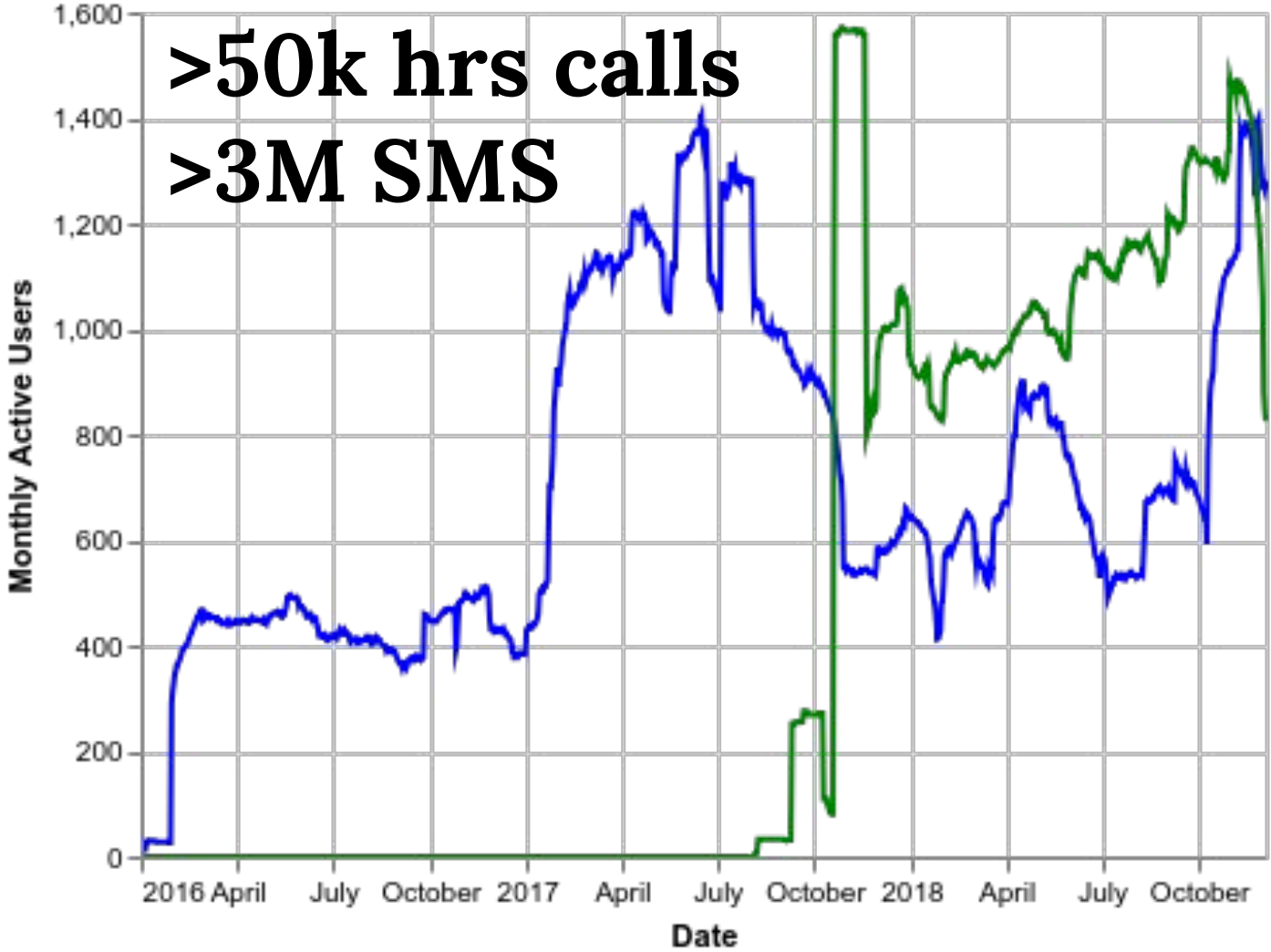
- Sabang-Limbok
- Dikapinisan
- Dibut
- Diatorin
- Bacong-Market
- Dianao

**Globe Sites** ●

- Tanay
- Talisay
- Binobohan
- Ginulagan
- Balogo
- Casalaan
- Banat-i
- Mayaposi
- Golden Valley
- San Mariano
- Binucayan

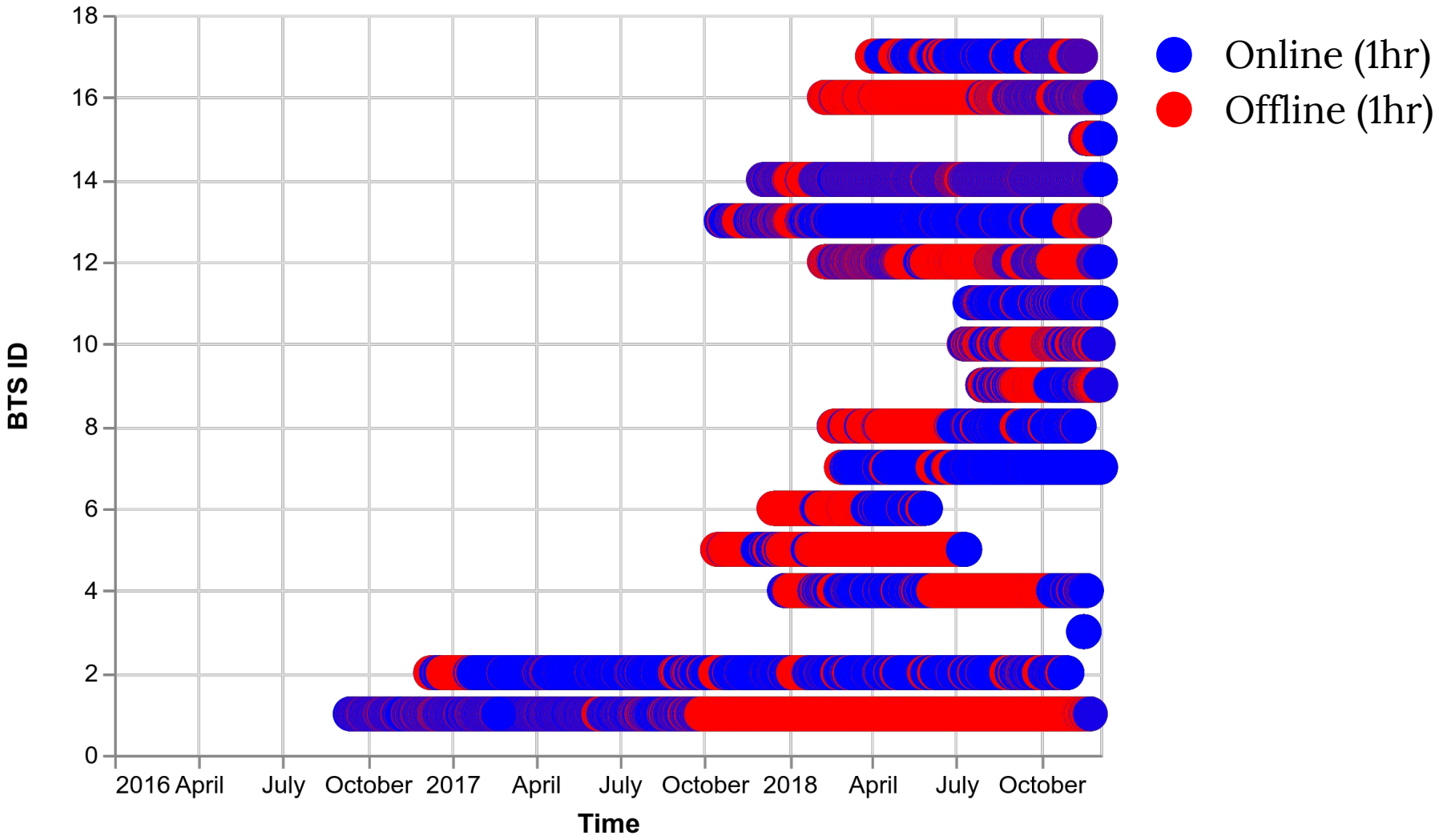


**>50k hrs calls**  
**>3M SMS**

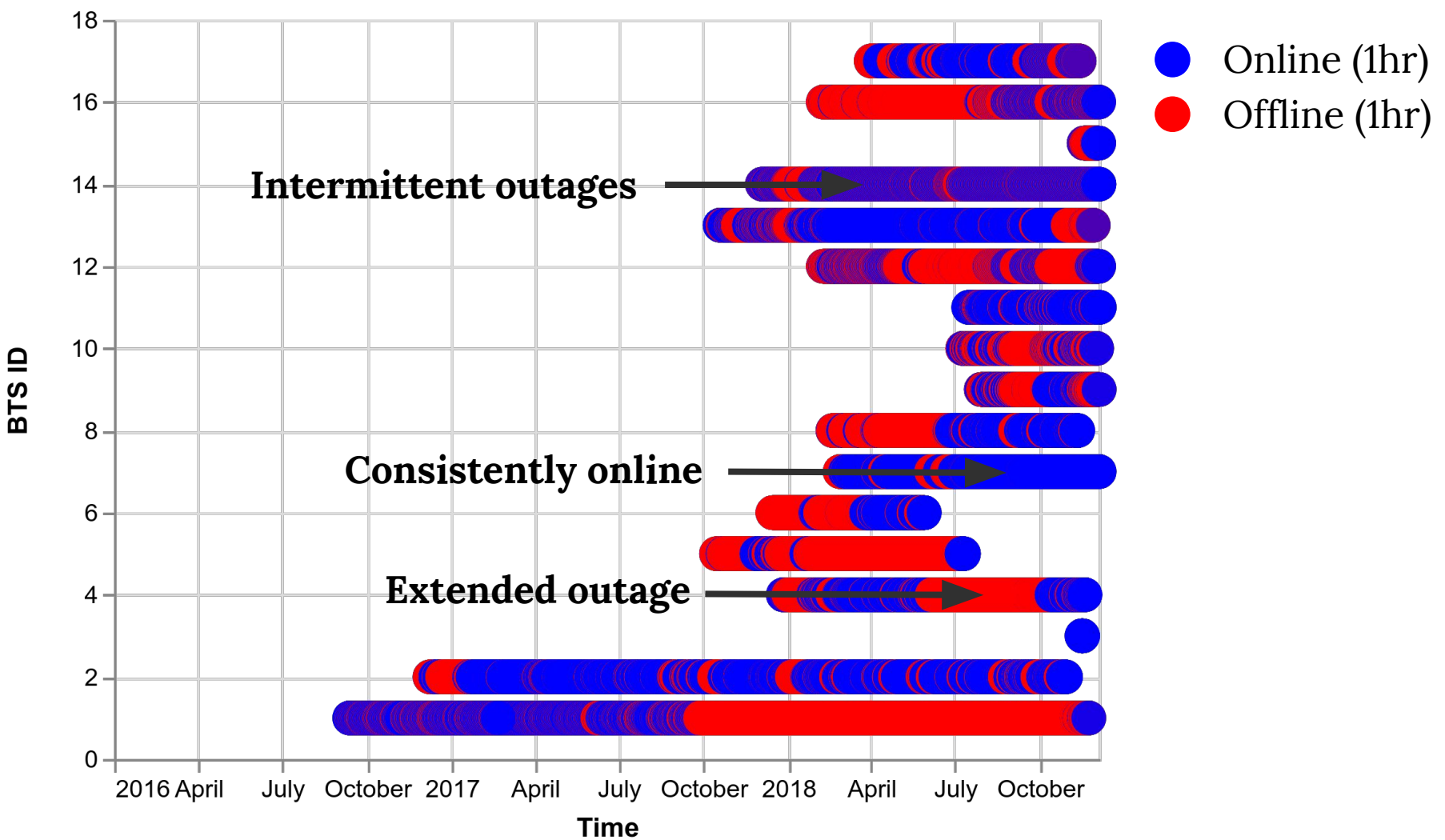


— Globe  
— UP

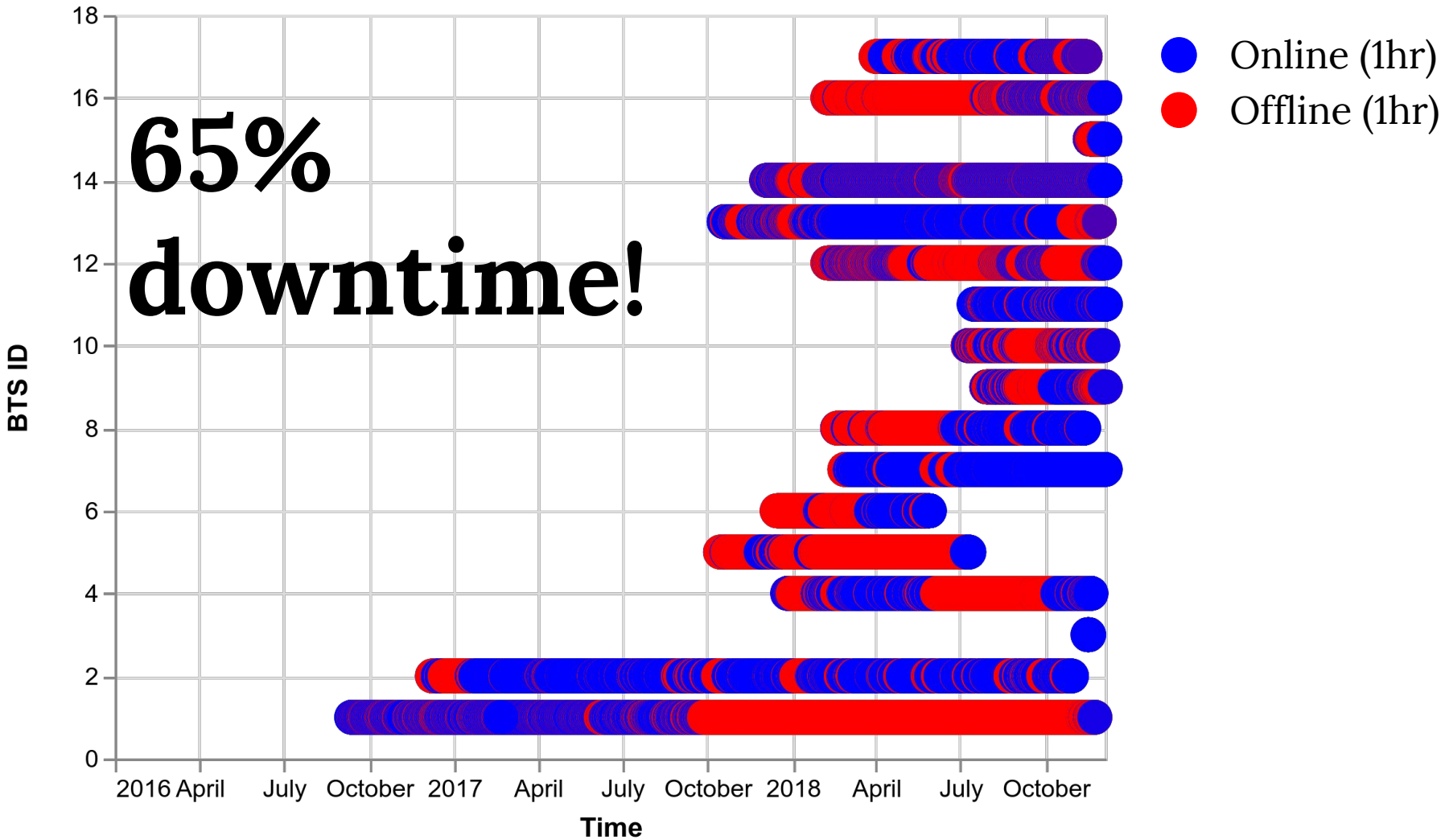








**65%**  
**downtime!**

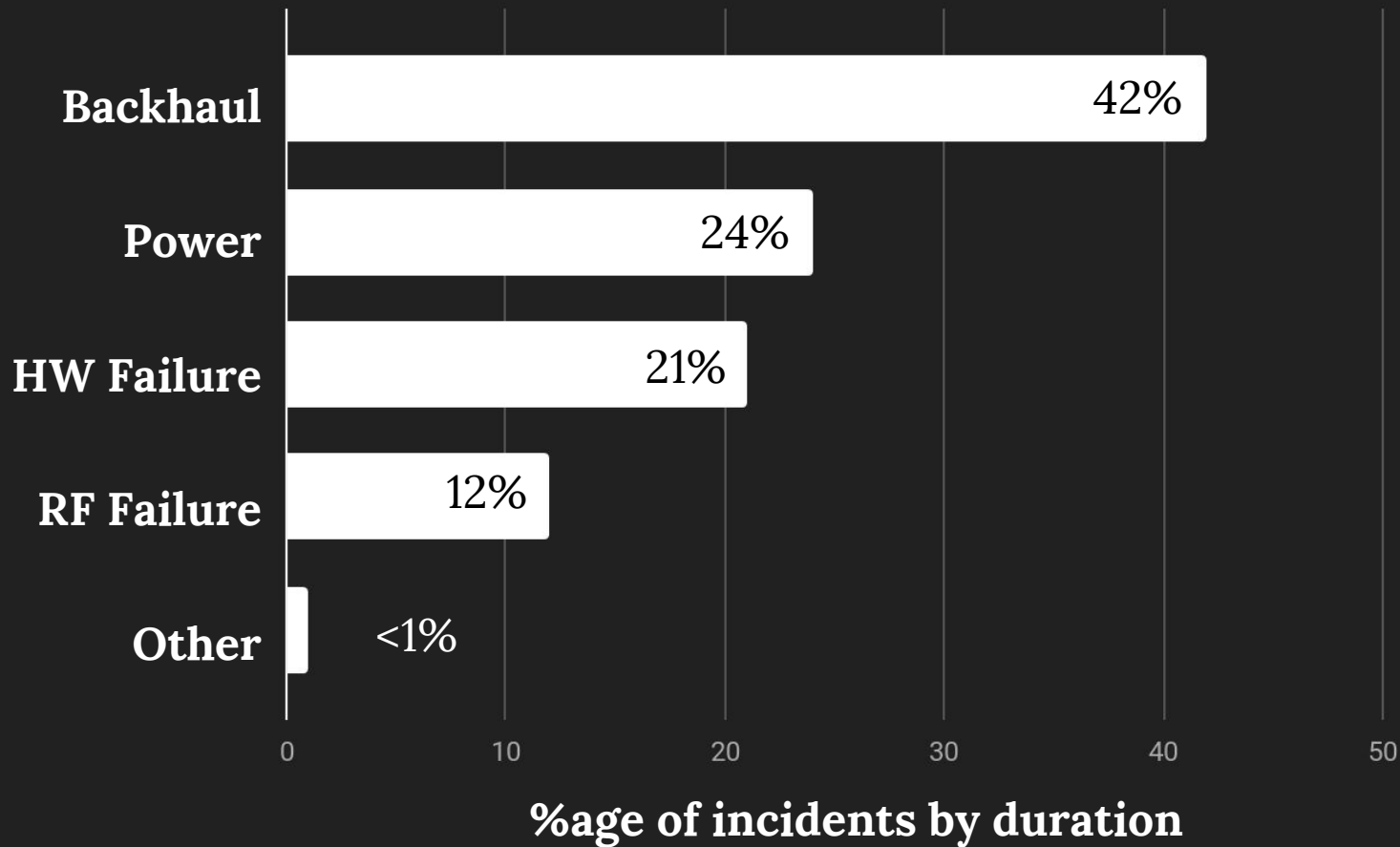




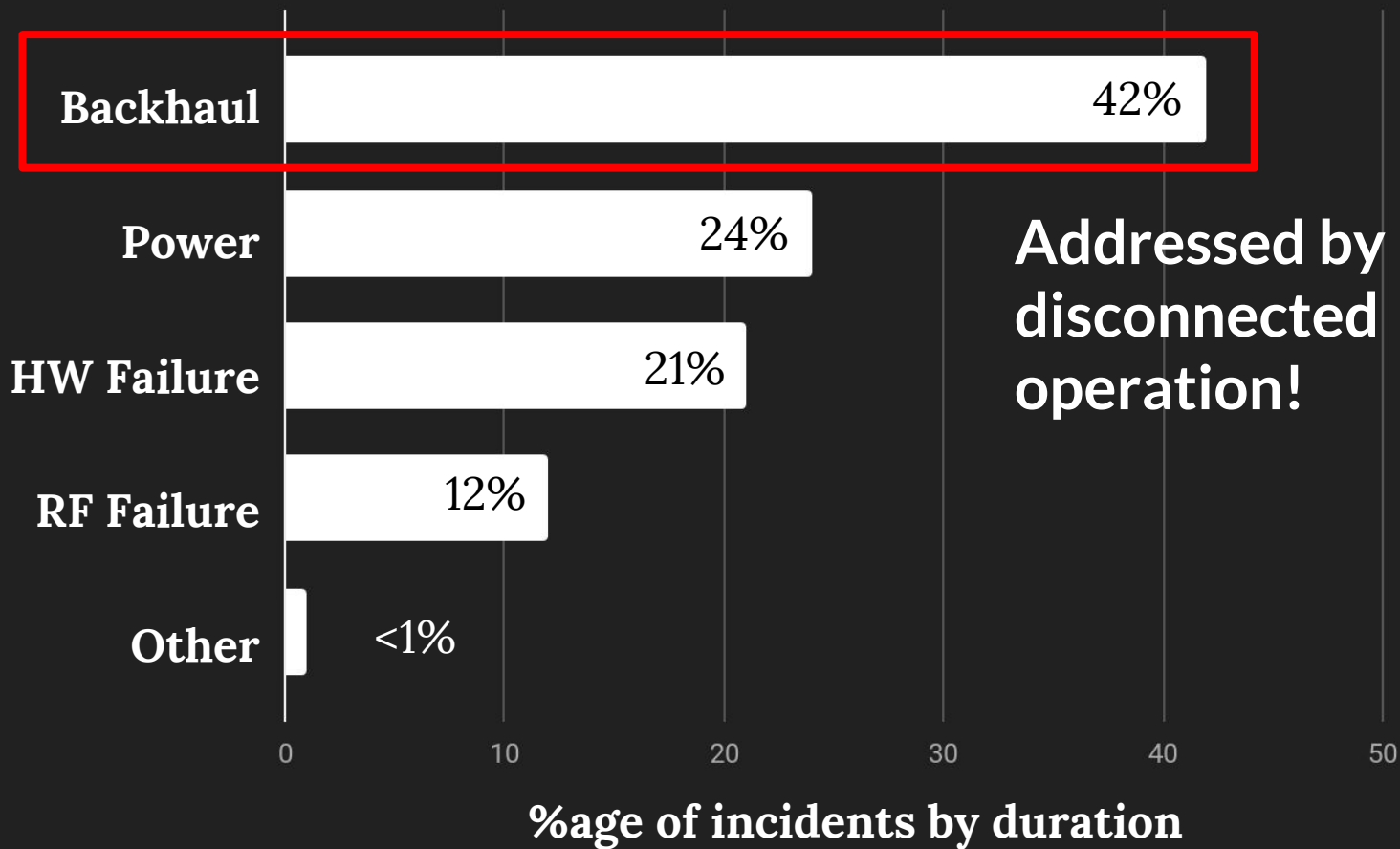
# Outage causes in UP sites

<b>Cause</b>	<b>Example</b>
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

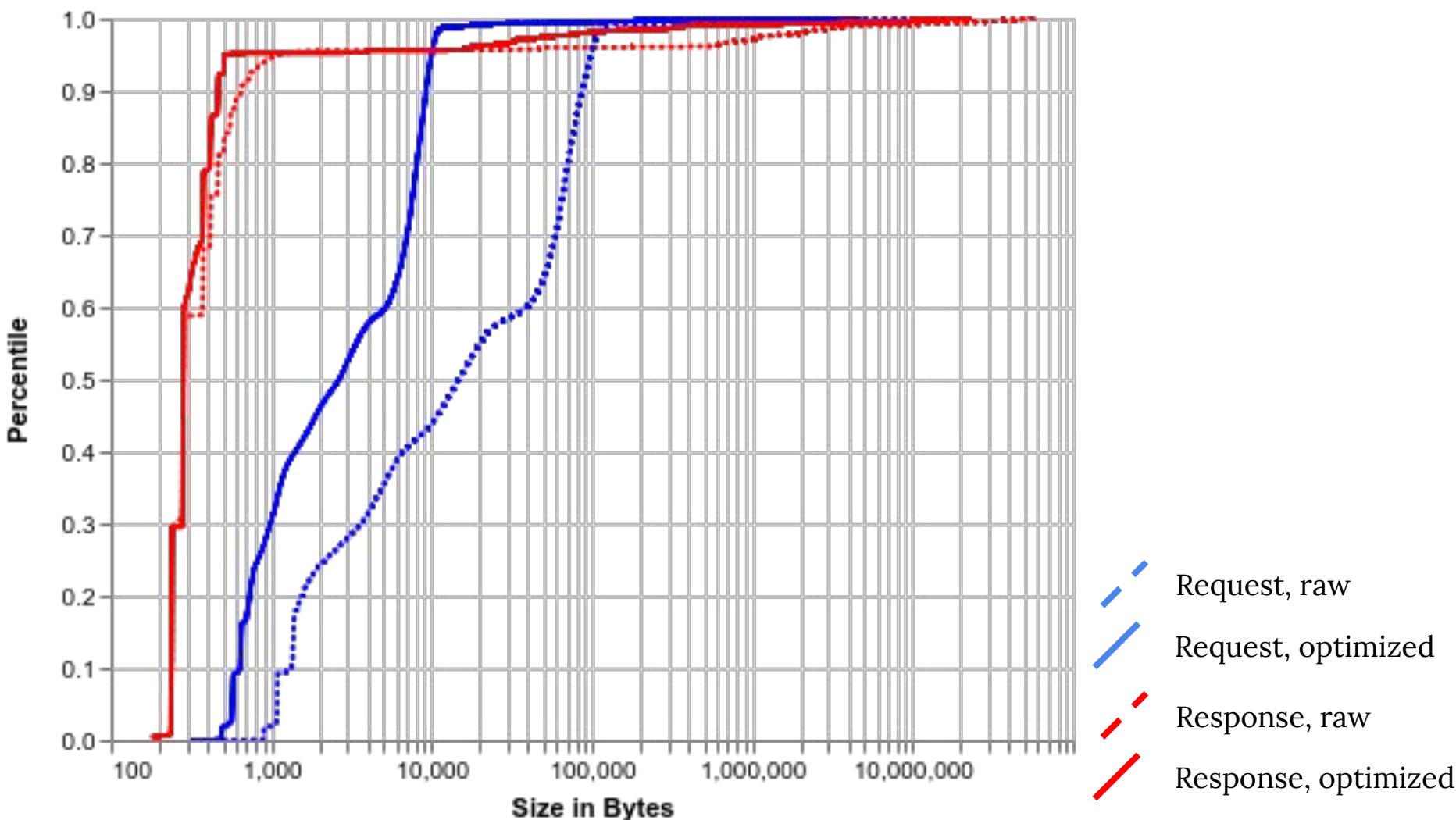


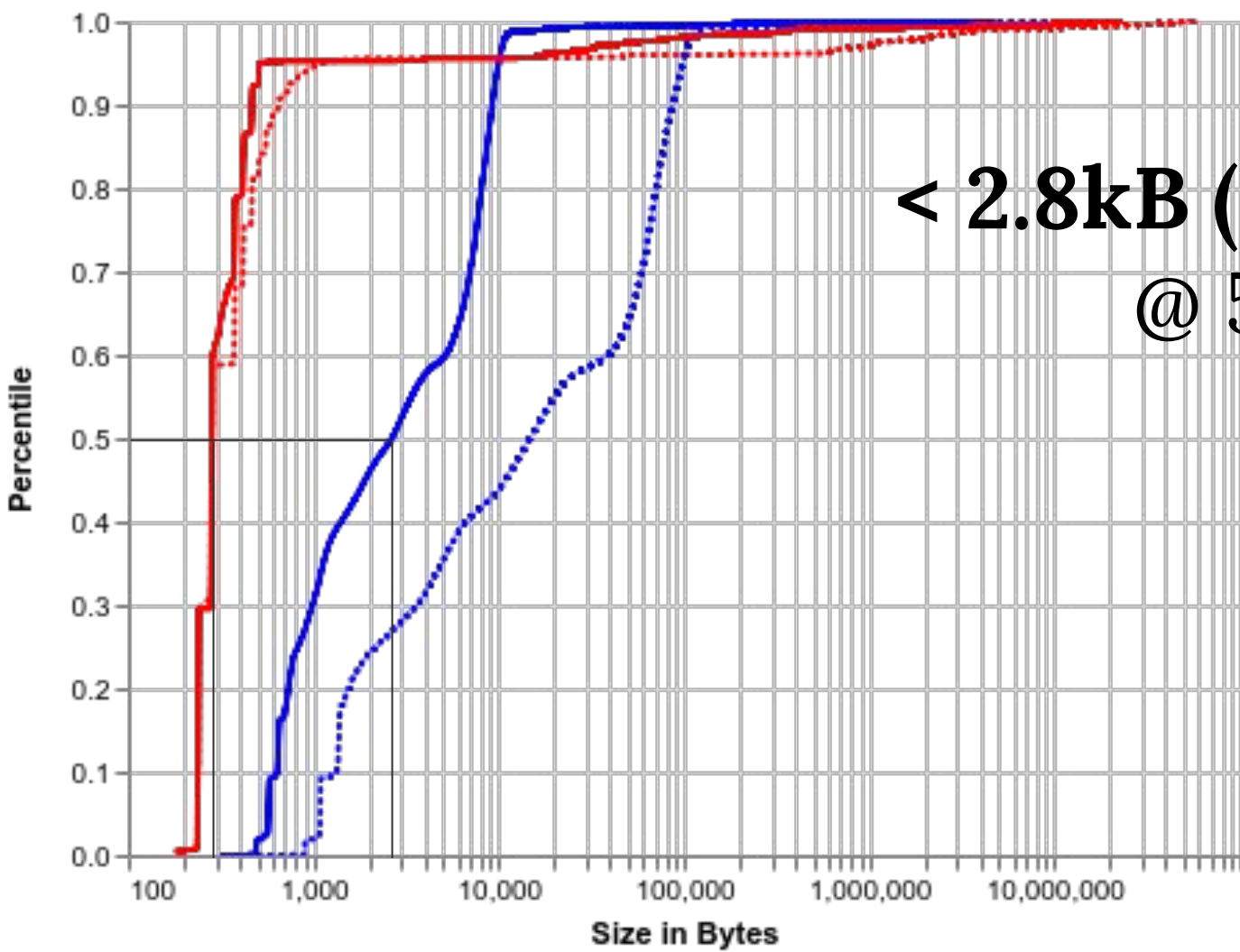
**+19%**

local calls + SMS

**+16%**

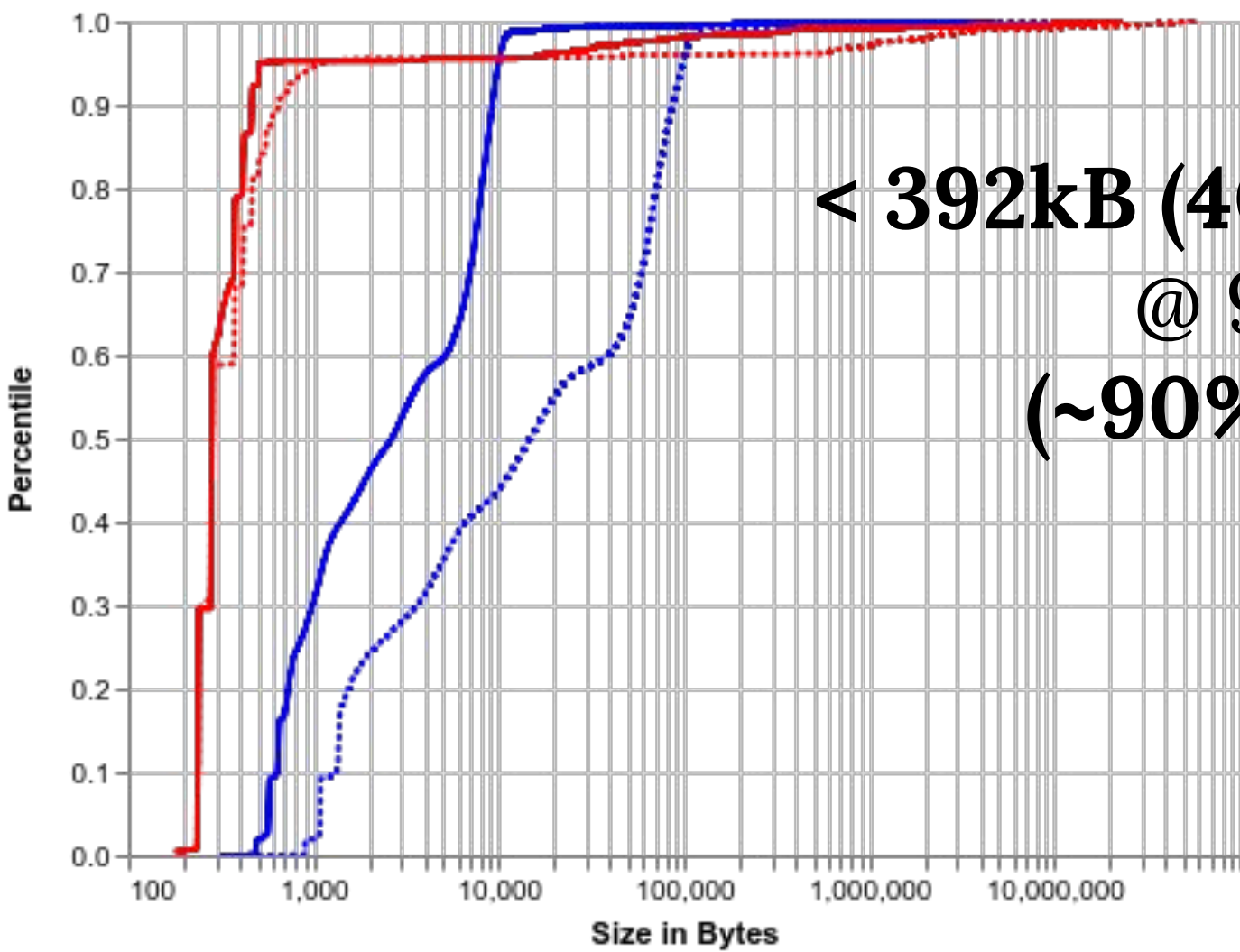
credit transfers (sales)





**< 2.8kB (6 sec call)**  
**@ 50th %tile**

- Request, raw
- Request, optimized
- Response, raw
- Response, optimized



**< 392kB (40 sec call)**  
**@ 99th %tile**  
**(~90% savings)**

- Request, raw
- Request, optimized
- Response, raw
- Response, optimized

# Local Services

## UP Sites

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

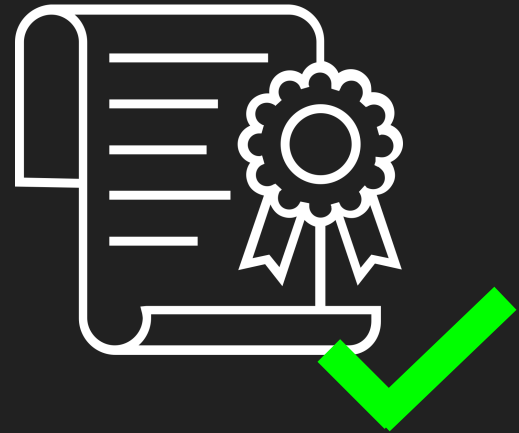




**What next?**

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

# CommunityCellularManager

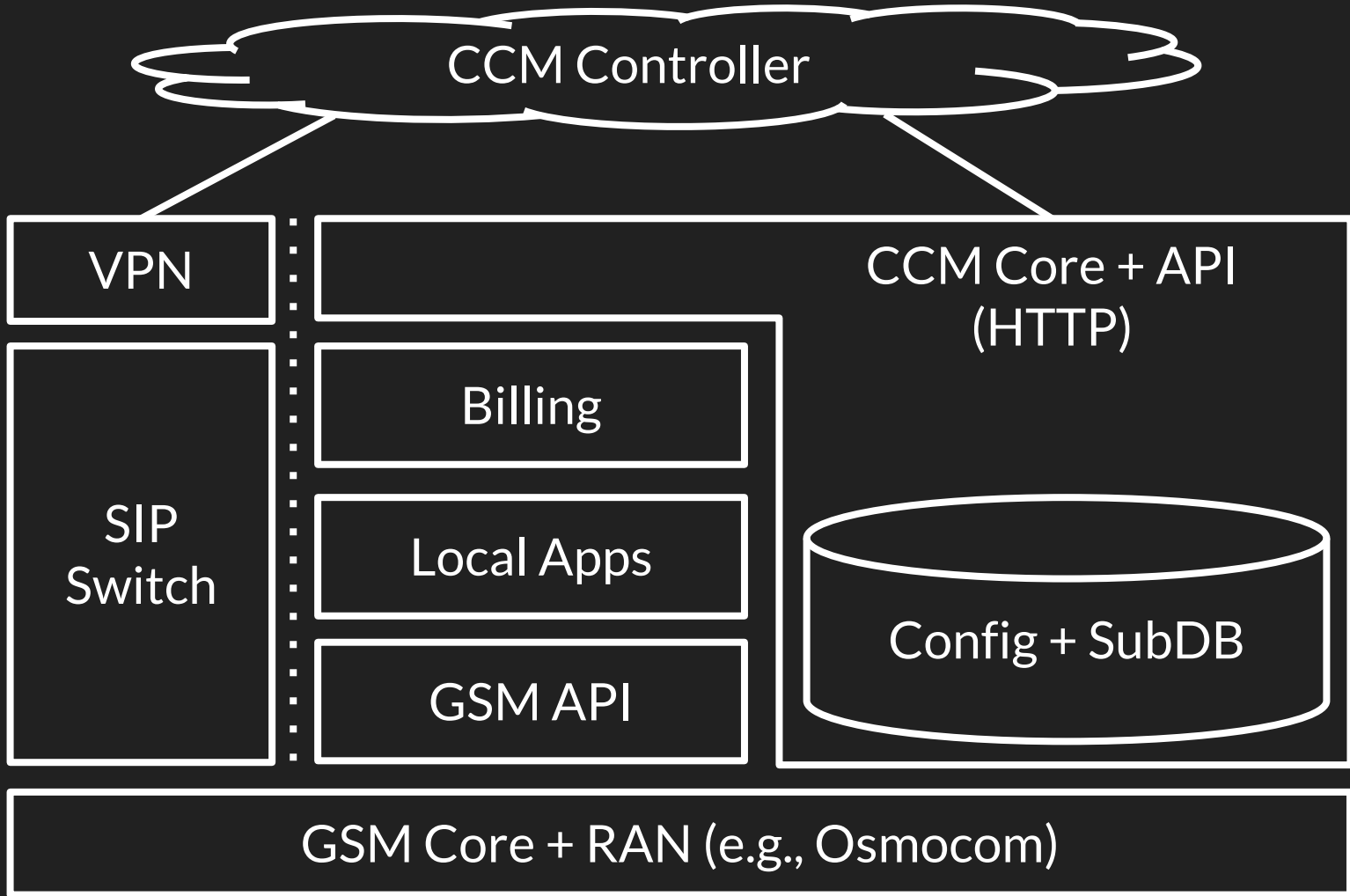
1. Provides **autonomy** for community cellular networks
2. Degrades **gracefully** in the face of failures
3. Enables **cooperation** between community cellular networks and telcos
4. Supports the **largest** community cellular network deployment to date

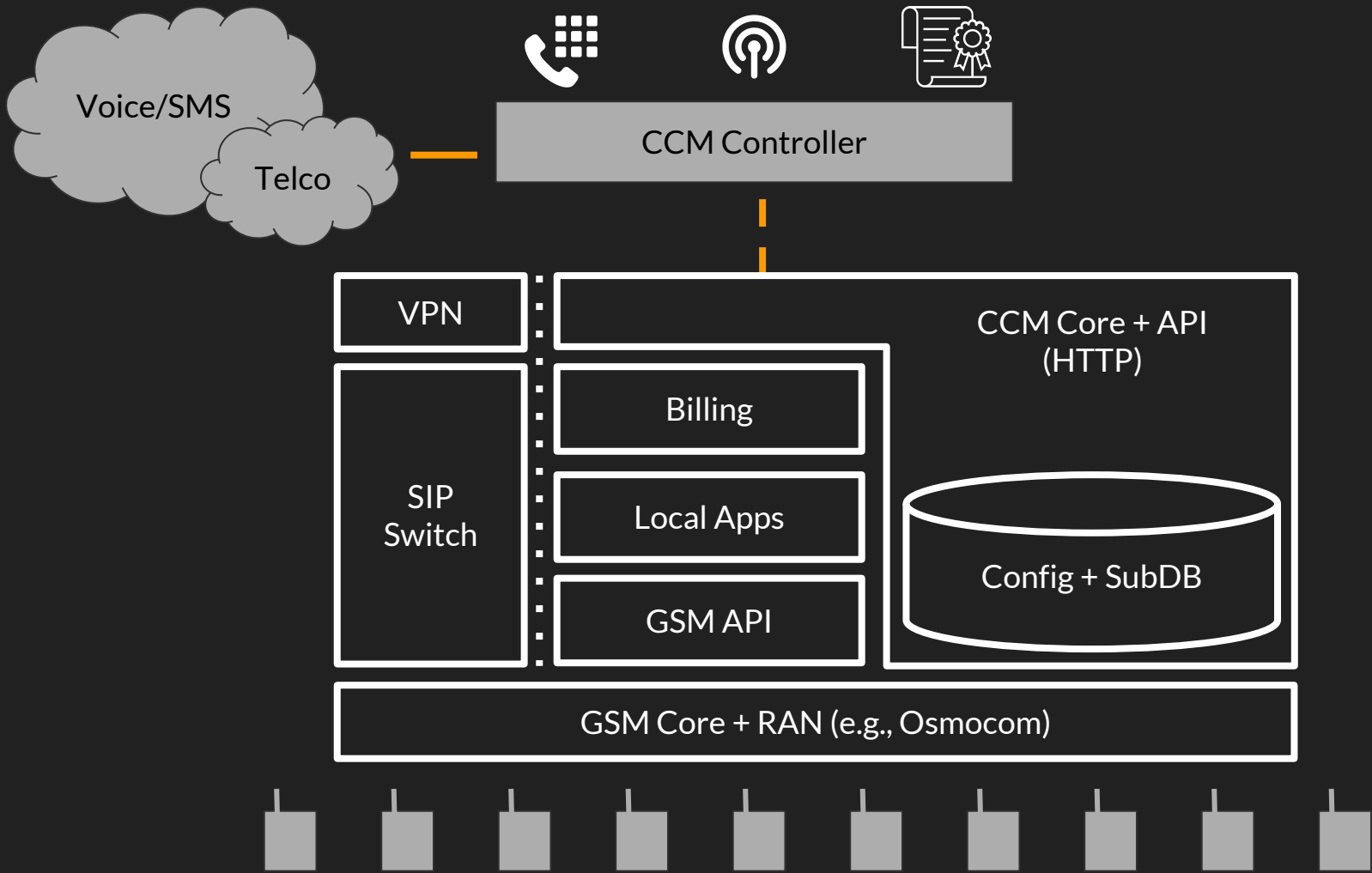


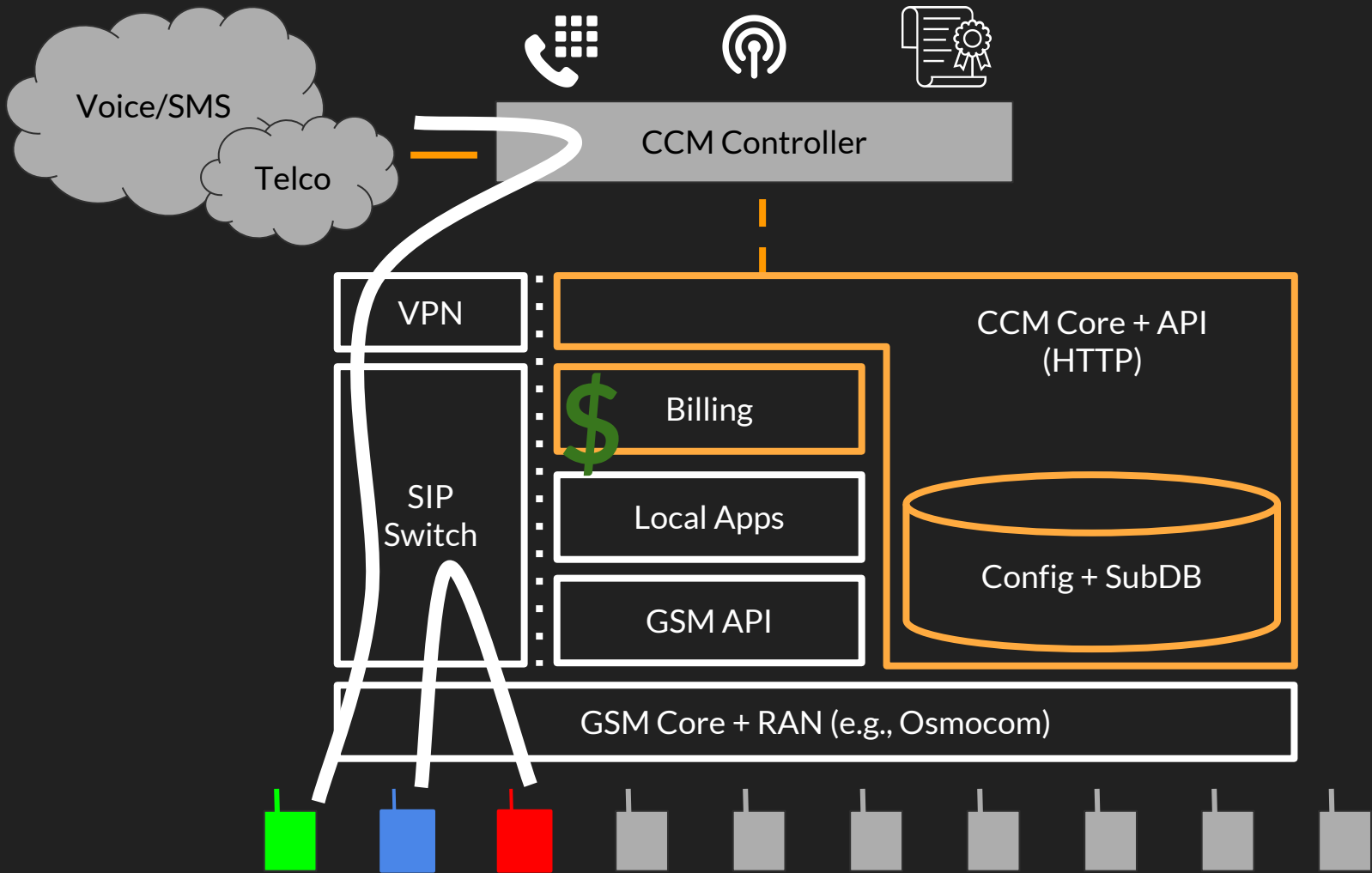
# Thanks!

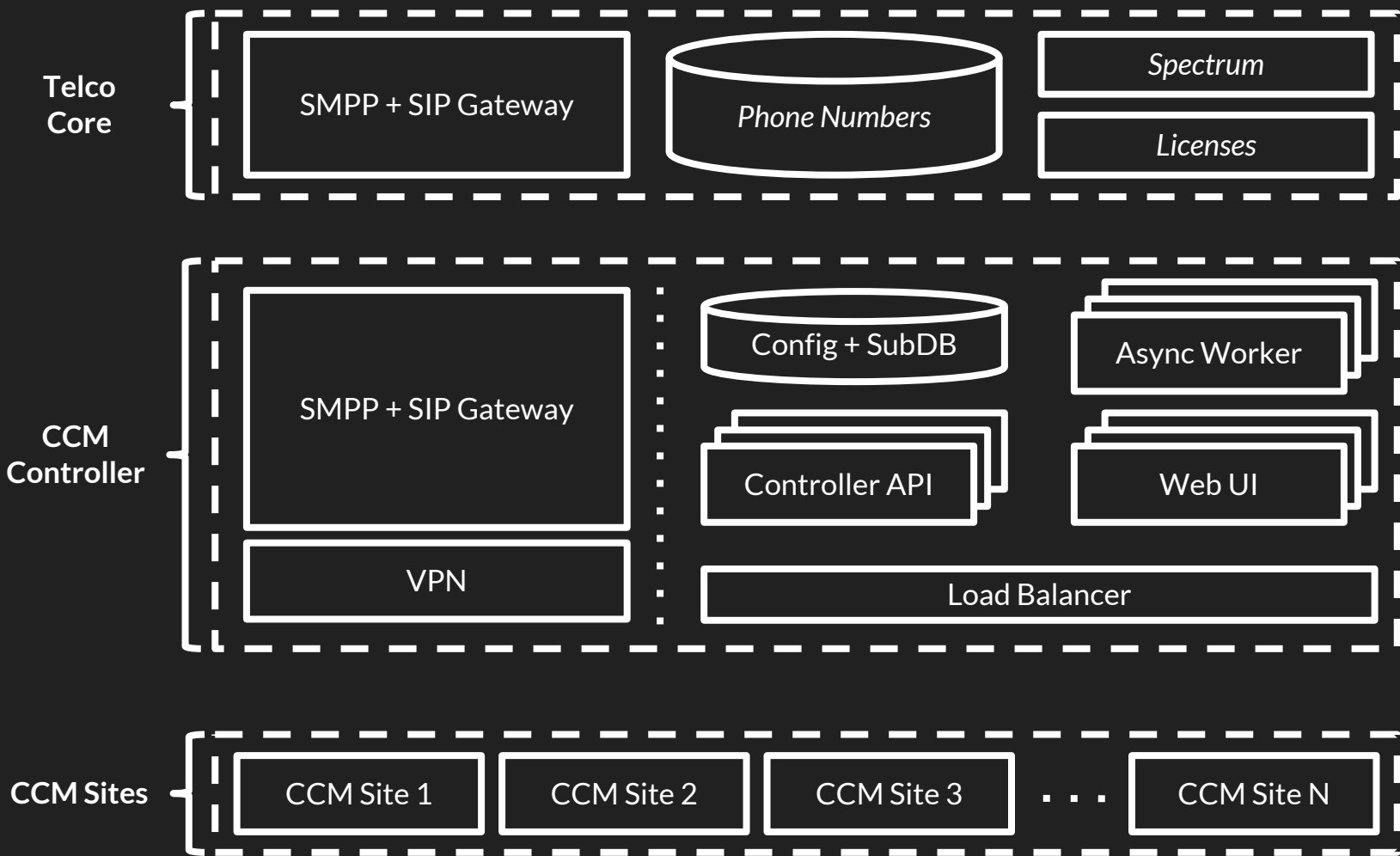


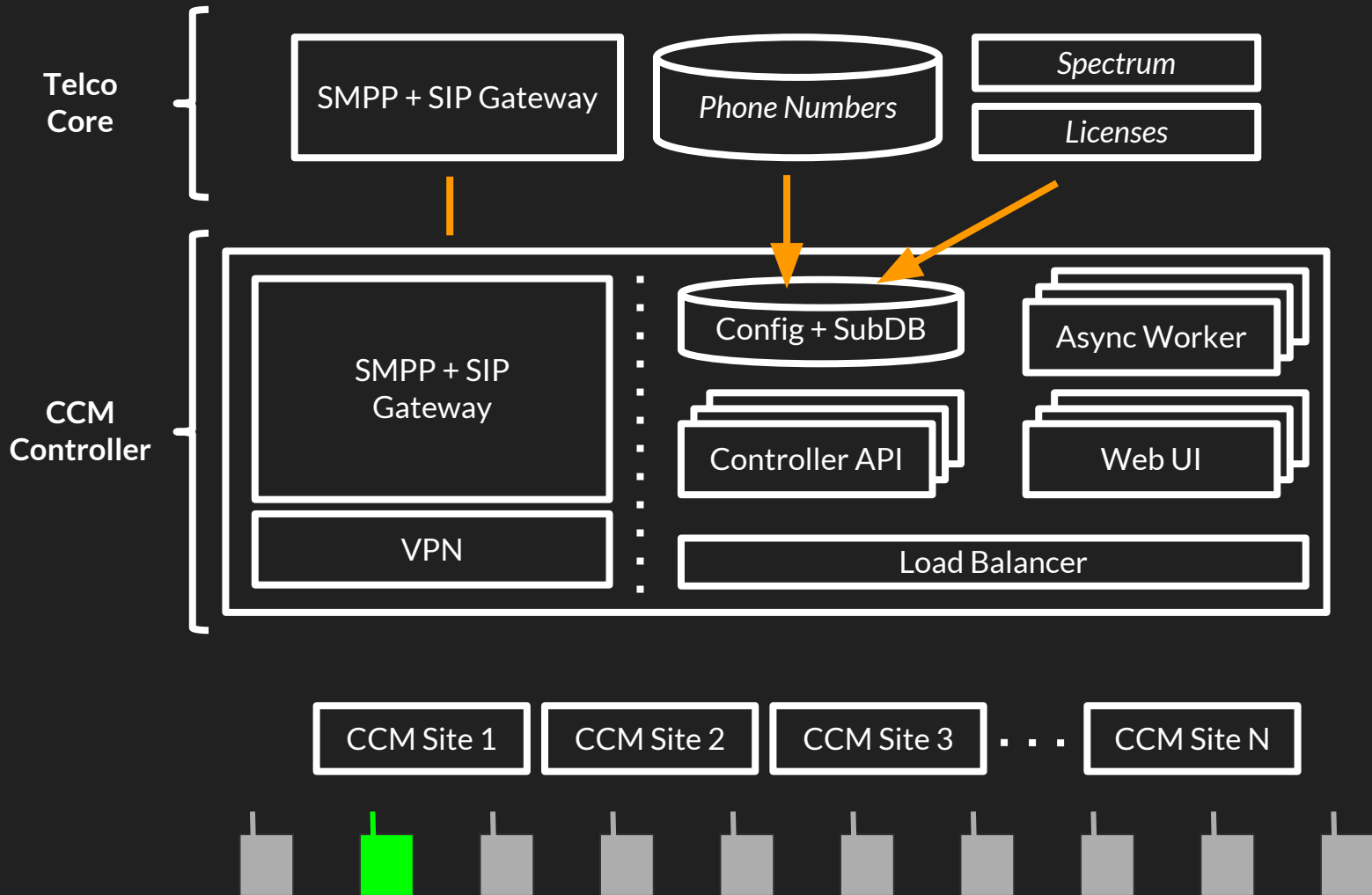
**Shaddi Hasan**  
shaddi@cs.berkeley.edu  
@shaddih  
github.com/co-cell/ccm

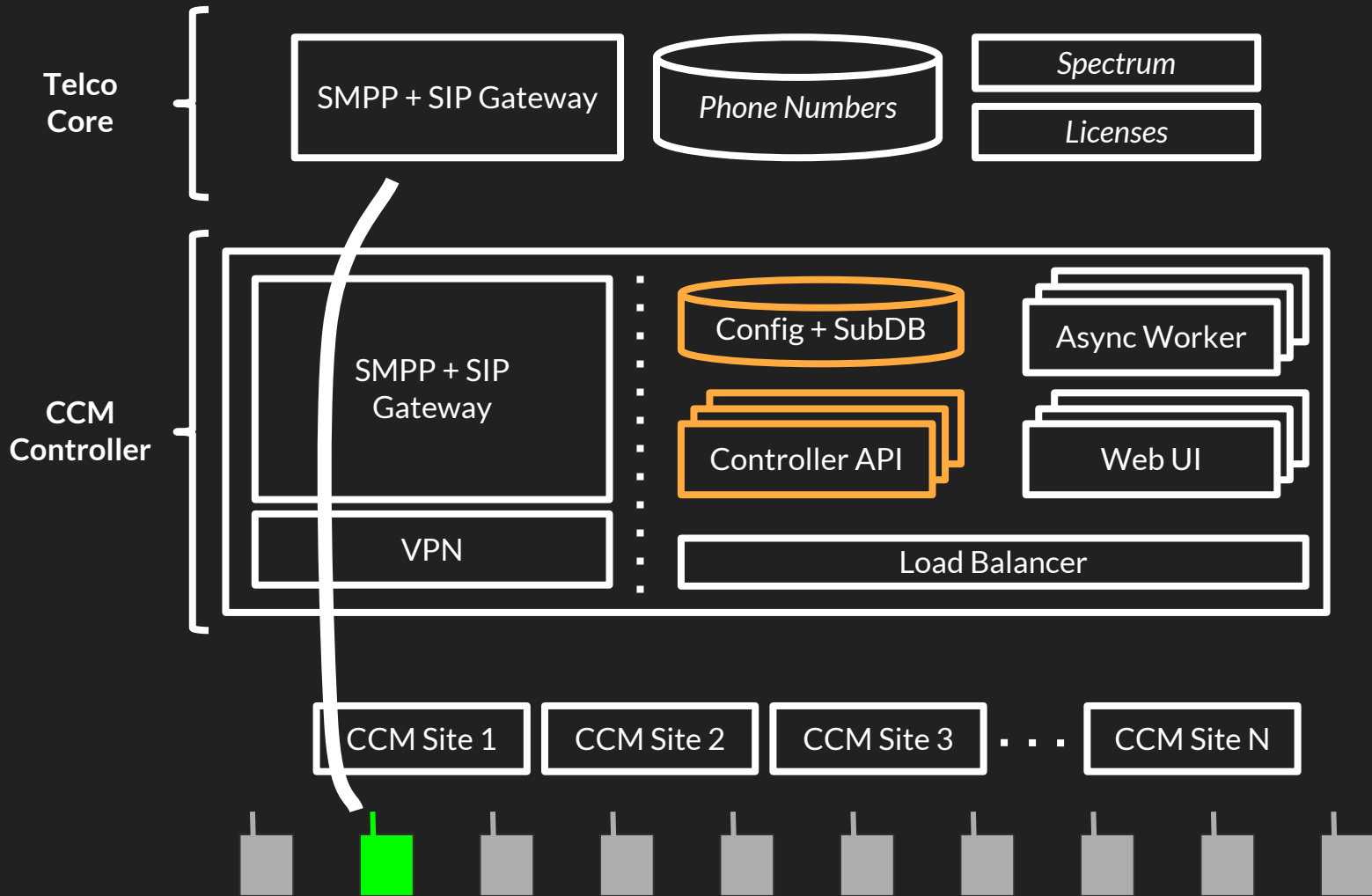


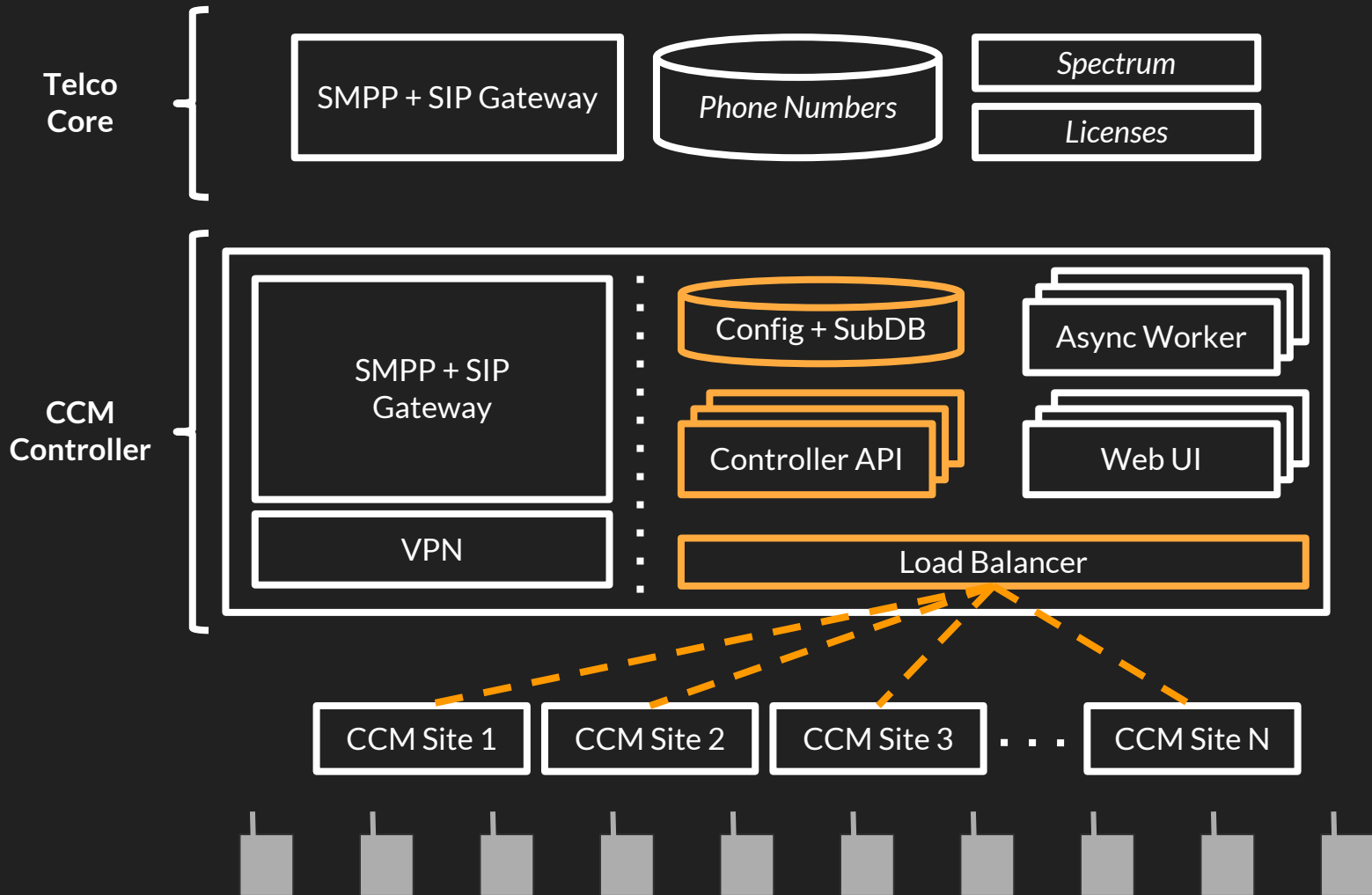




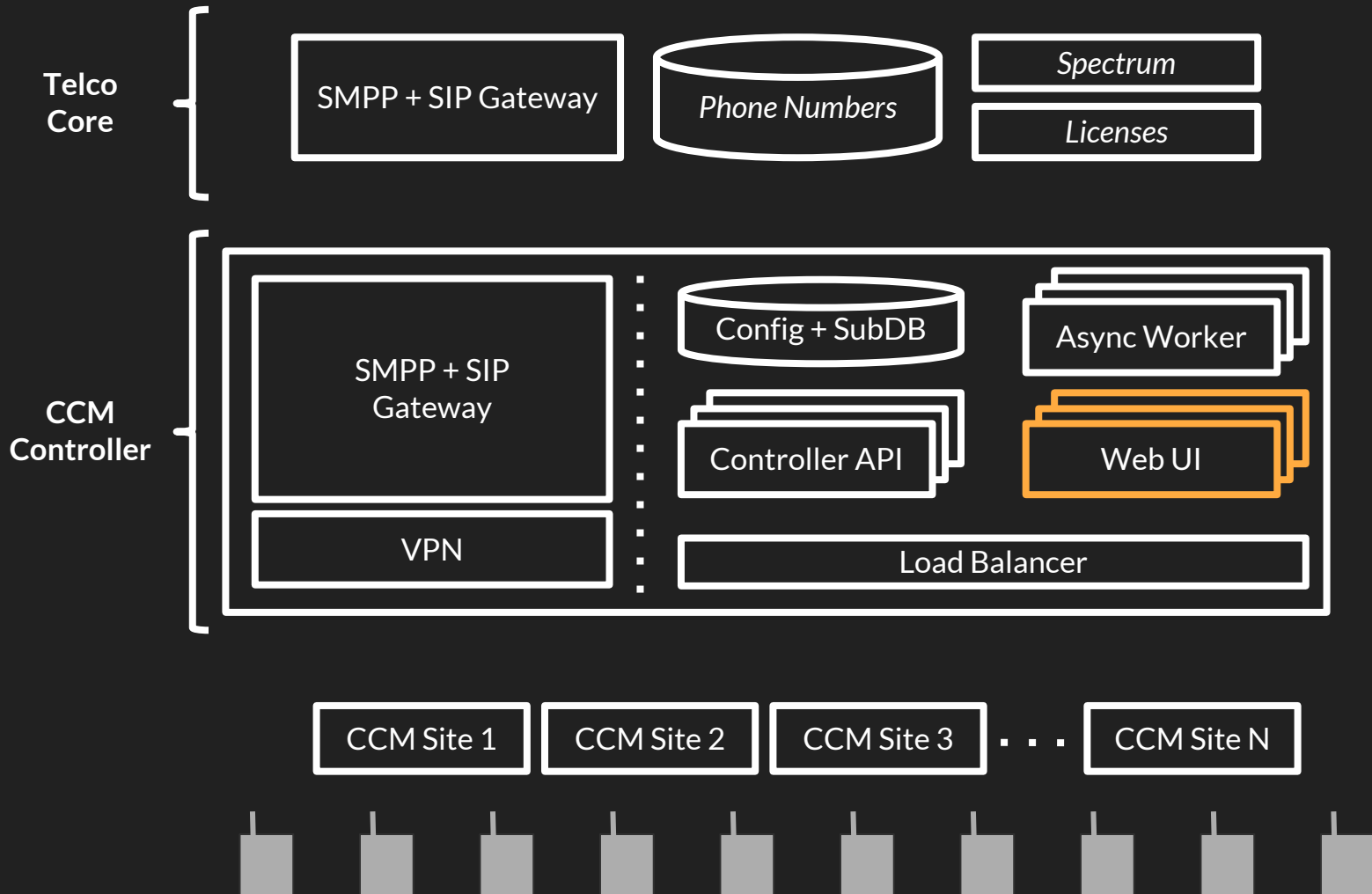


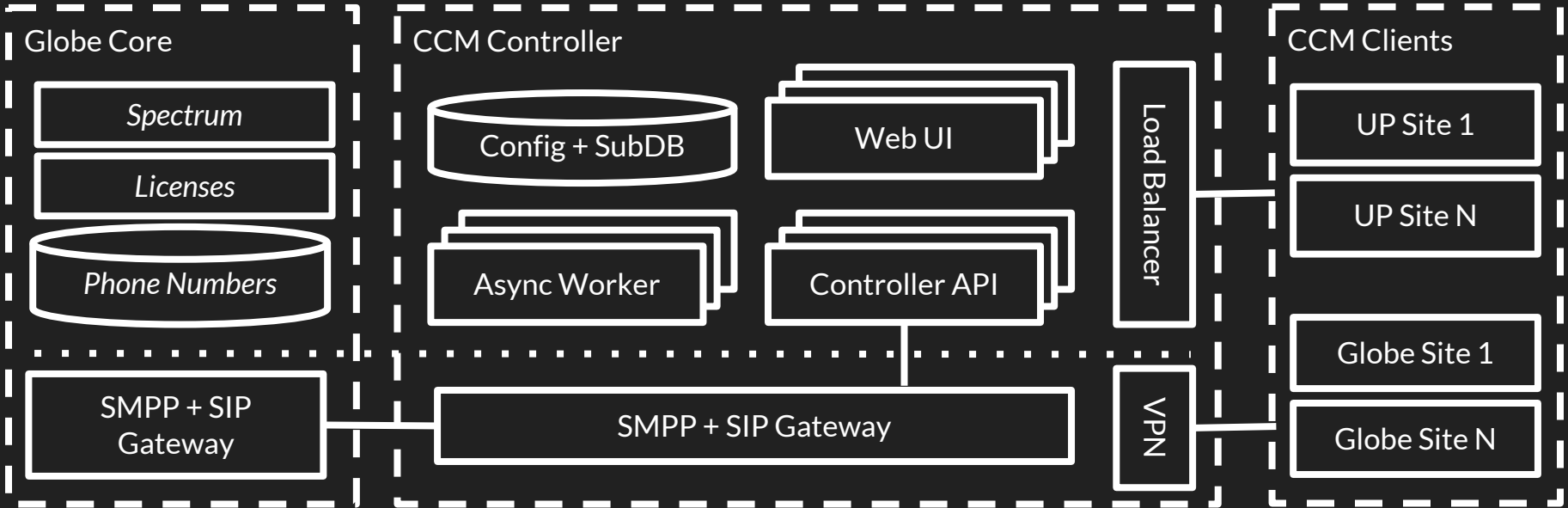












# Autonomy for the community.

Every site should be able to provide service without reliance on external systems.

