# gsmws

## An Opportunity for Rural Cellular Service

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Sean Roberts, Anant Sahai, Eric Brewer

# Shaddi Hasan

## UC Berkeley TIER/Endaga

# Thanks to...

Tapan Parikh

Peter Bloom, Ciaby, and Rhizomatica

Steve Song and Village Telco

David Haag, Scotty and Heidi Wisely, and the OA crew

The OpenBTS community

USAID DIL, NSF, Blum Center for Developing Economies

**... Many others!**

RURAL
CELLULAR NETWORKS

# WHITE MEANS NO COVERAGE

# WHITE MEANS NO SPECTRUM IN USE

# ONE BILLION

## PEOPLE WITHOUT

# COVERAGE

Source: GSMA

# COMMUNITY CELLULAR NETWORKS

Micro-scale GSM networks that rural communities build and run themselves.

280 Subscribers

$1,000/mo revenue

300,000 SMS/Voice Min.

Critical Infrastructure

"Local, Sustainable, Small-Scale Cellular Networks", Heimerl et al. ICTD 2013

RHIZOMATICA

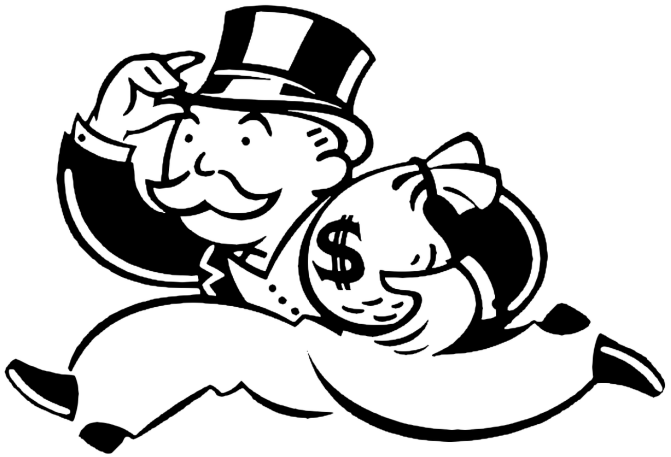
# Oaxaca, Mexico

# PROBLEM

Limited room for CCNs in today's regulatory frameworks.

So,

# How should CCNs be regulated?



# GSM WHITESPACE

Let CCN operators
use spectrum on a secondary basis
that licensed carriers aren't using.

# GSM WHITESPACE

| | |
|---|---|
| Safety | Don't interfere with existing licensed operators. |
| Backwards Compatibility | Don't require new or modified client devices. |
| Spectrum Flexibility | Avoid another "garage door opener" fiasco. |
| Independence | Don't make CCNs and Big Telcos talk to each other. |
| Trustworthiness | Let regulators control what spectrum is used and where. |

# Why GSM Whitespace?

And why those goals in particular?

| | Regulators | CCN Operators | Carriers |
|---|---|---|---|
| Safety | X | X | X |
| Backwards Compatibility | | X | |
| Spectrum Flexibility | X | | X |
| Independence | | X | X |
| Trustworthiness | X | | |

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# Regulators

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➔ Put rules in place that encourage good practices

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➔ Put rules in place that encourage good practices

➔ Incorporate a database for monitoring and control

- Gives long-term regulatory flexibility

# Regulators

2) Improved rural communication access

➔ Current mechanism: USO

- Expensive
- Ineffectual!

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|---|---|---|---|
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# CCN Operators

1) Stable regulatory environment

➔ Small-scale businesses: getting shut down rare, but disastrous

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➔ Small-scale businesses: getting shut down rare, but disastrous

➔ Stability encourages investment

# CCN Operators

2) Use existing client devices

➔ GSM phones are EVERYWHERE

# CCN Operators

2) Use existing client devices

➔ GSM phones are EVERYWHERE

➔ In Papua, 1500 unique phones detected in village

- No power
- No cellular coverage (yet!)
- Primarily used for listening to music (not smartphones)

# CCN Operators

3) Little to no overhead

➔ Yo ho ho! Pirate's life isn't bad

- Enforcement is unlikely
- As easy as running an unlicensed network

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➔ Little power or ability to negotiate with carriers
- Village schools aren't going to send lawyers to Jakarta
- Minimal formal economy

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# Existing License Holders

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➔ Problem:
Make sure CCNs don’t become reliant on a particular channel.

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➔ Problem:
Make sure CCNs don't become reliant on a particular channel.

➔ Solution:
Require CCNs to change channels frequently and proactively.

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Don’t want to interact with 100’s of CCNs.

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➔ Problem:
Don’t want to interact with 100’s of CCNs.

➔ Solution:
Use sensing as primary sharing mechanism.
Make database usage optional.

# Existing License Holders: Even More Incentives

- → Share spectrum to fulfill rural service obligations
  - DB gives visibility into what spectrum CCNs use to provide rural service
  - License holders could receive credit for CCN activity in their spectrum

- → Opens up new rural markets
  - CCNs prove rural markets, without investment from incumbents
  - CCN customers call incumbents' customers: free money

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- ➔ CCNs don't have to talk to anyone
- ➔ CCNs aren't using spectrum anyone else is using
- ➔ Licensed users can still use spectrum as they please
- ➔ Sufficiently low sensing threshold restricts sharing to underserved areas only.

# ...but plenty of good does.

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- ➔ Rural areas get communications service
- ➔ Rural entrepreneurs get a sustainable business

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- ➔ Rural areas get communications service
- ➔ Rural entrepreneurs get a sustainable business
- ➔ Existing carriers keep building out their networks like they always have

# GSM WHITESPACE

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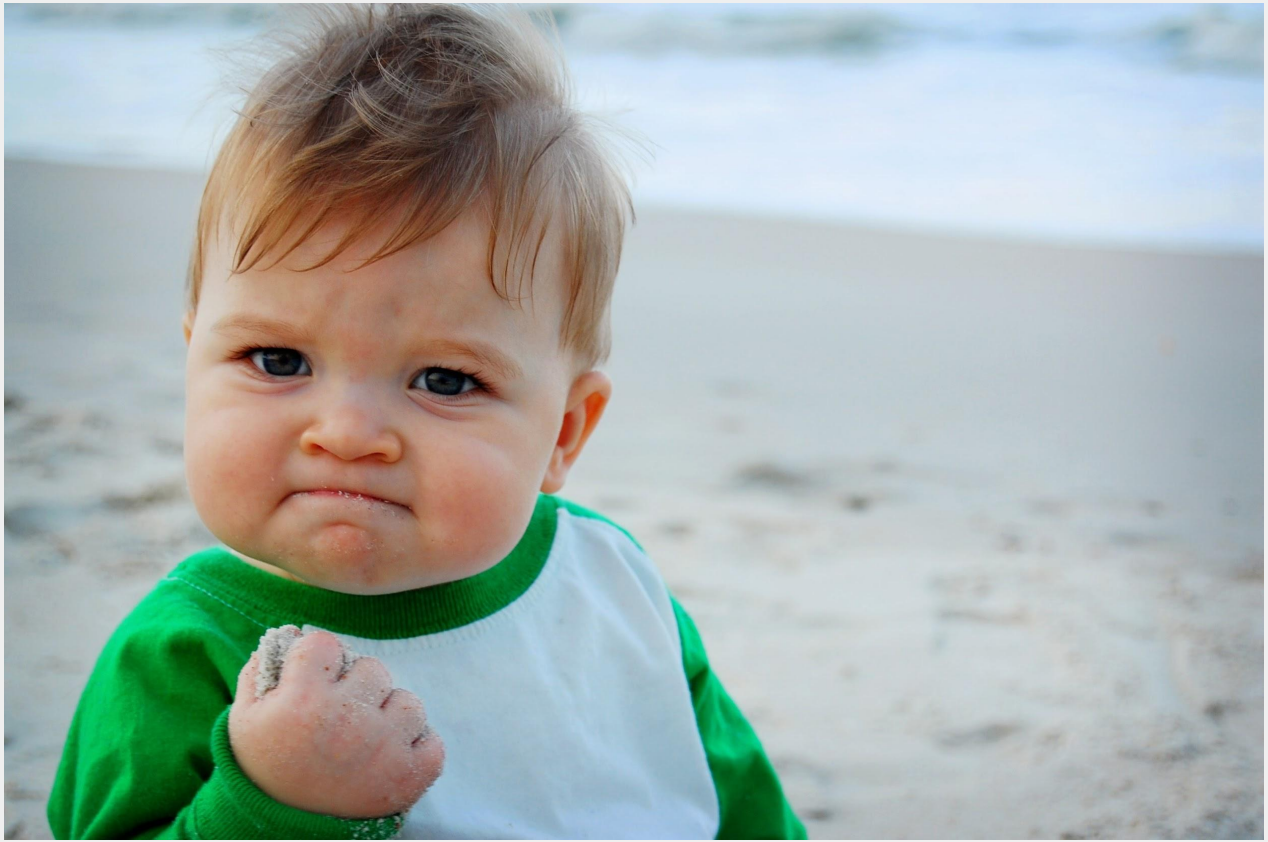
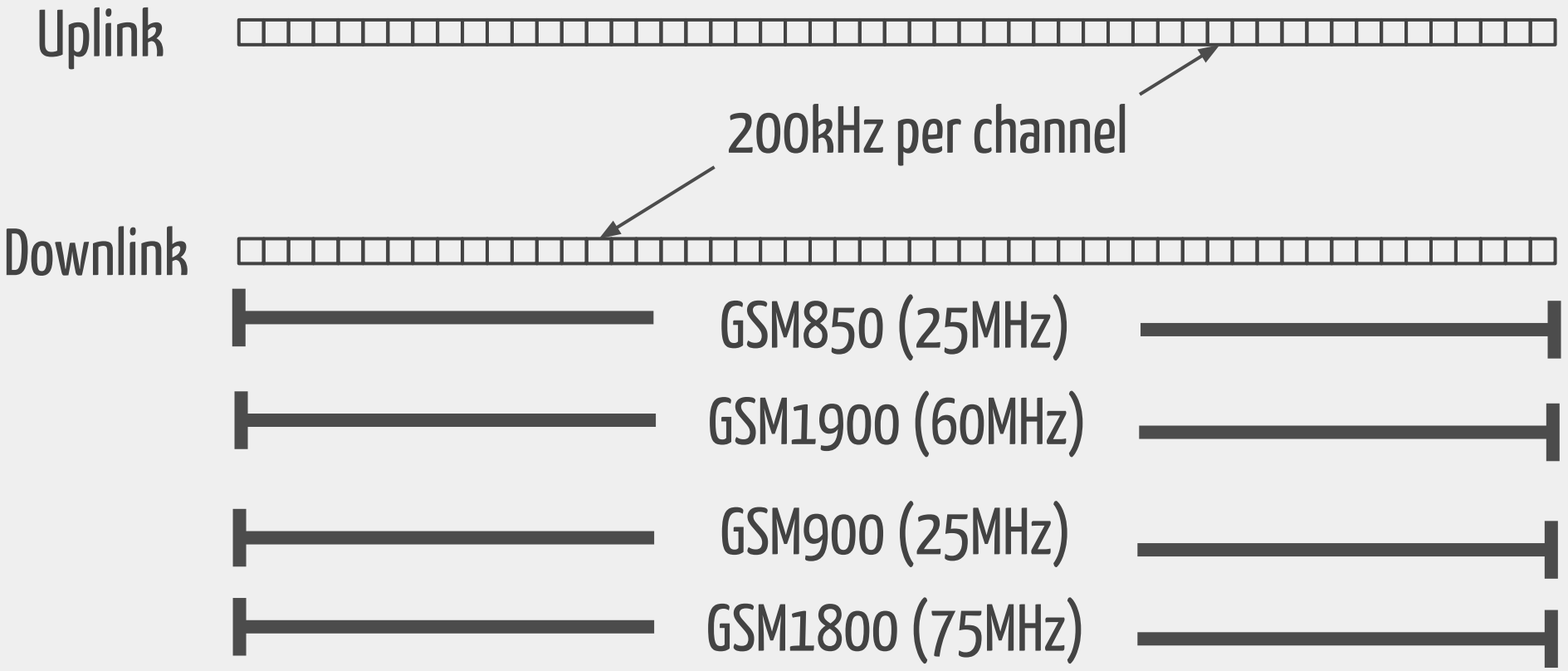
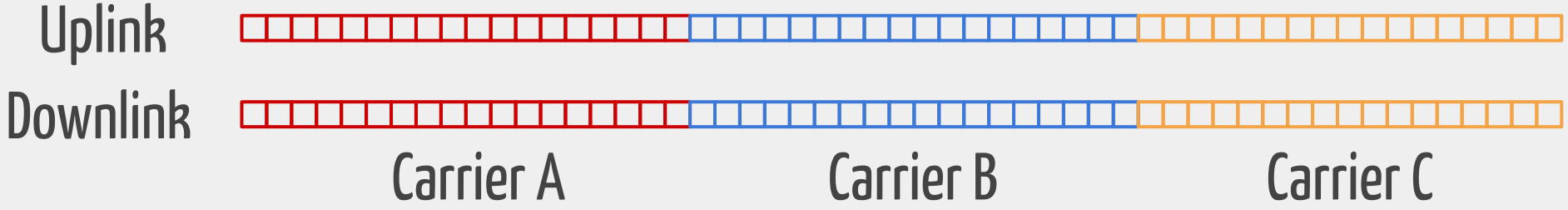
# Crazy Possibilities -> Good Practices

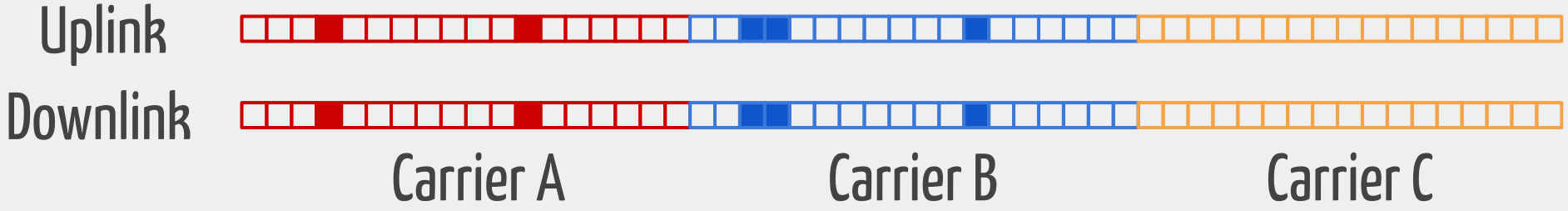


THAT'S UNPOSSIBLE!


Uplink
200kHz per channel
Downlink
GSM850 (25MHz)
GSM1900 (60MHz)
GSM900 (25MHz)
GSM1800 (75MHz)




- 7 concurrent voice calls
- 100's SMS/min
- 100's active subscribers

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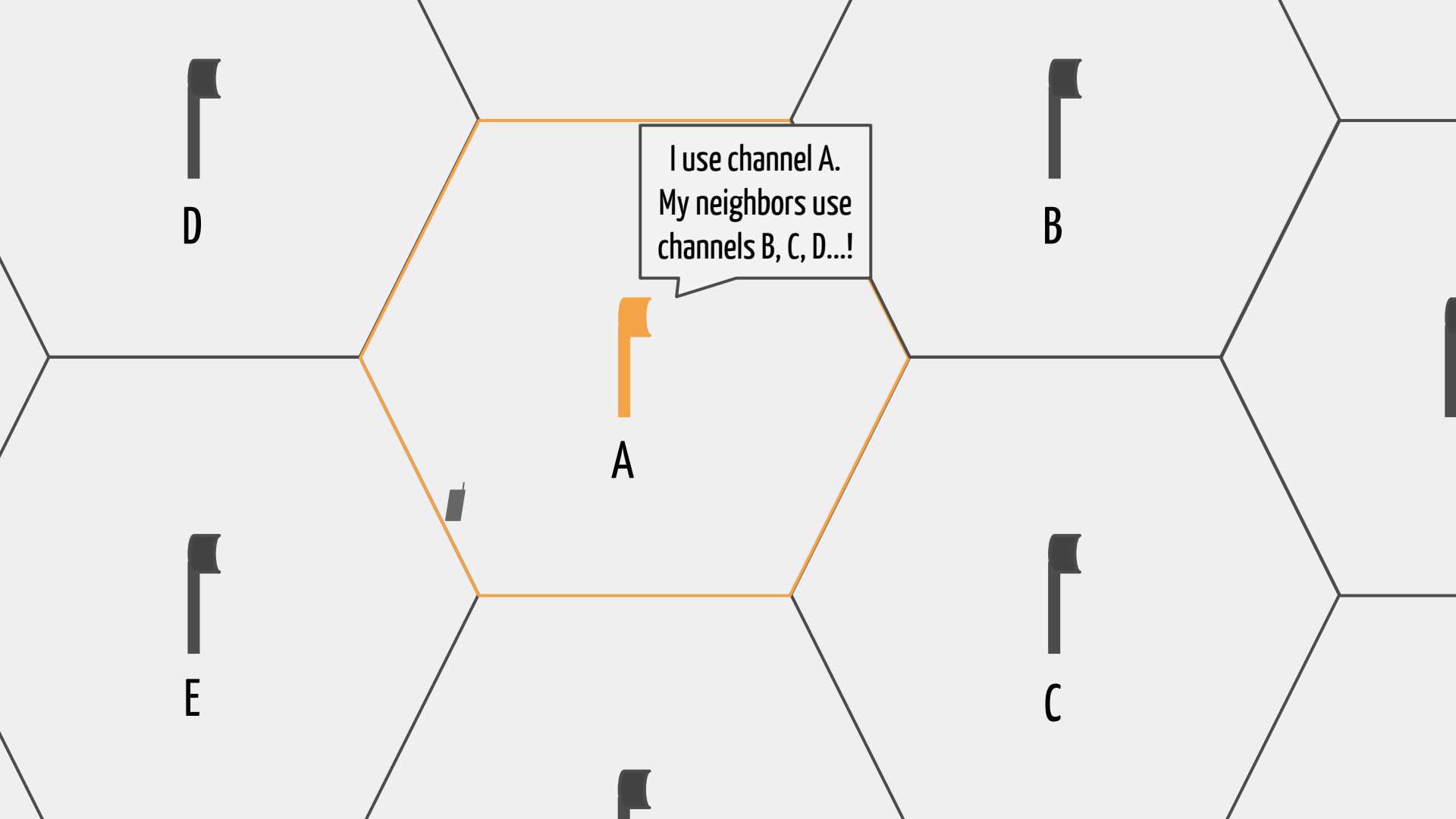
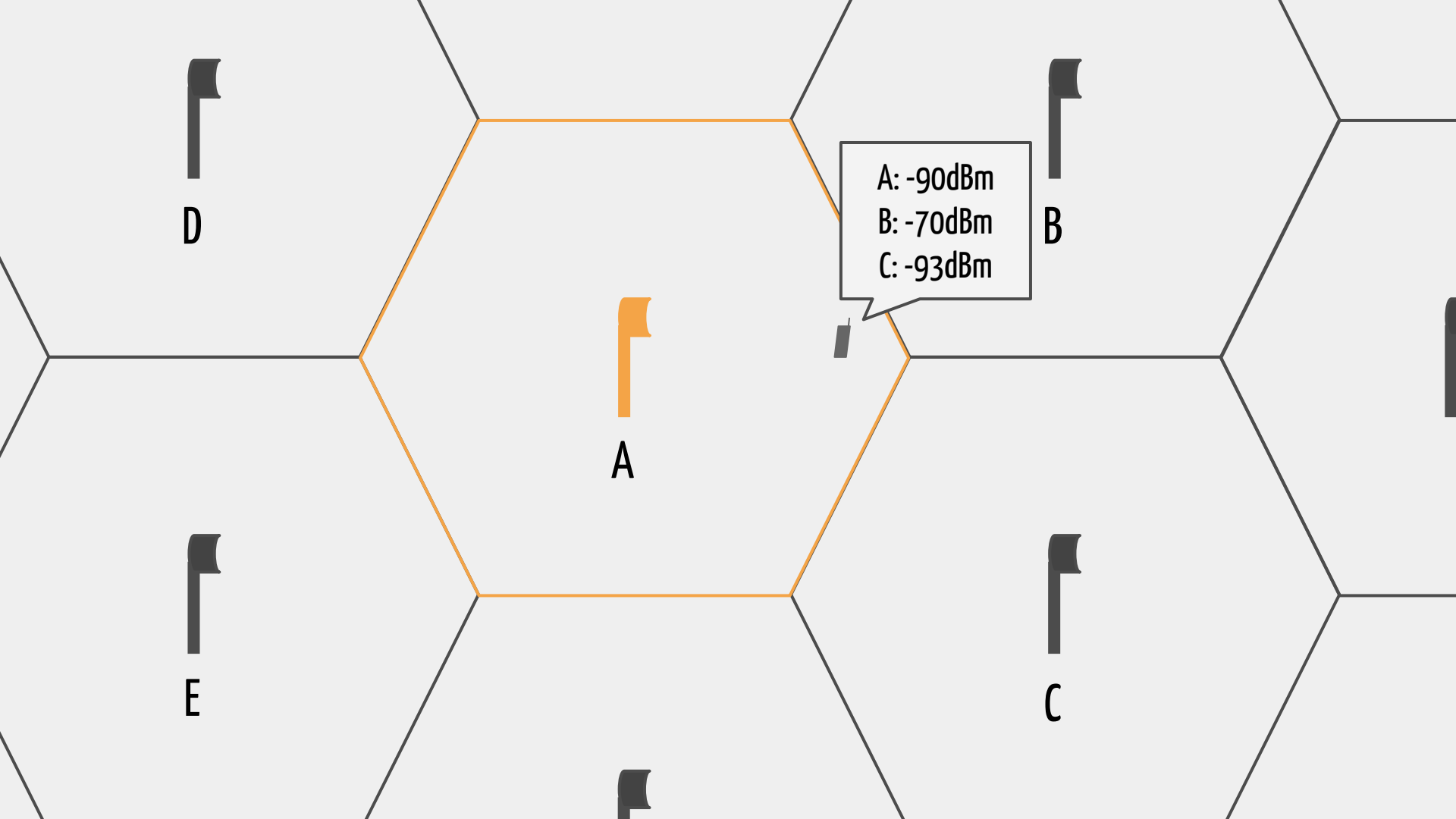
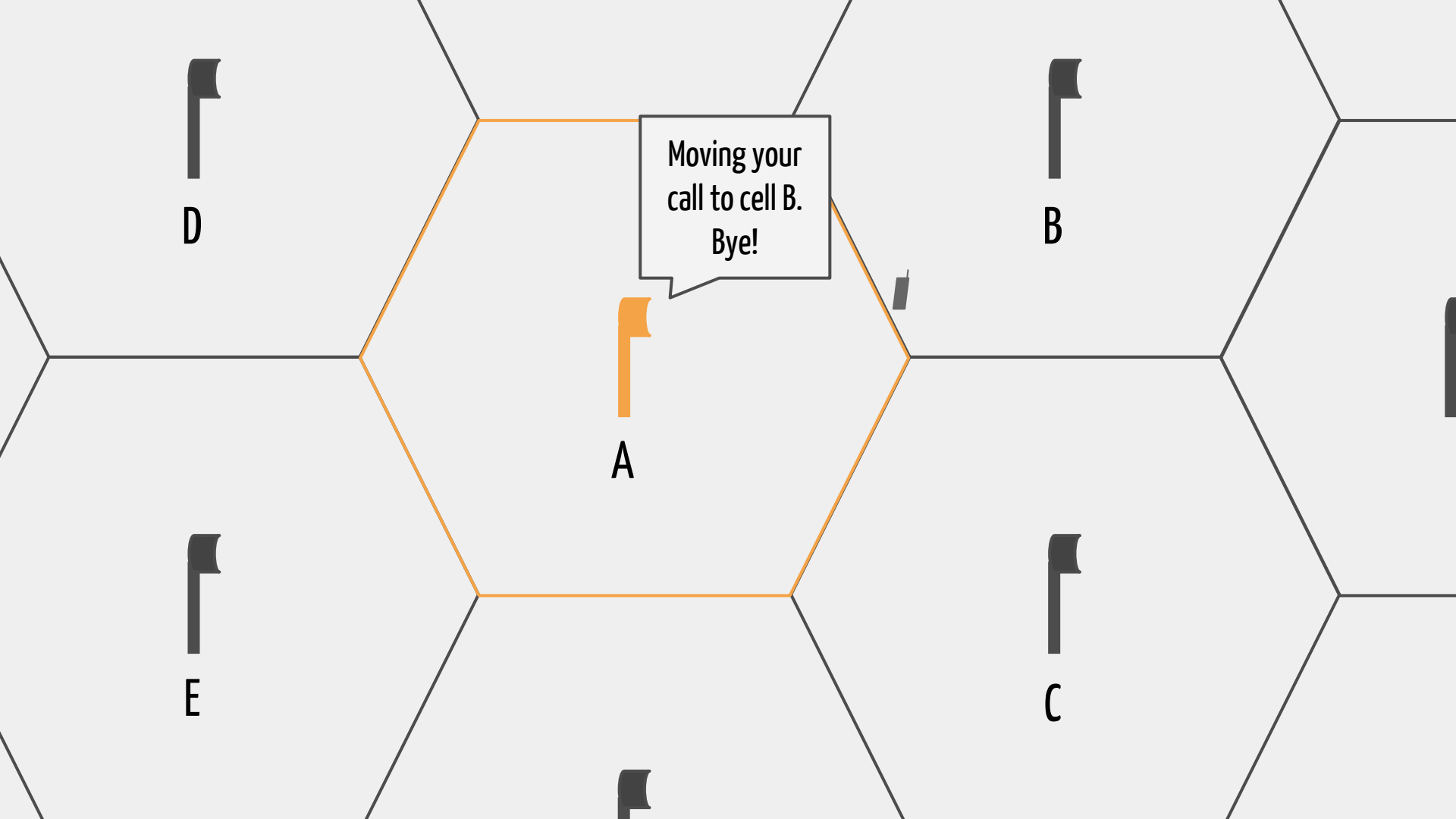
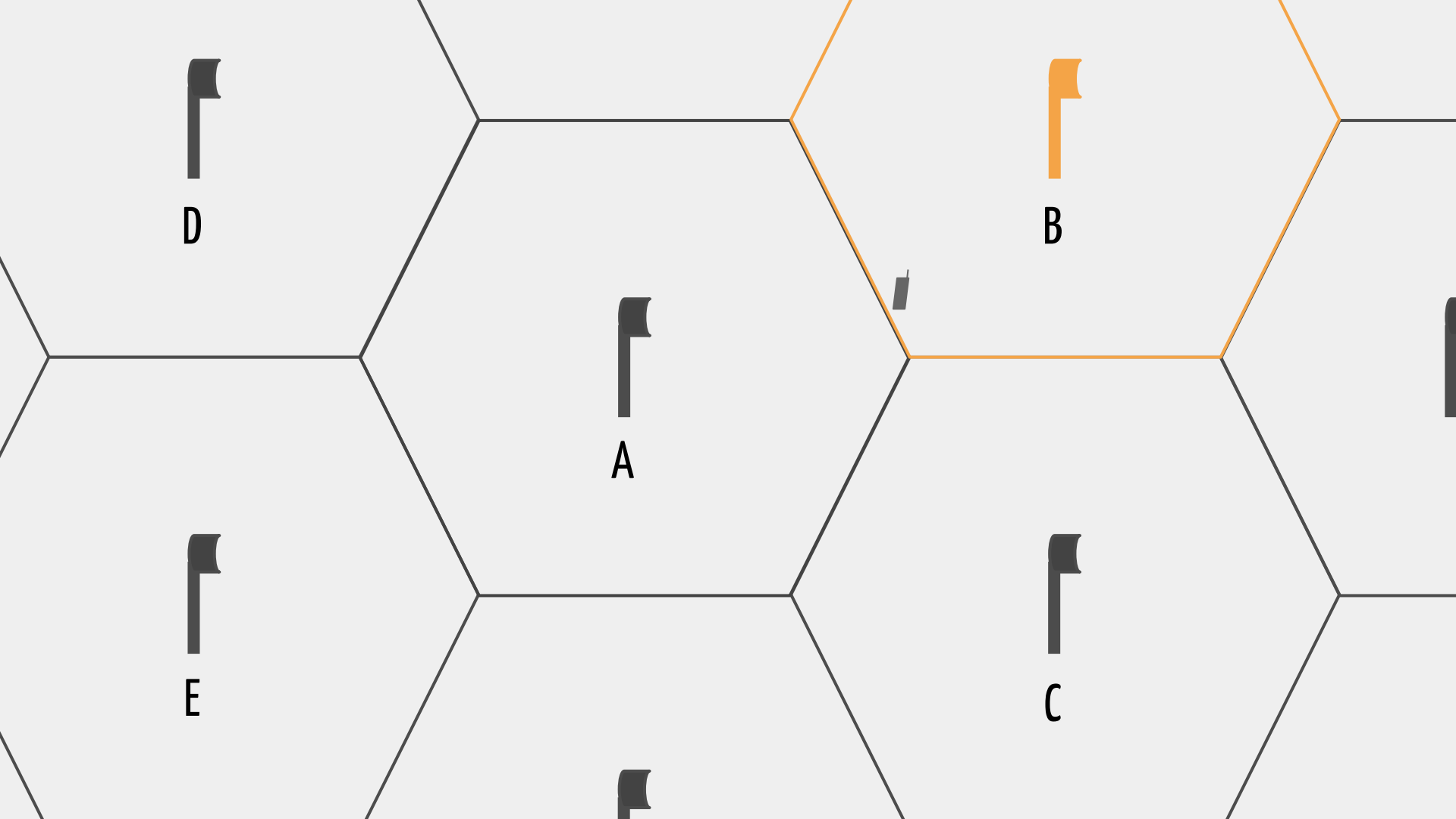

I use channel A.
My neighbors use channels B, C, D...!
D
B
A
E
C


A: -90dBm
B: -70dBm
C: -93dBm
D
B
A
E
C


Moving your call to cell B. Bye!
D
B
A
E
C


D
B
A
E
C

1996's hottest gadget.

Also a cognitive radio.

**Key idea #1:**

Use phones to scan for in-use channels.

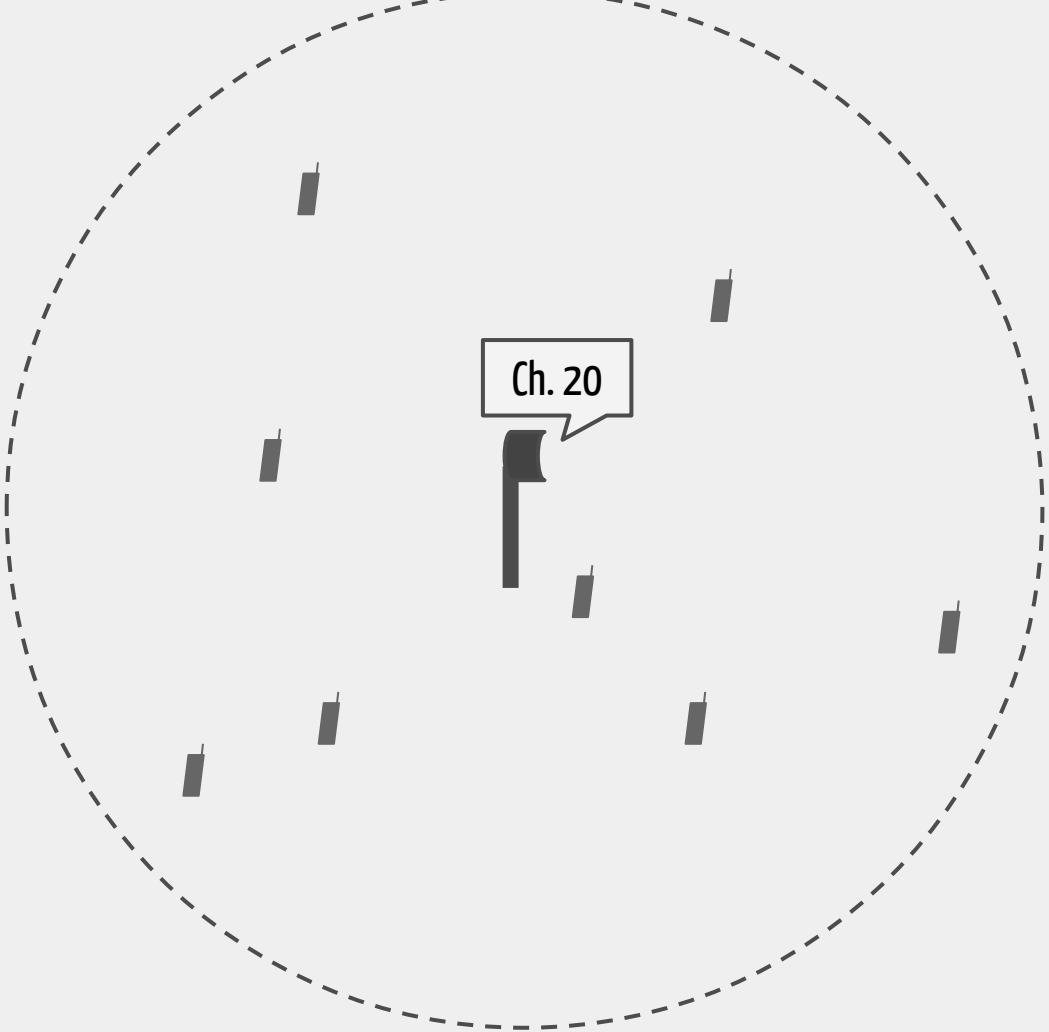
**Key idea #2:**

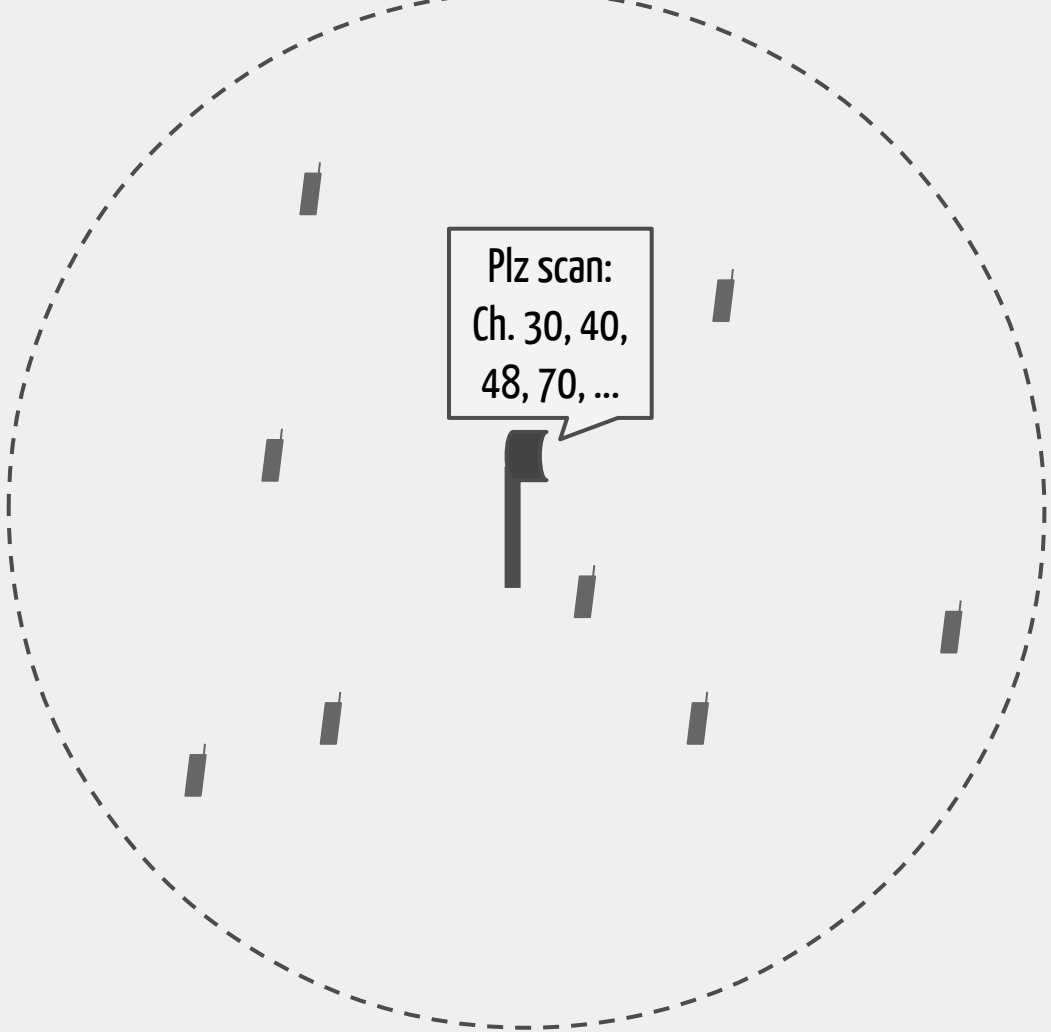
Constantly change channels to prevent squatting.

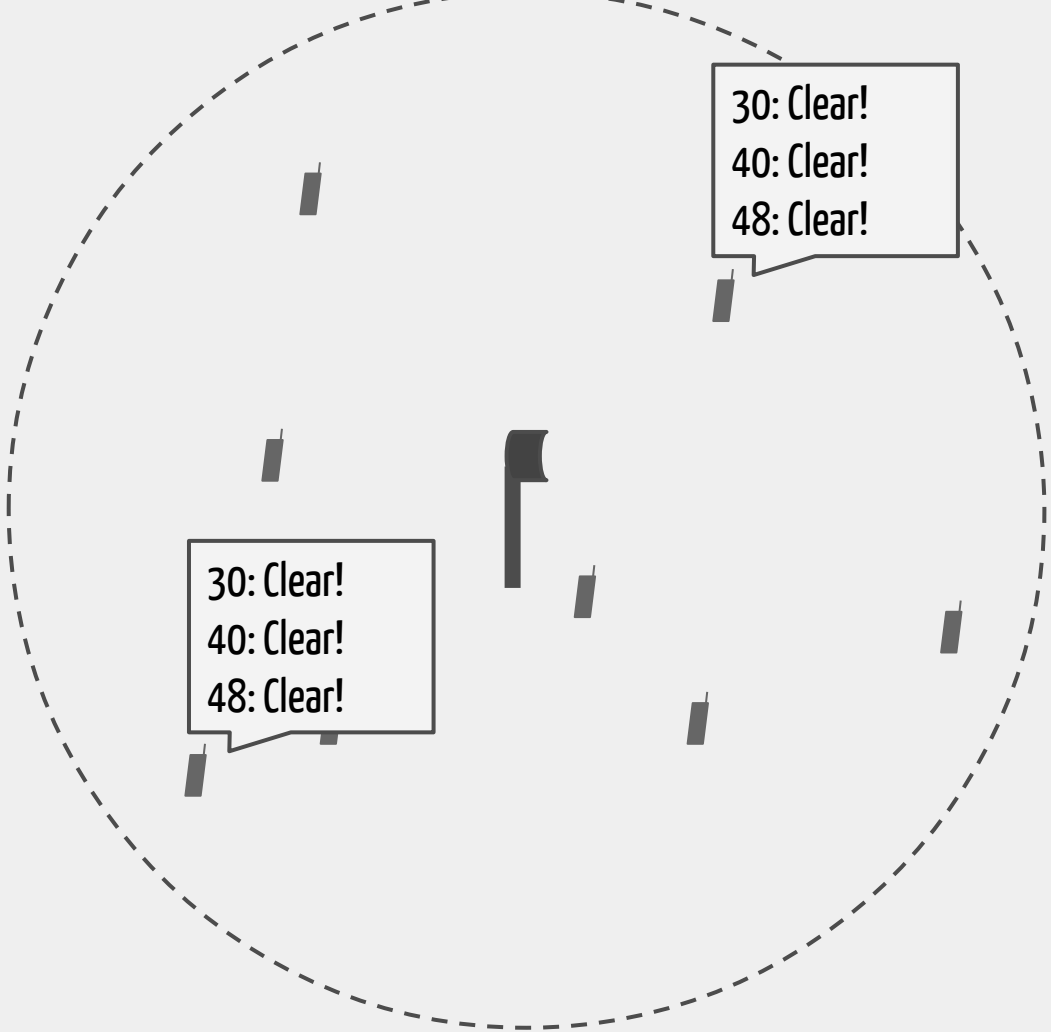
**Key idea #3:**

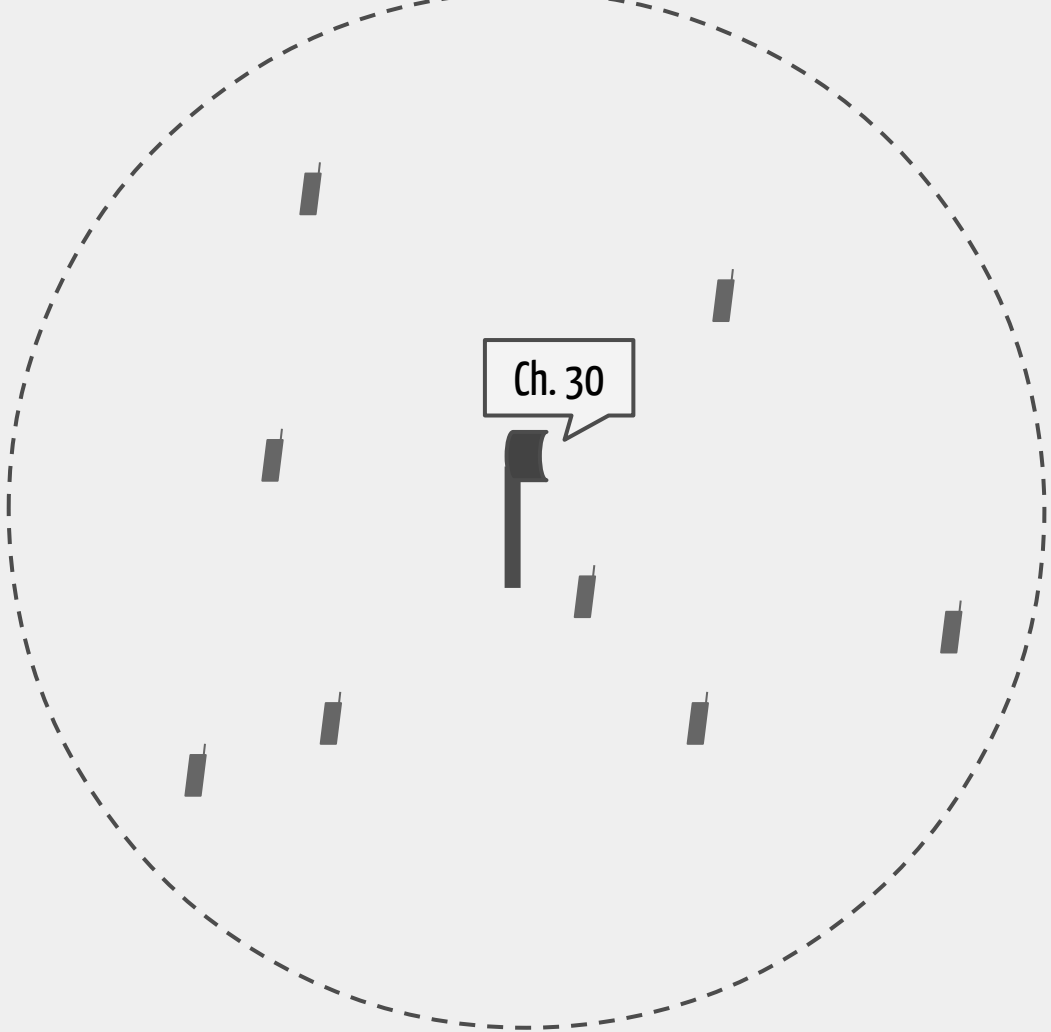
Use a database to monitor and control CCNs.

Ch. 20

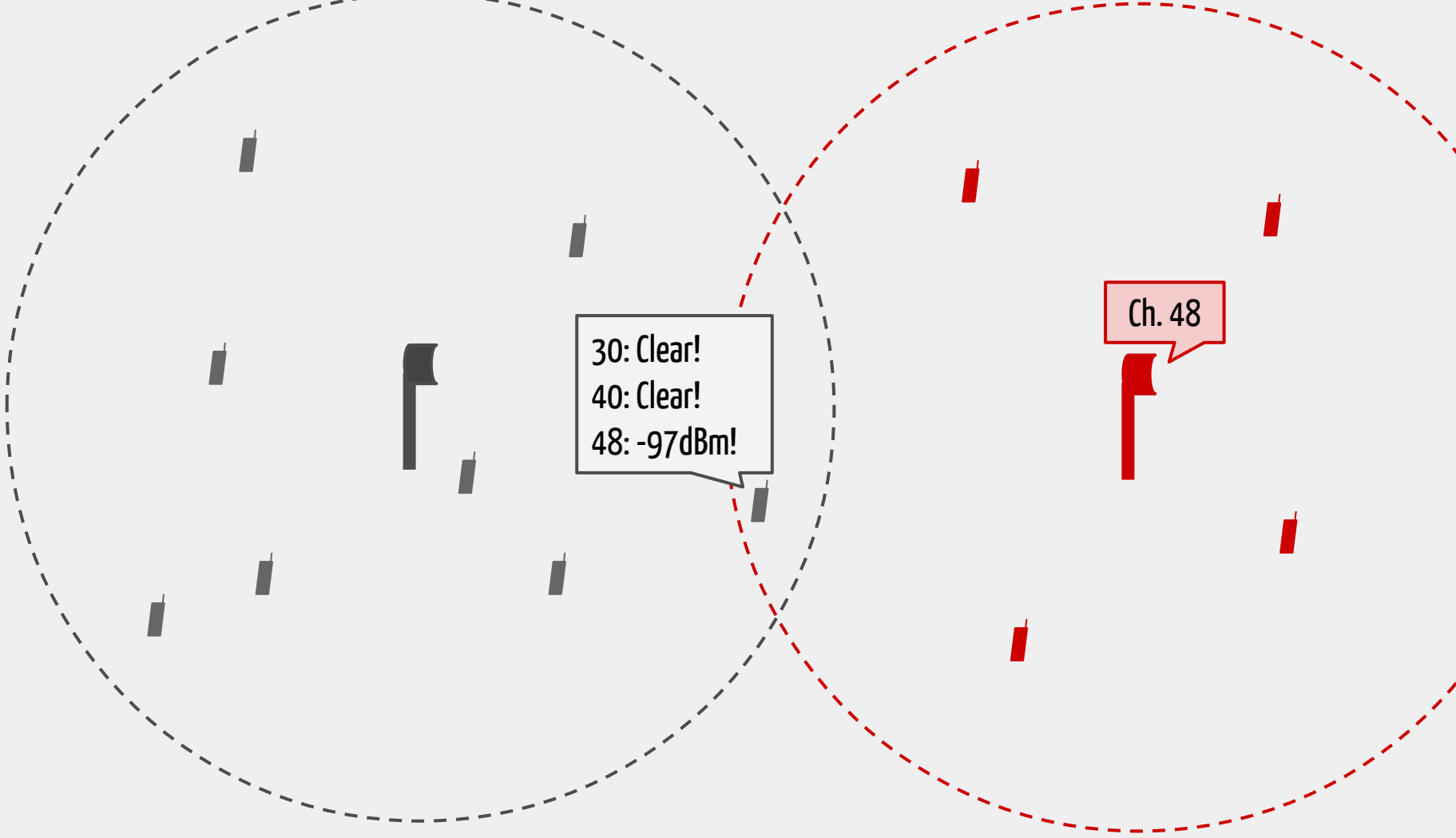

Ch. 20

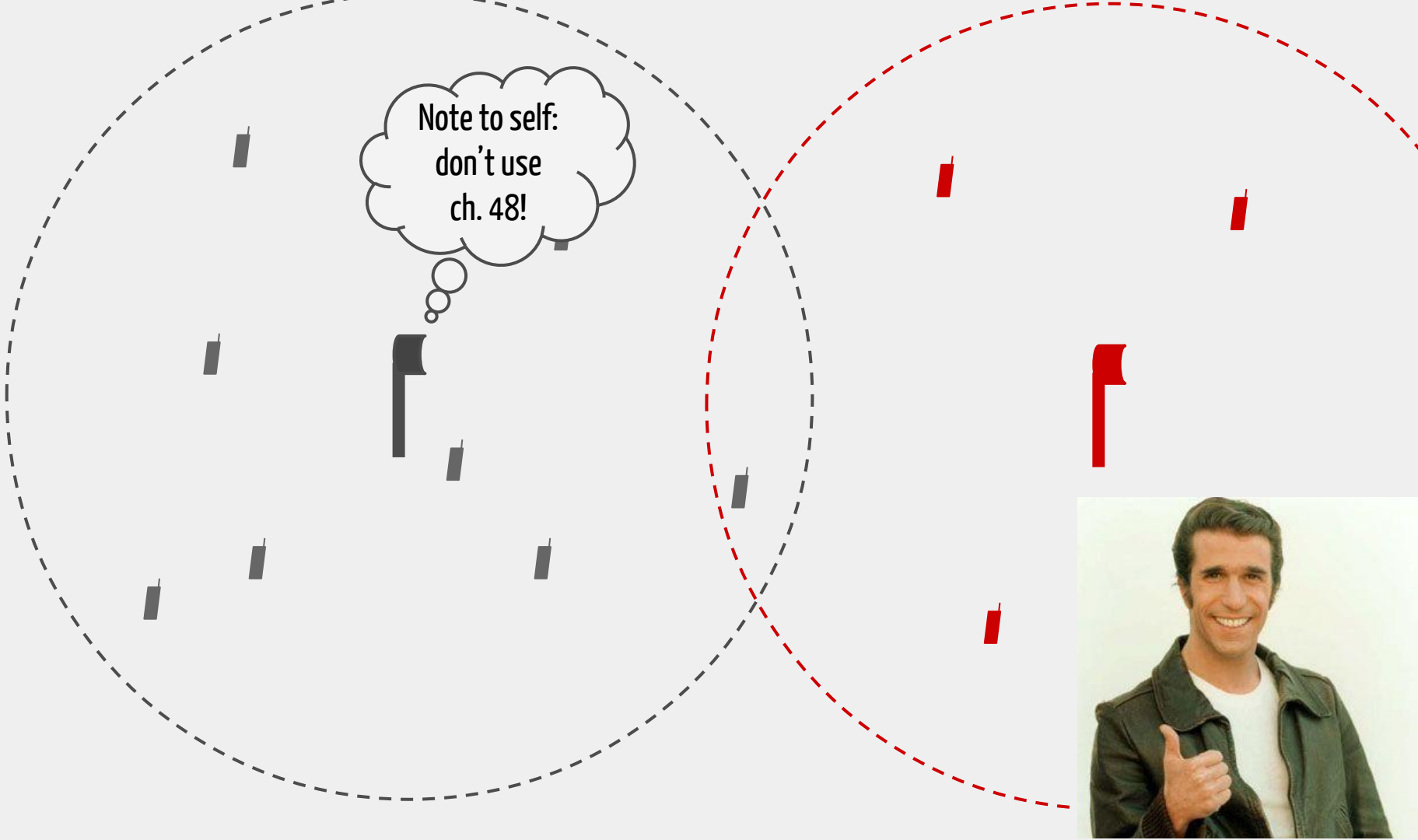

Plz scan:
Ch. 30, 40,
48, 70, ...


30: Clear!
40: Clear!
48: Clear!
30: Clear!
40: Clear!
48: Clear!



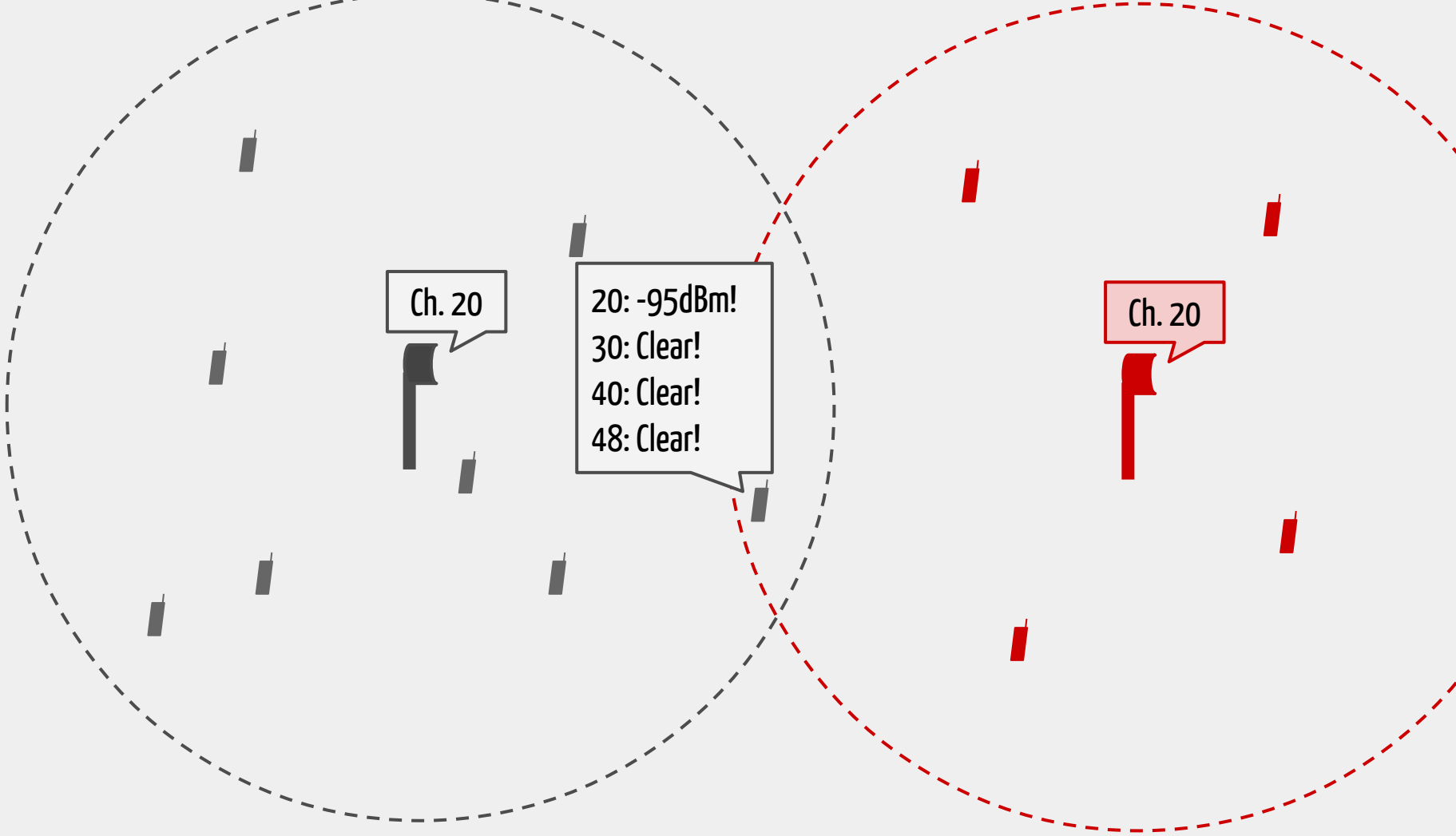

After a few hours...


30: Clear!
40: Clear!
48: -97dBm!
Ch. 48

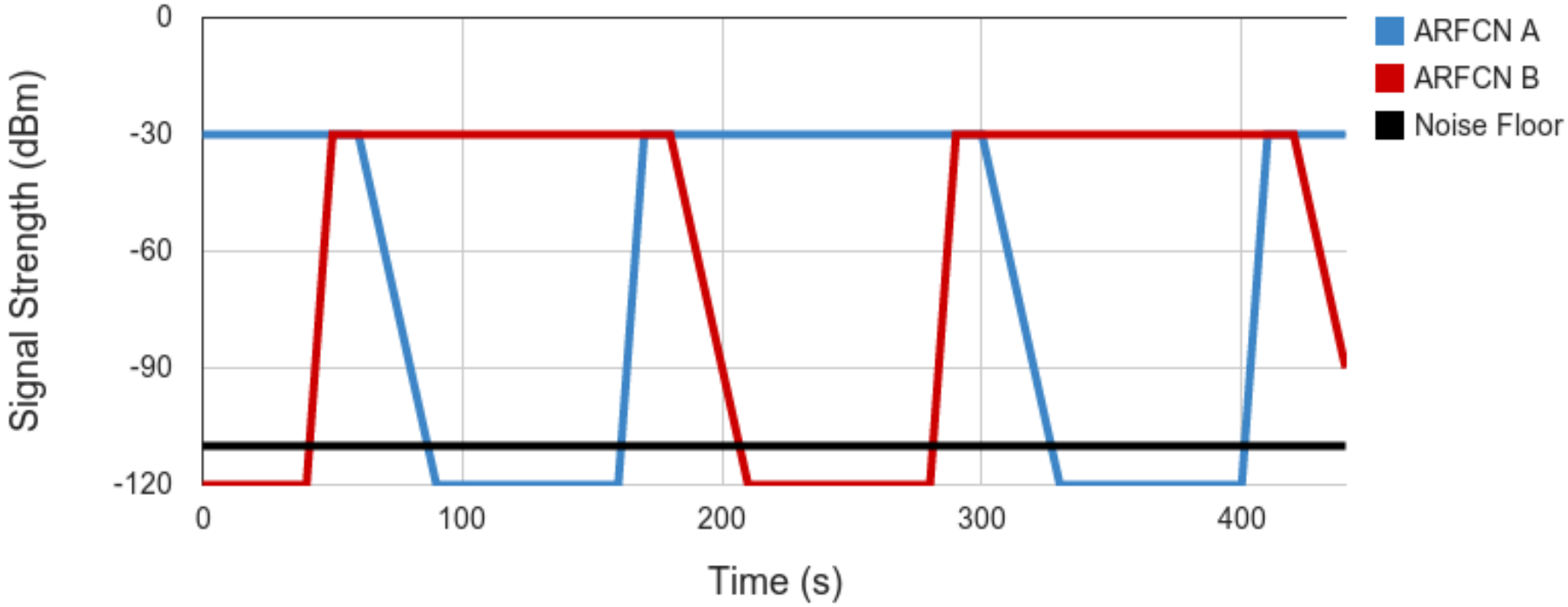

Note to self:
don't use
ch. 48!

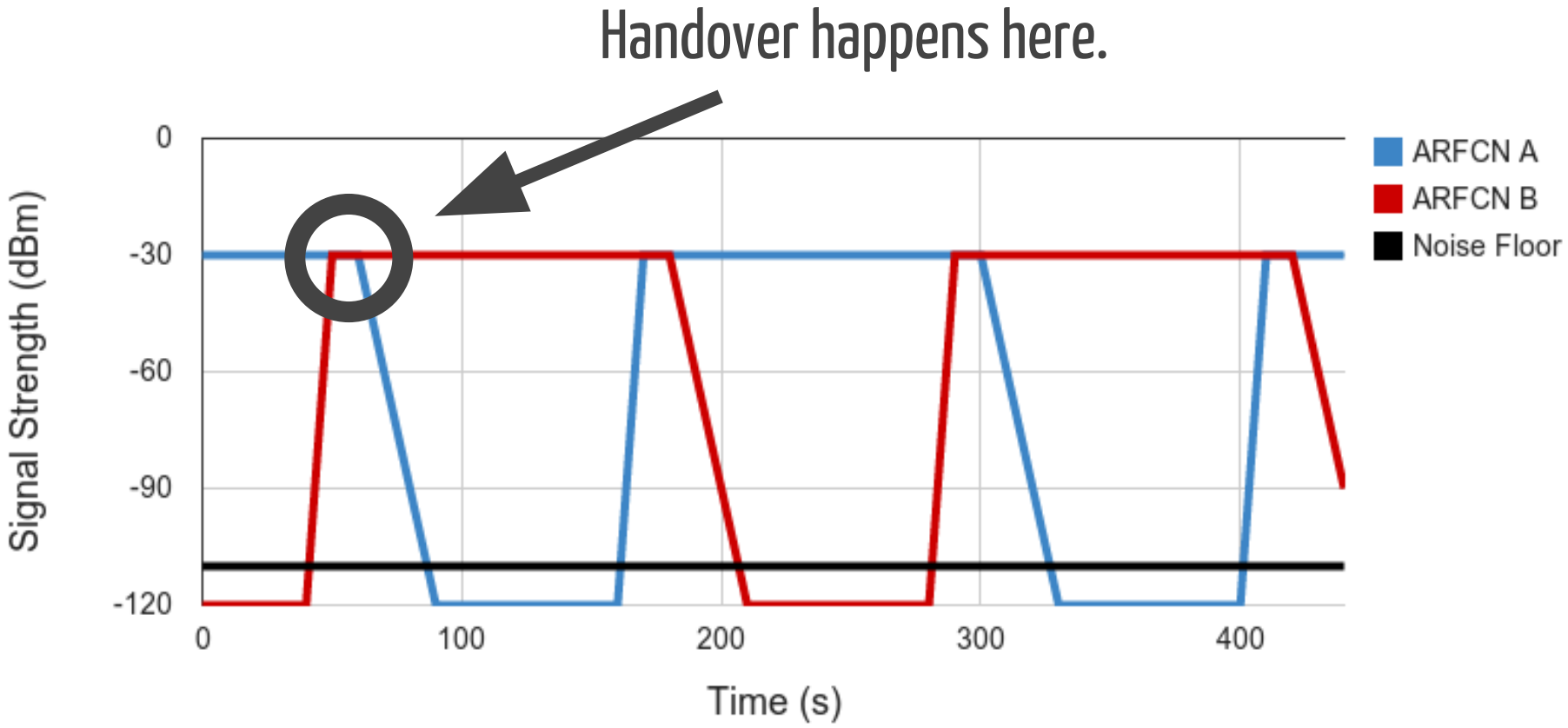
30: Clear!
40: Clear!
48: Clear!

Ch. 98

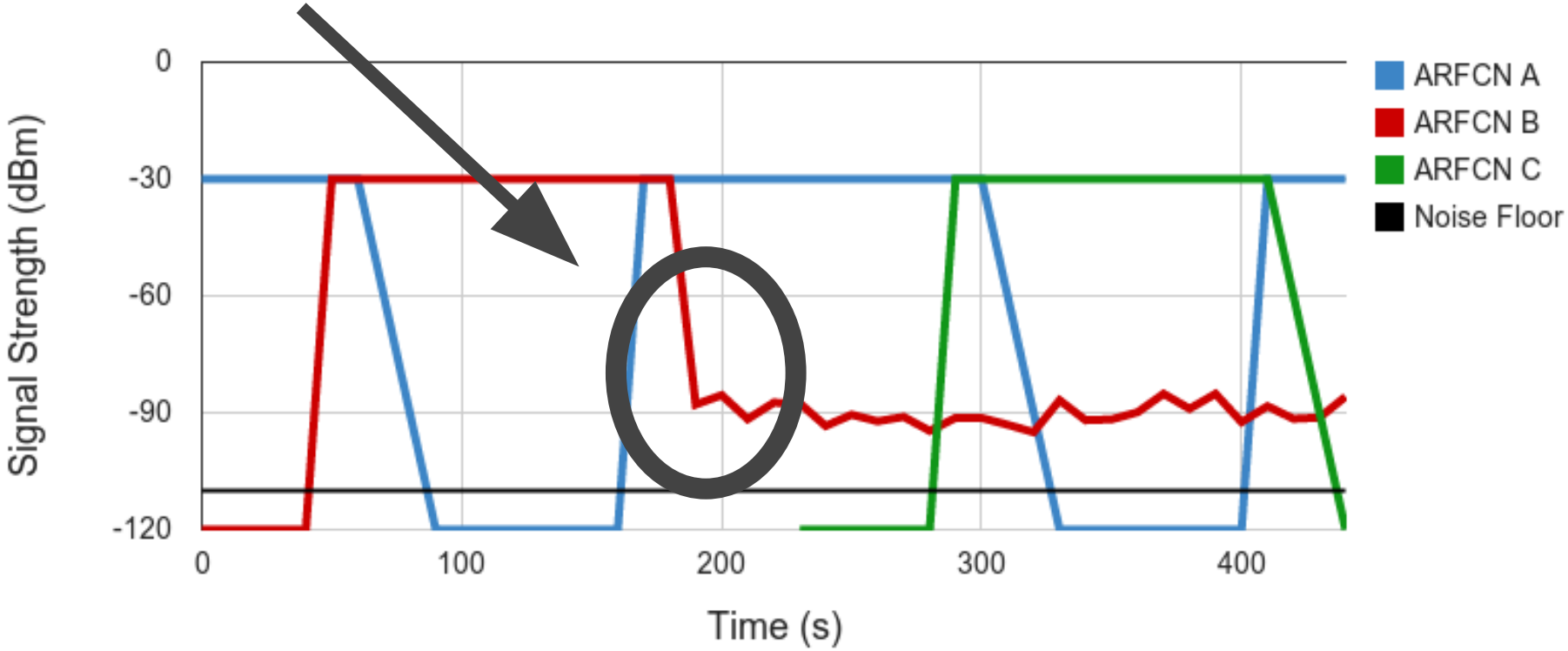

Ch. 20
20: -95dBm!
30: Clear!
40: Clear!
48: Clear!
Ch. 20

# Solution: Simulate Handover!

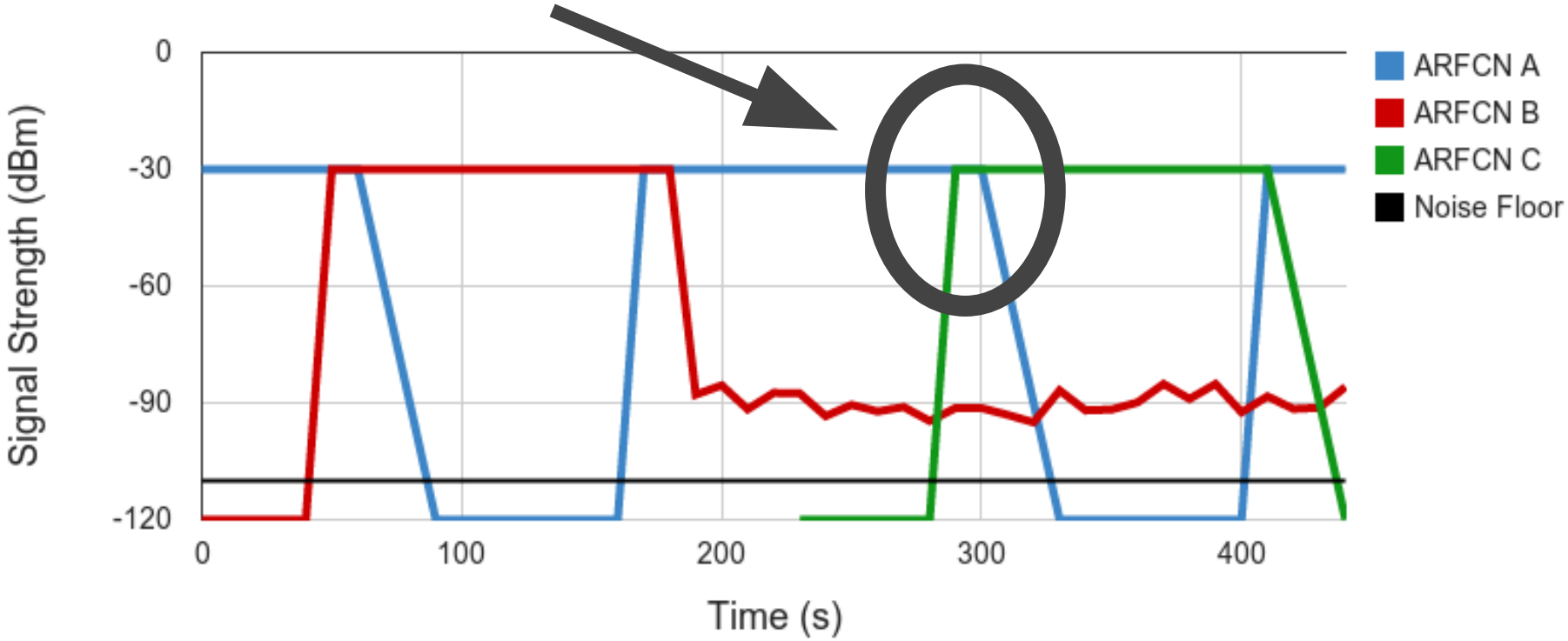



Handover happens here.
Signal Strength (dBm)
0
-30
-60
-90
-120
0
100
200
300
400
Time (s)
ARFCN A
ARFCN B
Noise Floor

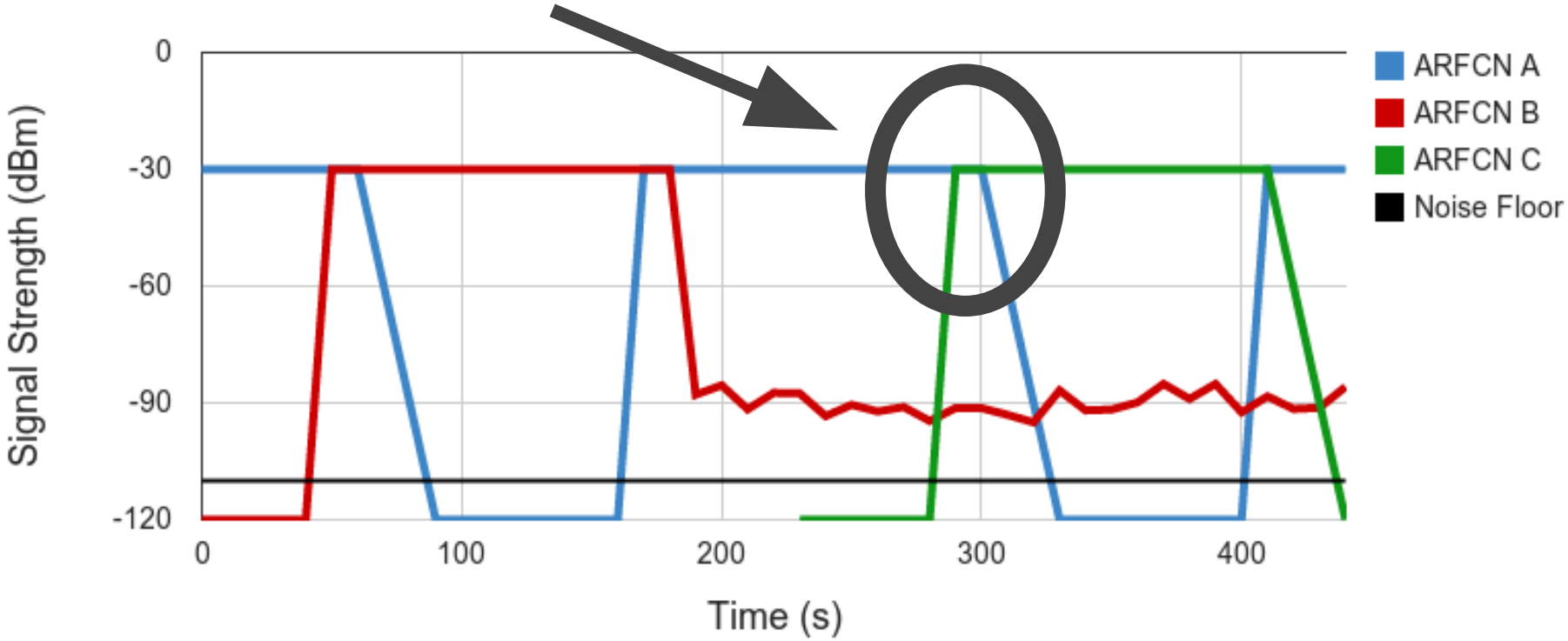
# Someone else is on a channel we're using!



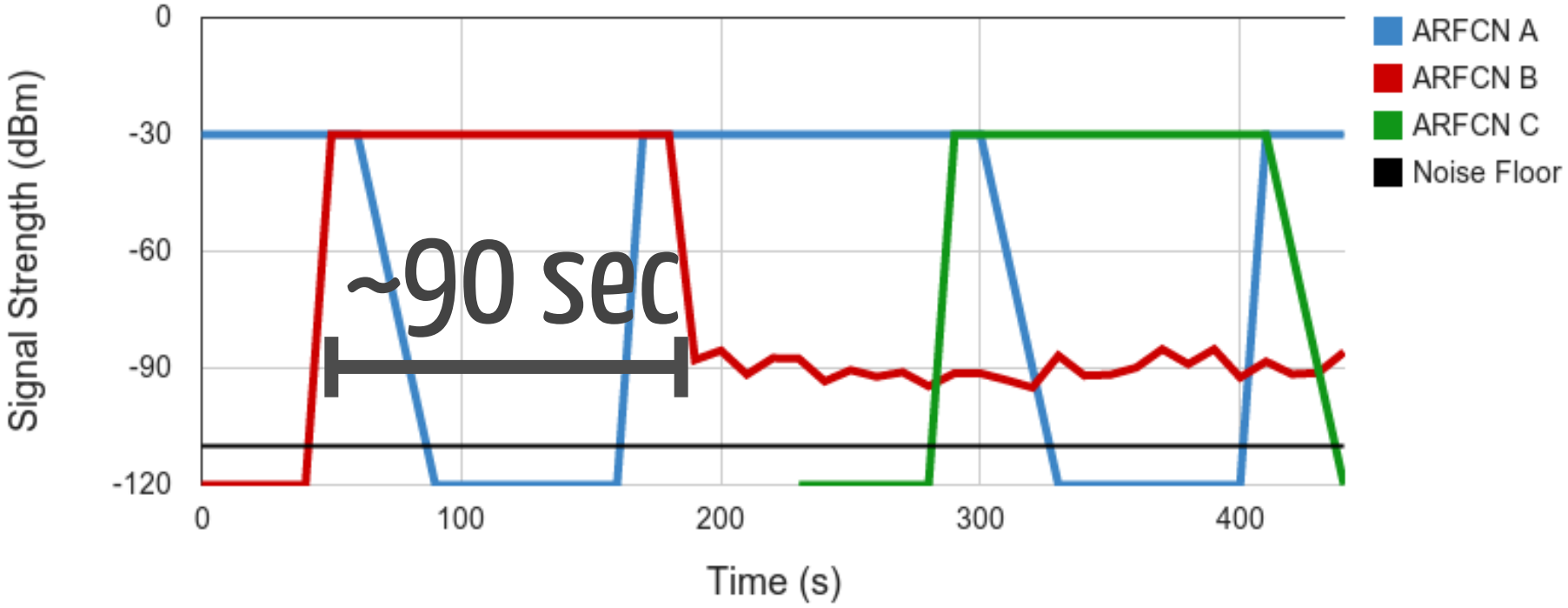
# We should switch to a new safe channel.



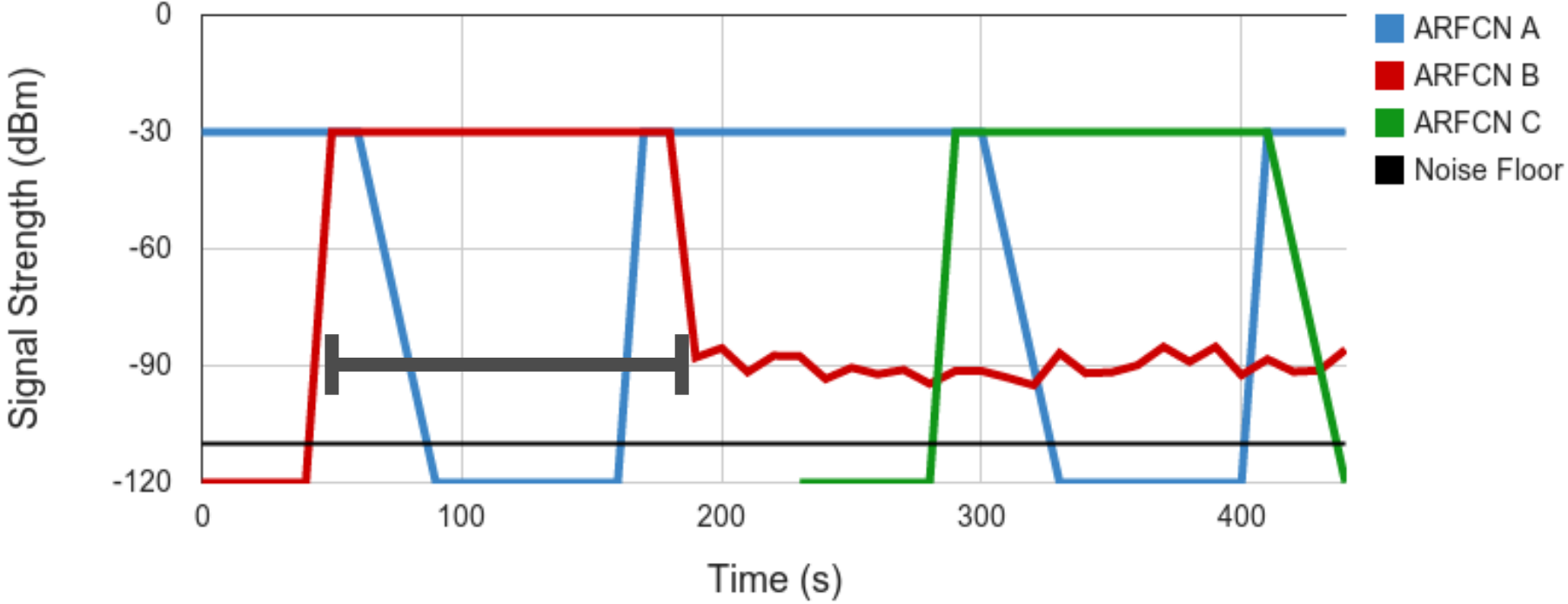
# Phones handover to the new channel.



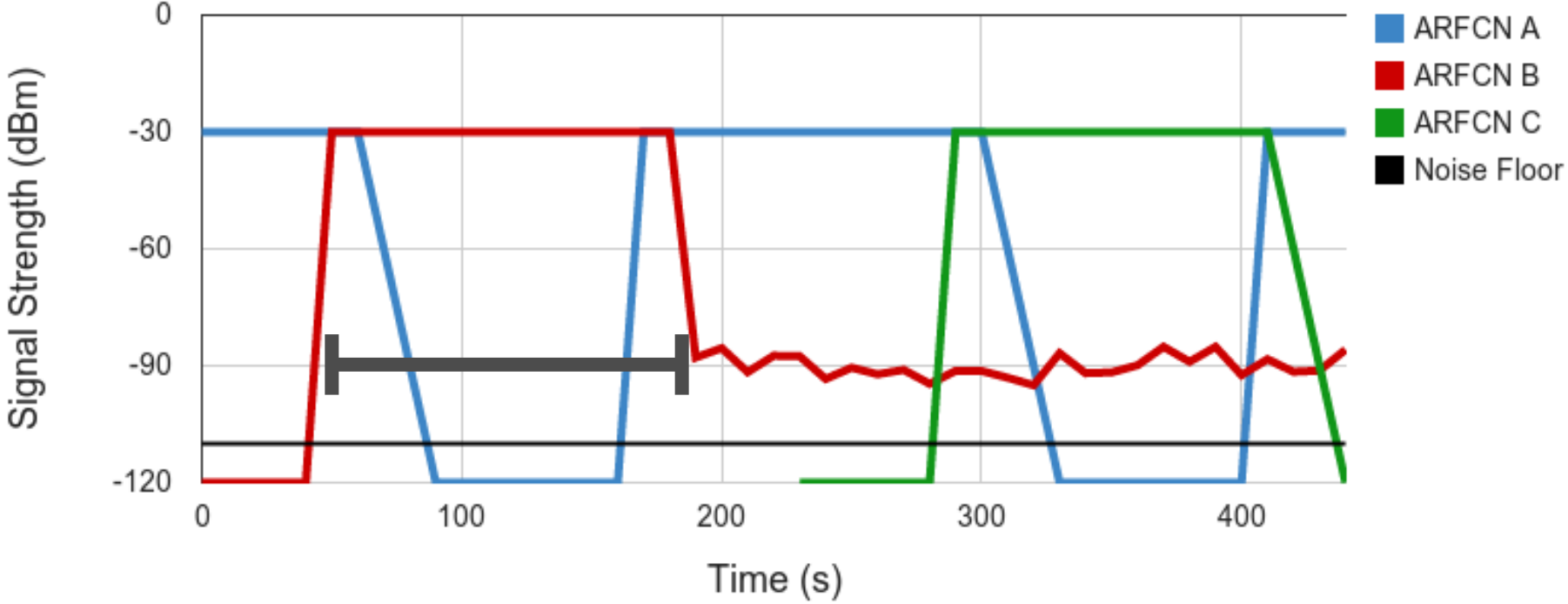
# Worst case detection speed = cycle time



# 90 sec << rate carriers add rural base stations



# 90 sec = probably excessive



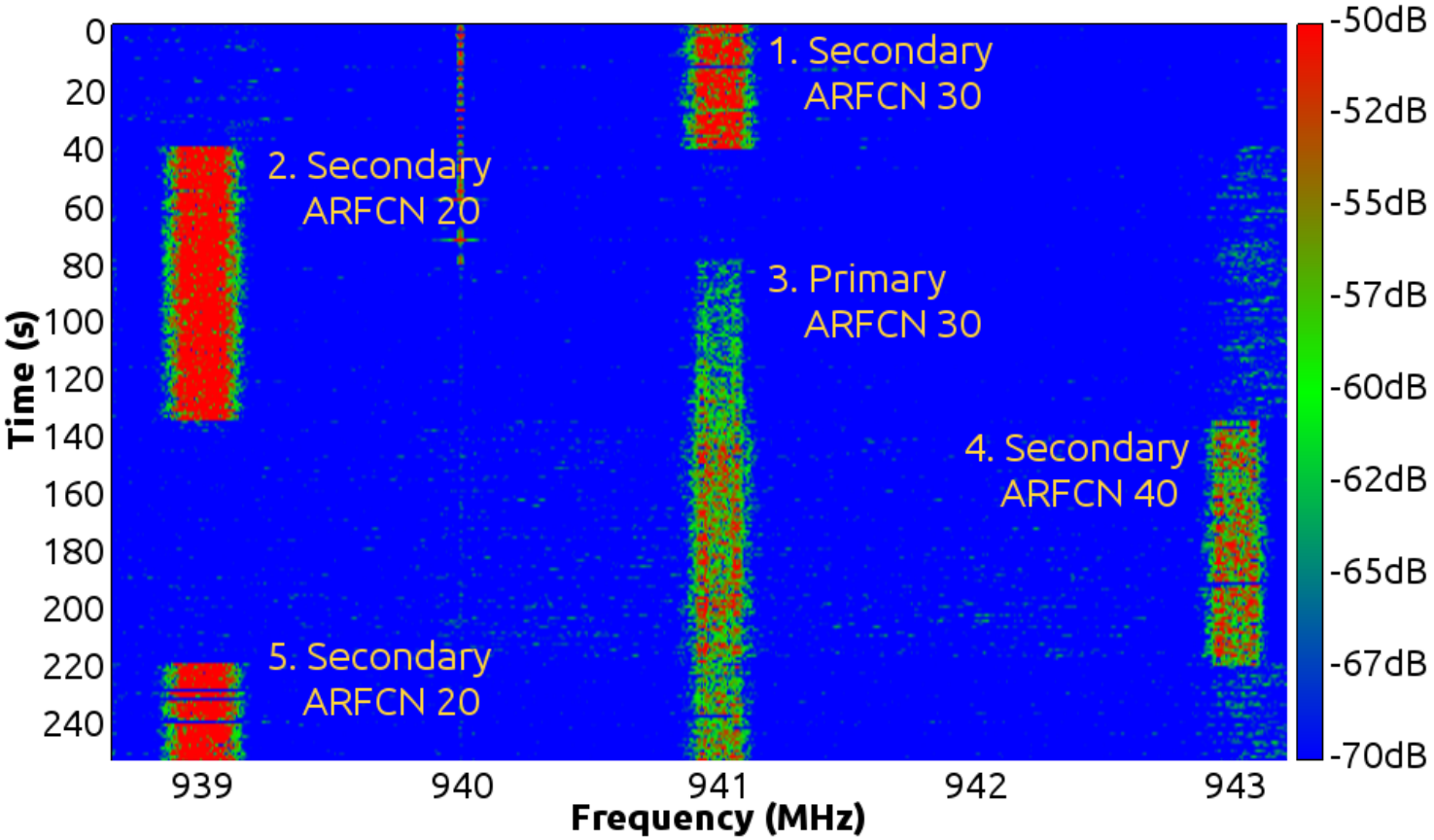
# Evaluation

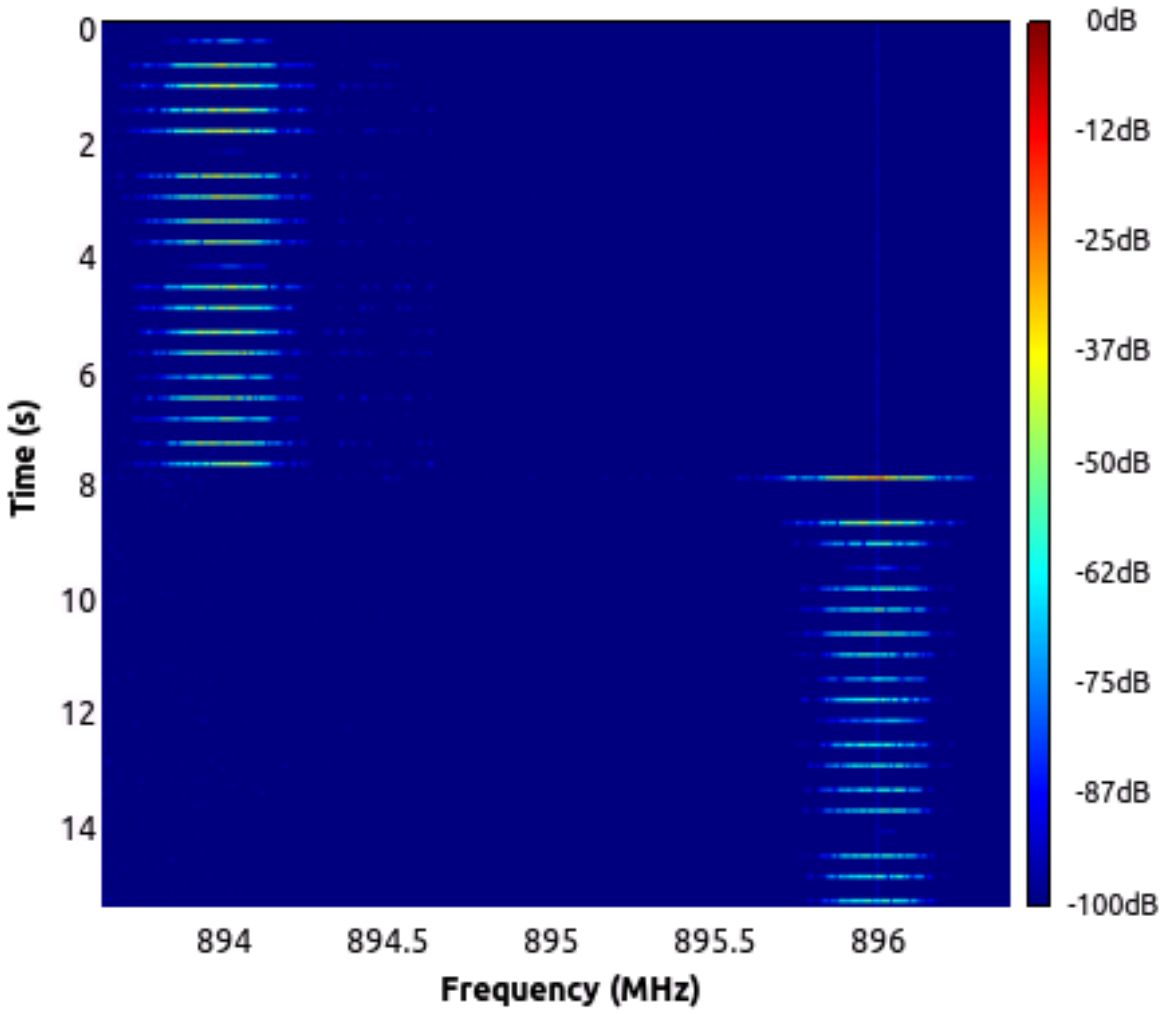
Lab Experiments + Real World Deployment

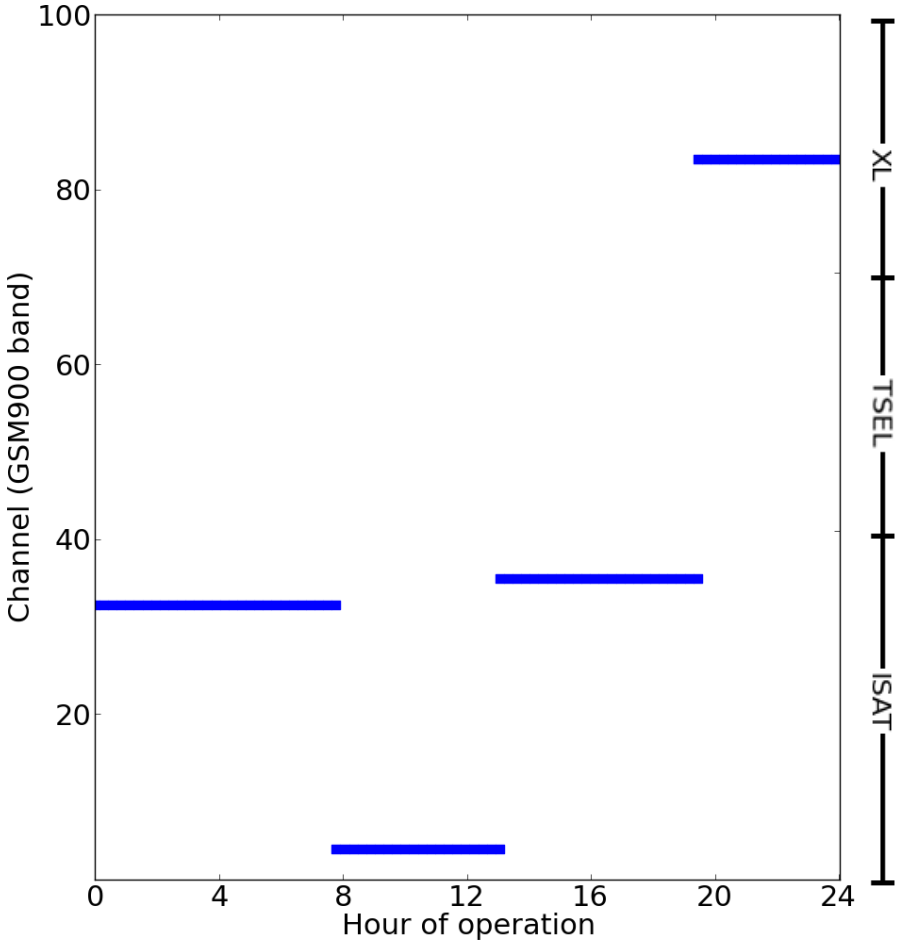
MODEL: 2010-901
SERIAL # 201305281001

github.com/shaddi/gsmws
(Runs on OpenBTS)

# Detecting a new primary user

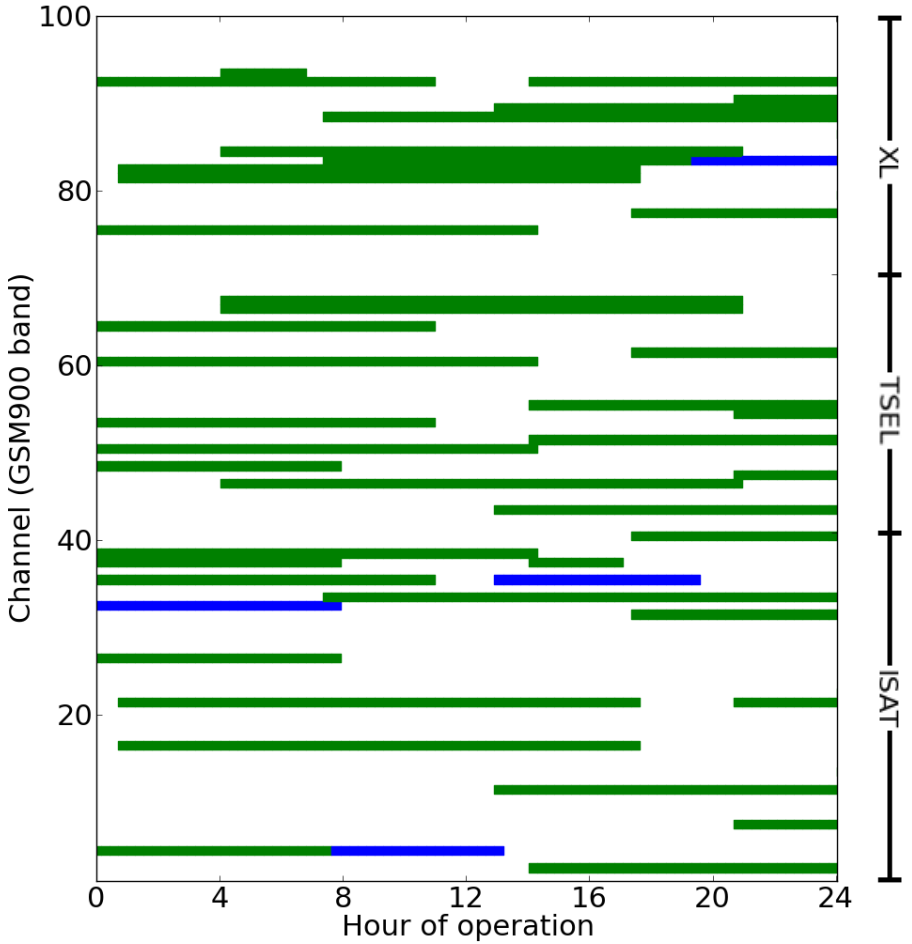



0
2
4
6
8
10
12
14
Time (s)
894
894.5
895
895.5
896
Frequency (MHz)
0dB
-12dB
-25dB
-37dB
-50dB
-62dB
-75dB
-87dB
-100dB



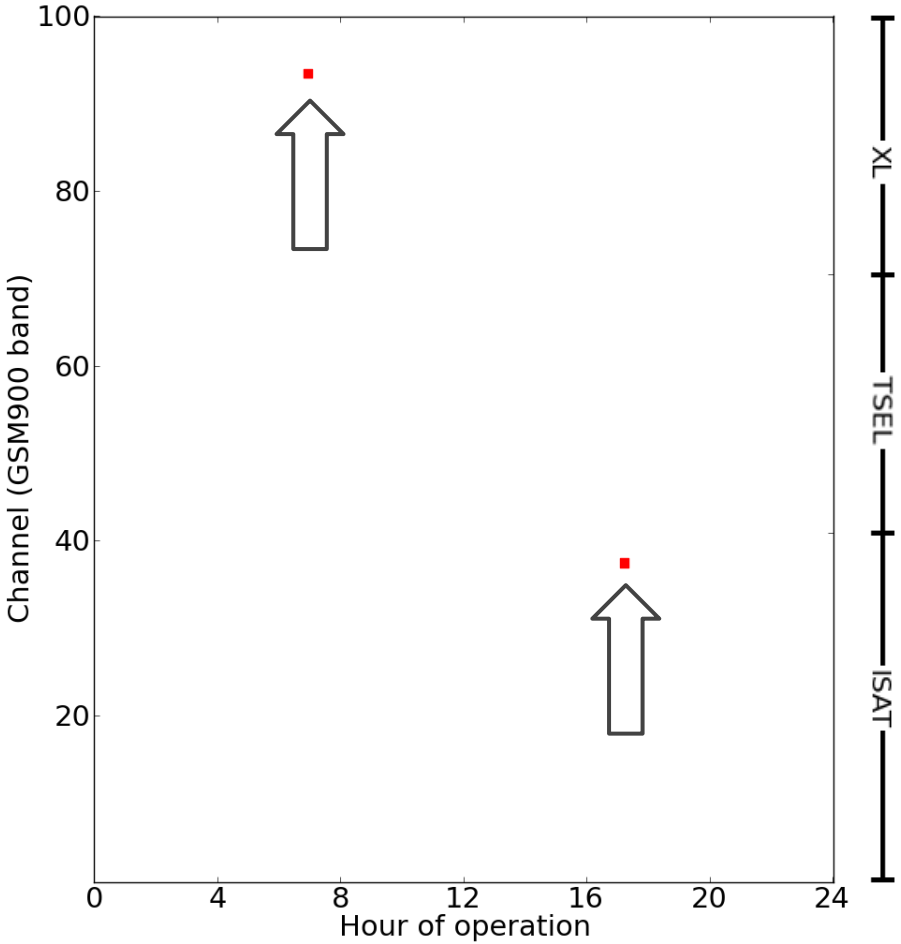

# Papua: Measured spectrum usage

# In-use channel




# Papua: Measured spectrum usage

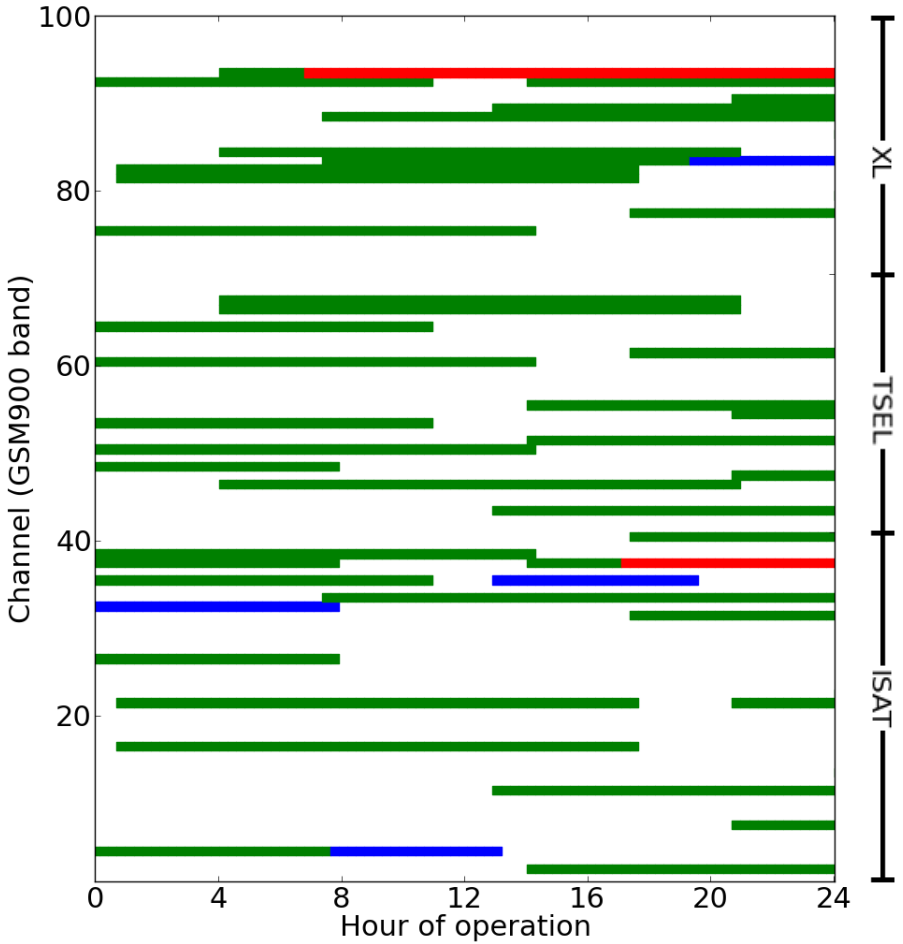
# In use + “safe” chans




# Papua: Measured spectrum usage

# Two detection events

(probably spurious reports)




# Papua: Measured spectrum usage

- → Switched channel every night, after power failures
- → No impact on usage of network

# Future work

- → Field trial in Mexico
  - Full system deployment
  - Lots of real users
  - Detect real intereference events

We're looking for
telco and regulator partners for
GSMWS trial deployments.

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