


# 7 Wege als Wireless Experte zu versagen

# Wer sind wir?



**system.de** => Die Service Manufaktur für digitale Transformation

 **ROUTE 128** => Technologieführer für IPv6-Migration

- Gründung system.de 1994 – seit 2000 Cisco Premier Partner – 50 MA
- Seit 2017 Cisco Networking Academy & eigene system.de-Akademie
- Planung, Implementierung und Betrieb komplexer Netzwerke
- Cisco Servicelieferant und Lab-Betrieb 100 Racks für Behörden (28 Red Badges)
- Kunden aus allen Branchen bis hin zu DAX-Konzernen
- Alle Bundesbehörden nutzen weltweit einmaliges  **ROUTE 128** -IPv6-Smartkit

Wir bilden FISI aus und bieten Einsteigern einen perfekten Start!

# Agenda

- Introduction
- Evolution of Wi-Fi
- The Baseline
- 7 fails...
- Conclusion

everyone: stays home

everyone's WiFi



# There's **7** Ways to Fail

- Learn how **NOT** to #Fail
- It will be educational
- It will be interactive
- It will be fun

“ I don't care *how* you remember it,  
as long as you remember it”

*Steven Heinsius*



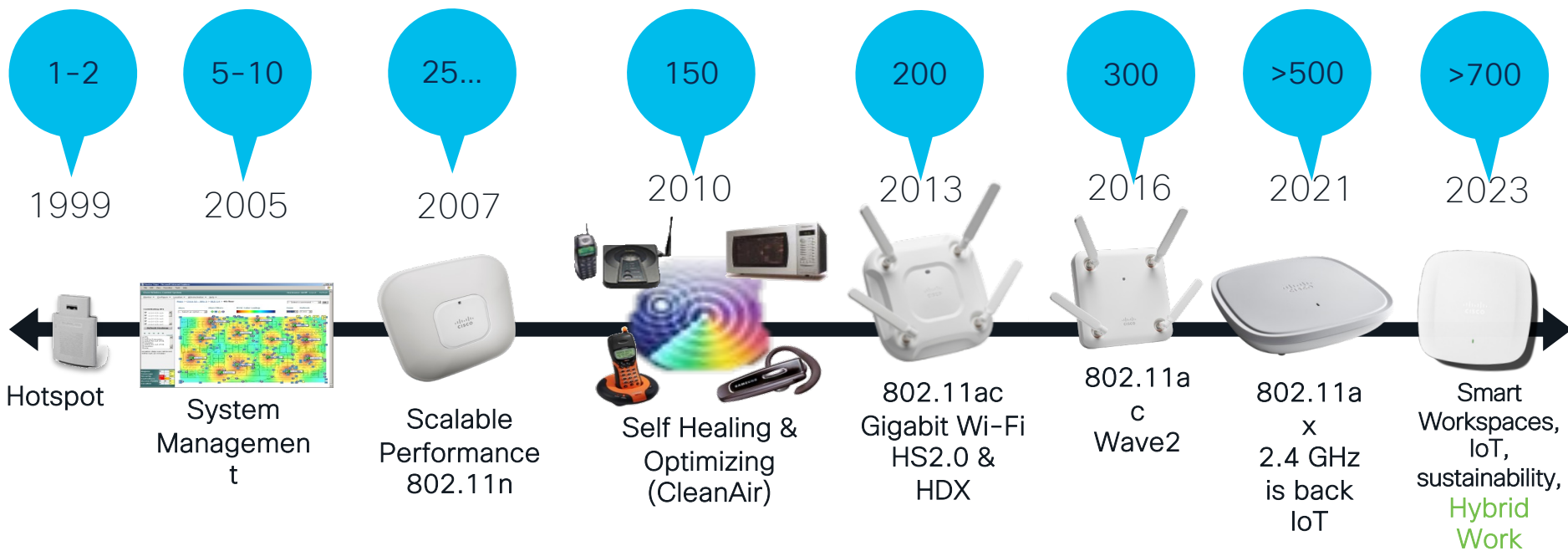


# Evolution of Wi-Fi

# From nice to have – to best effort... **to mission critical**







# Imagine yourself a customer site – with 100 employees



# Bandwidth & Data rate



802.11	Frequency	Data rate	Channels	Channels 'usable'
a	5 GHz	54 Mbps	25	25
b	2.4 GHz	11 Mbps	13	3
g	2.4 GHz	54 Mbps	13	3
	2.4 GHz & 5 GHz	(min) 65, 150, 300, 450, (max) 600 Mbps	2.4 GHz & 5 GHz Rules apply.	2.4 GHz & 5 GHz Rules apply.
	5 GHz	867 Mbps 1.3 Gbps	5 GHz. → 25 / 37	5 GHz. → 25 / 37
	2.4 GHz & 5 GHz	1.2 Gbps 9.6 Gbps	2.4 GHz. → 13 / 11 5 GHz. → 25 / 37	2.4 GHz. → 3 / 3 5 GHz. → 25 / 37
	2.4 GHz & 5 GHz  and 6 GHz		2.4 GHz. → 13 / 11 5 GHz. → 25 / 37 6 GHz. → 25 / 59	2.4 GHz. → 3 / 3 5 GHz. → 25 / 37 6 GHz. → 25 / 59



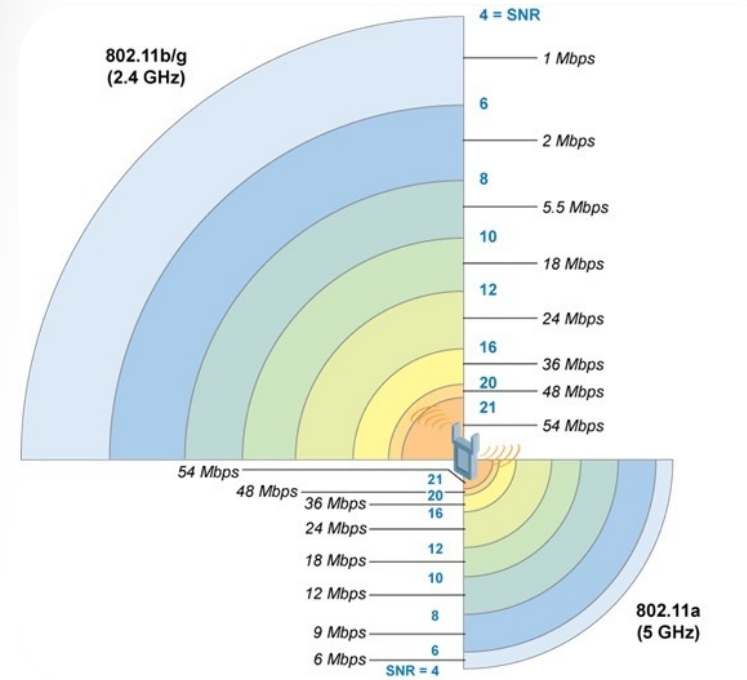
# FREQUENCY SEPARATION

imgflip.com





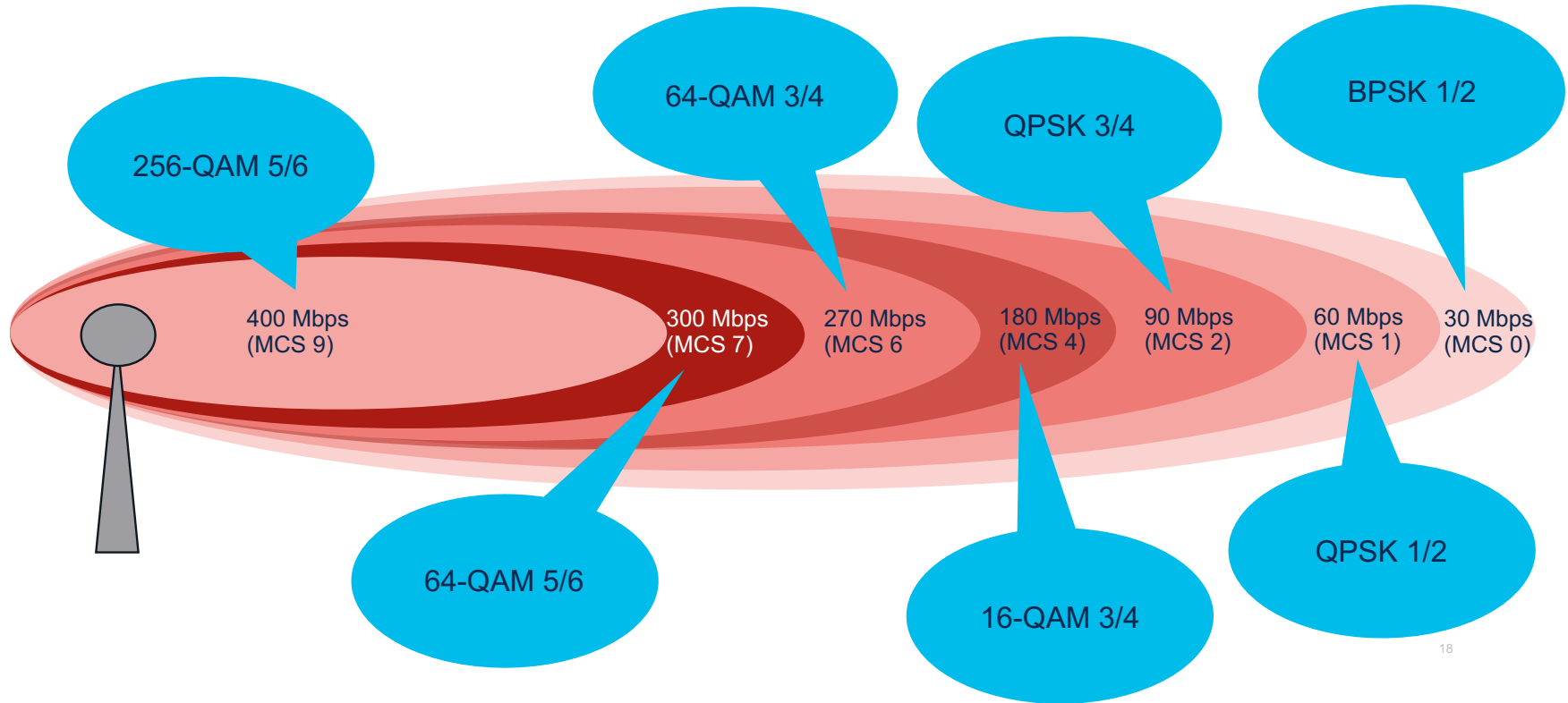
# What is Modulation & Dynamic Rate Shifting (DRS)





# Dynamic Rate Switching (DRS) & Modulation

(given 802.11ac / VHT - 2 spatial streams, 40 MHz channels & 400 MS GI)



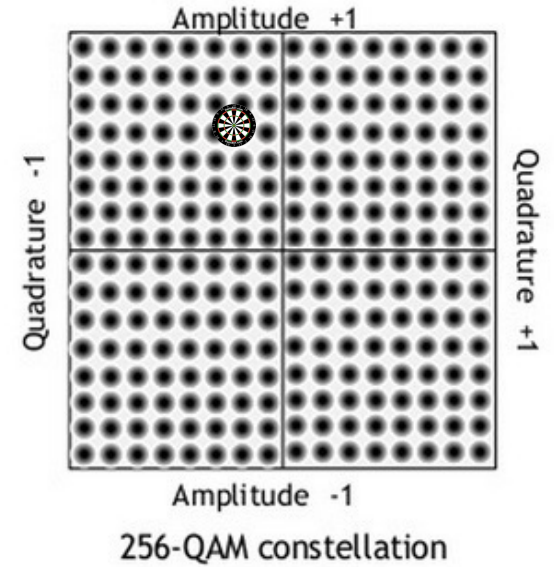
# The Closer I Get to You

Roberta Flack



**Modulation**

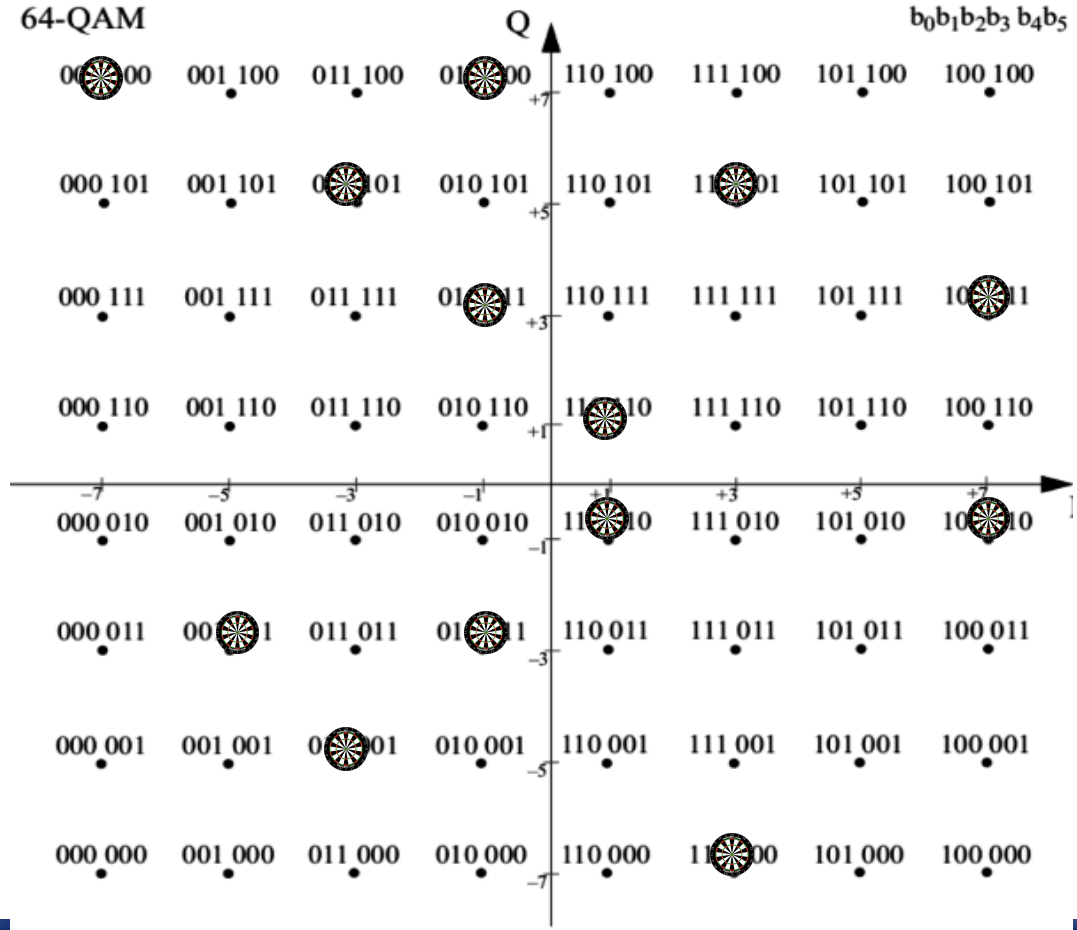


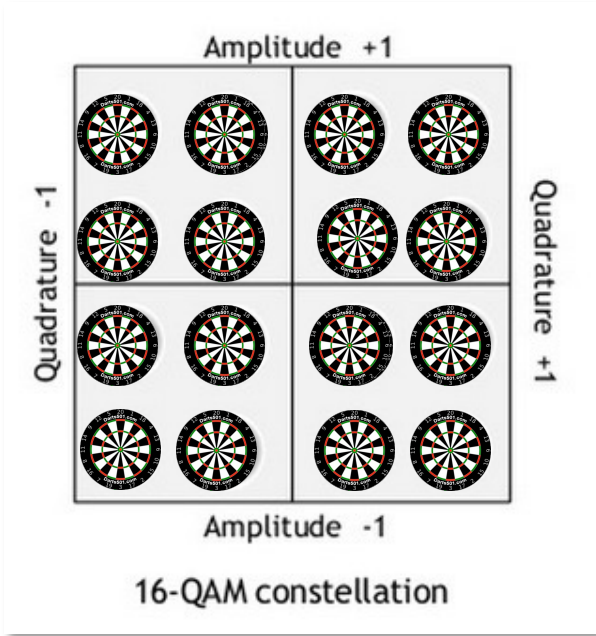






# 64-QAM





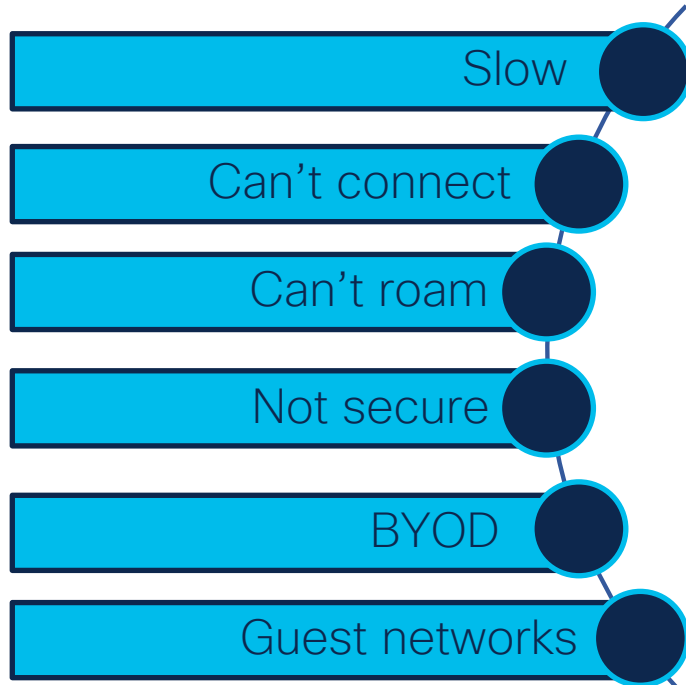
*Get It?*



# What else happens in the air?



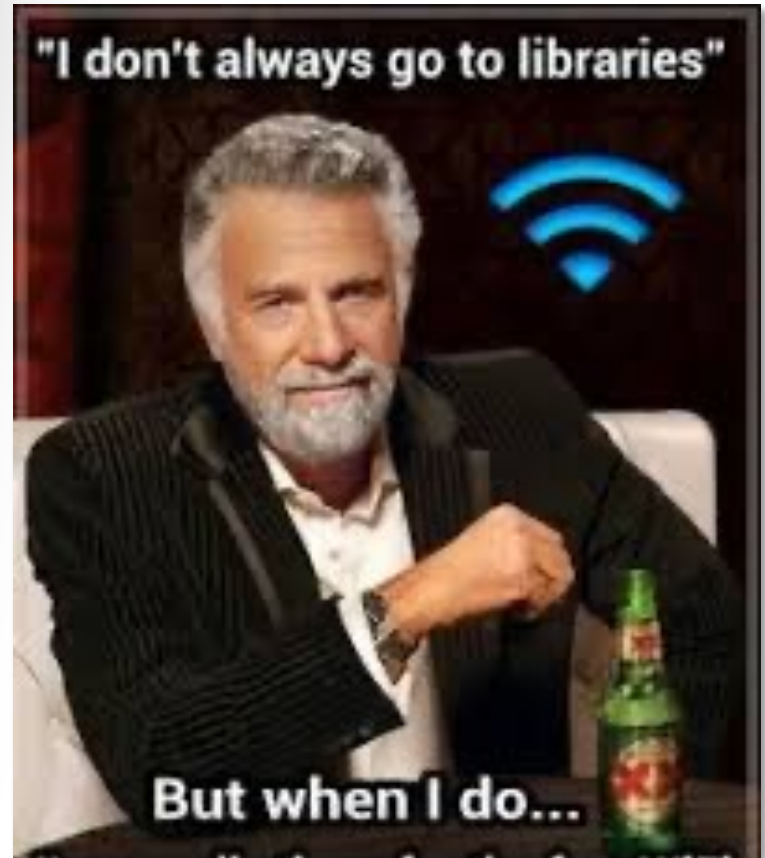
# More challenges in Wi-Fi



- Coverage
- Interference
- Changing environments
- Internet of Things
- 99.999% of availability
- Primary access method



What is  
Wi-Fi 6



802.



11b

Wi-Fi 1

11a

Wi-Fi 2

11g

Wi-Fi 3

11n  
Wi-Fi 4

11ac  
Wi-Fi 5

11ax  
Wi-Fi 6

High Efficiency  
4x Capacity  
IoT Scale



Much more efficiency for getting on- and off the medium



Higher power efficiency benefits clients including IoT



Greater IoT Coverage



Better app. performance in high density deployments



A fluffy, light-colored dog is looking at a black tire swing hanging from a chain. The dog's head is partially inside the tire. The background is a blurred green field with a fence.

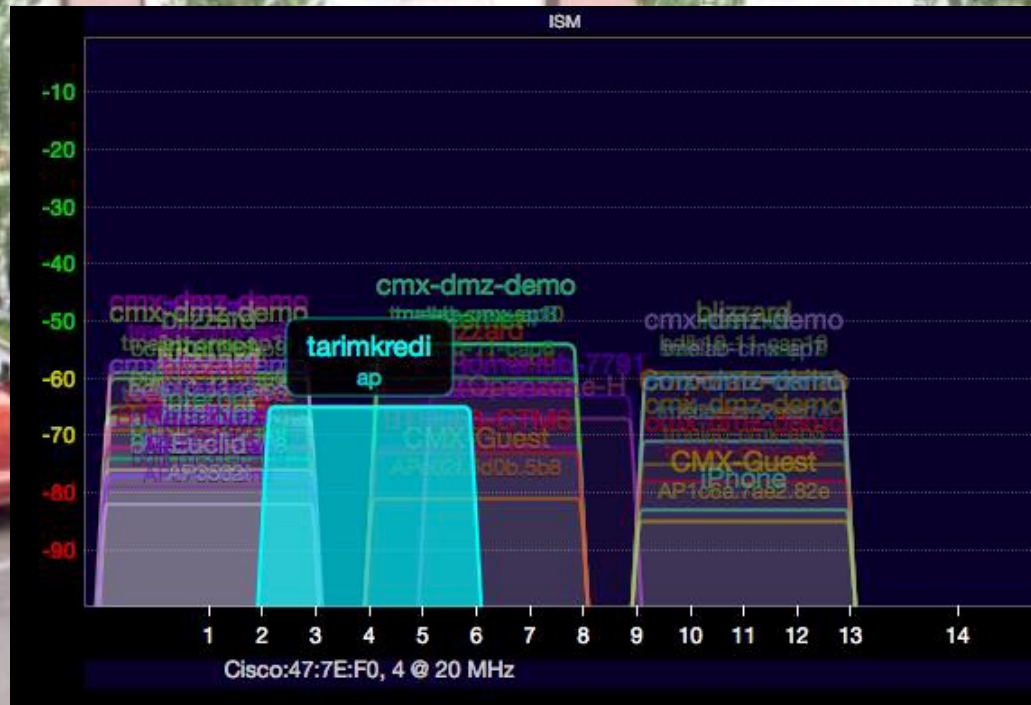
**FAIL**

Time to  
look at  
some Fails!

Fail 1

Forget those  
channels

I ALSO HAVE WI-FI IN MY CAR



SET TO CHANNEL 4



Simple Rule:

”Lead with a  
Channel Plan”

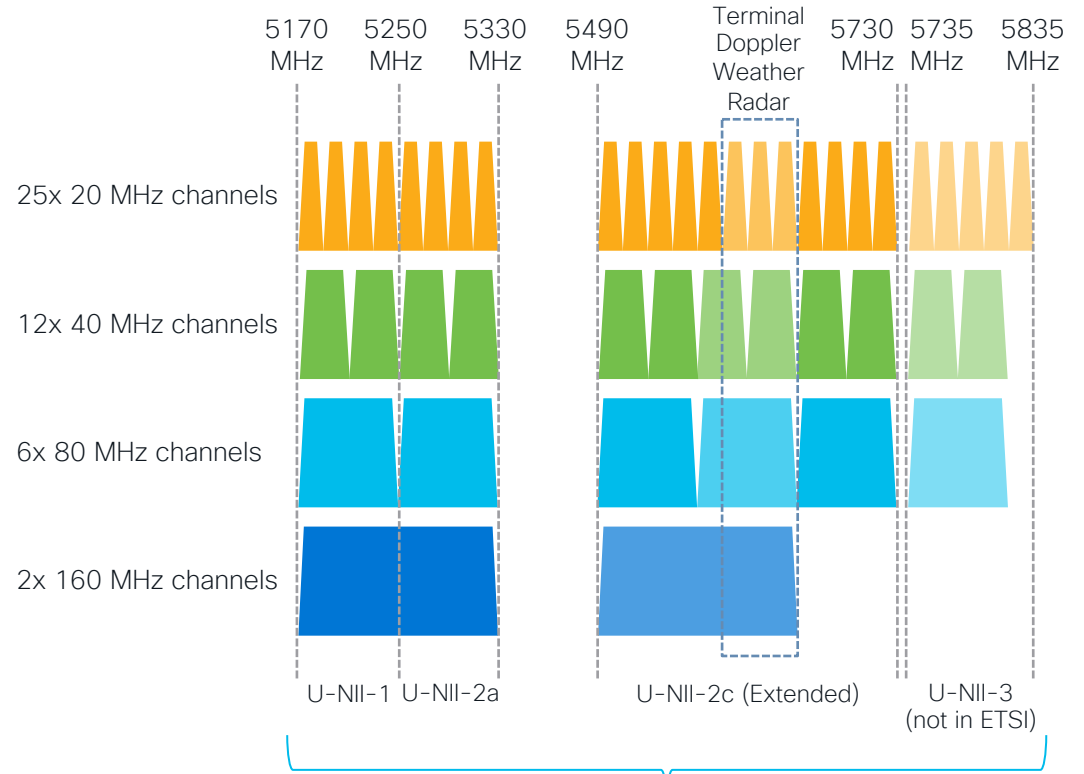
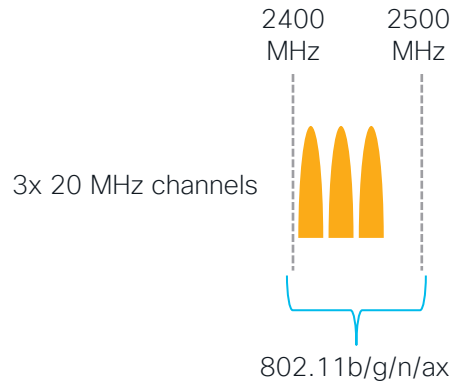
Fail 2  
Give me  
Wider channels





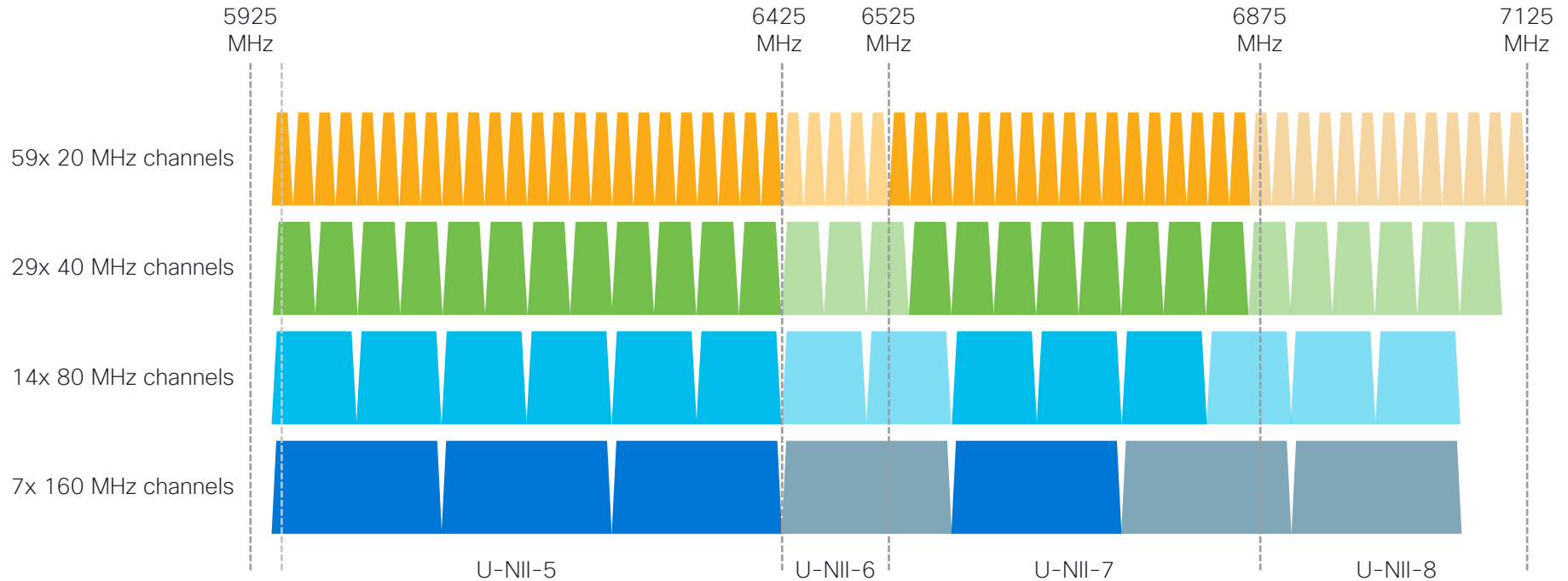
# Wider Channels

# The 2.4 GHz and 5 GHz bands today



802.11a/n/ac/ax

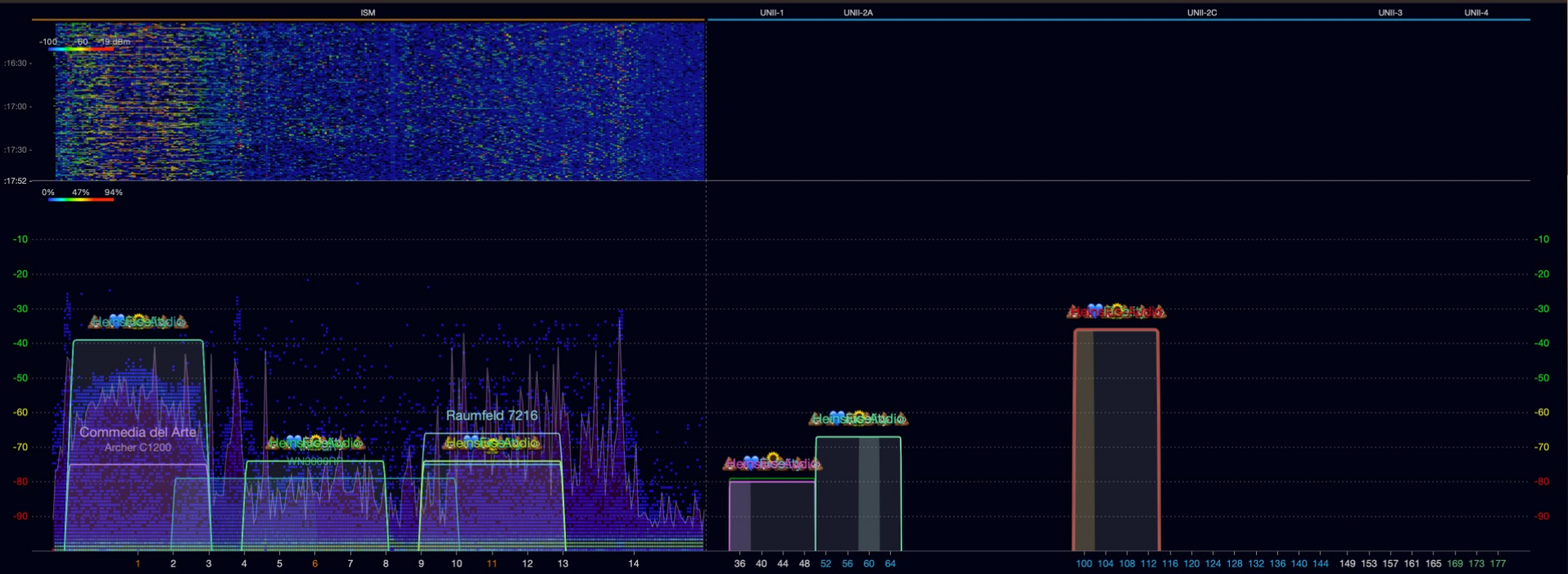
# The 6 GHz band today





BSSID	Network Name	Vendor	Annotations	Signal	Channel	Channel Width	Band	Country Code	Mode	Generation	Security	Max Rate	Seen
9A:18:18:69:F6		Cisco M...		-36 dBm	100	80 MHz	5 GHz	NL	a/n/ac/ax	6	WPA2 (PSK)	2402 Mbps	Just now
92:18:9...:69:F6	Hein...udio	Cisco Me...		-36 dBm	100	80 MHz	5 GHz	NL	a/n/ac/ax	6	WPA2 (PSK)	2402 Mbps	Just now
9E:18:9...:69:F6		Cisco Me...		-36 dBm	100	80 MHz	5 GHz	NL	a/n/ac/ax	6	WPA2 (PSK)	2402 Mbps	Just now
96:18:9...:69:F6	Fidelity	Cisco Me...		-36 dBm	100	80 MHz	5 GHz	NL	a/n/ac/ax	6	WPA2 (PSK)	2402 Mbps	Just now
98:18:8...:69:F6		Cisco Me...		-39 dBm	1	20 MHz	2.4 GHz	NL	b/g/h/ax	6	WPA2 (PSK)	573.5 Mbps	Just now
92:18:8...:69:F6	Hein...udio	Cisco Me...		-39 dBm	1	20 MHz	2.4 GHz	NL	b/g/h/ax	6	WPA2 (PSK)	573.5 Mbps	Just now
9E:18:8...:69:F6		Cisco Me...		-39 dBm	1	20 MHz	2.4 GHz	NL	b/g/h/ax	6	WPA2 (PSK)	573.5 Mbps	Just now
96:18:8...:69:F6	Fidelity	Cisco Me...		-39 dBm	1	20 MHz	2.4 GHz	NL	b/g/h/ax	6	WPA2 (PSK)	573.5 Mbps	Just now

Network Details Signal Strength Spectrum 2.4 / 5 GHz Advanced Details





Simple Rule:

”40 for 5, 80 for  
6,  
but whatever you  
do... Never Mix”

After all...



## Fail 3: Placements...

... Really? It matters?





Source: [www.bad-fi.com](http://www.bad-fi.com)  
& Twitter & Personal observations

# Channel bonding...





# Wireless Stacking



Low & Slow...



via @WirelessGuru

Who needs brackets...





Who needs brackets...





When you did the survey...

BEFORE



When they go live...



# Outdoor Wi-Fi...



MacGruber



# Placement & Positioning best practices

- ✓ AP **Horizontal** (vertical Polarization)
- ✓ Below obstructions
- ✓ Minimal **one meter (3ft) away** from obstructions (Fresnel zone)
- ✓ The correct antennas, only 1 type of antenna
- ✓ Access Points minimal **three meter (10ft) away** from **each other**
- ✓ **Not too high** (after 4 meter (14ft) high special implementations)
- ✓ Don't put behind a **metal cage**
- ✓ Use **Outdoor** AP's for **Outdoor** Coverage...

Simple Rule:

Like in  
Real Estate...

”Location,  
Location,  
Location”



Fail 4:  
I am secure  
Encryption &  
Authentication





# Statistics

General

Personal

Groups

Android

SSID/Manufacturers

Octet/Channel/File

Geographic

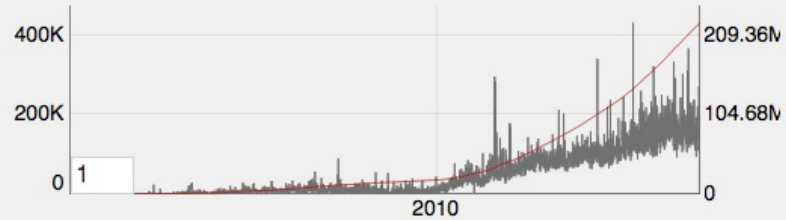
Unique WiFi networks in DB:	228,657,368
Unique networks w/ location:	226,196,720
Unique WiFi locations in DB:	3,228,957,847
Unique Cell towers in DB:	5,946,883
Unique Cells w/ location:	5,916,700
Registered Users:	176,695
Networks with default SSID:	8,262,679 (3.61%)
New unique networks today:	16,268
New today with location:	16,247
New yesterday with location:	135,596
Total Files parsed:	1,259,436
Files uploaded today processed:	63
Files 1 day ago / 2 days ago:	470 / 505
Files queued to process:	0

## Wireless Encryption

**WPA2:** 117,848,480 (51.54%)  
**WPA:** 20,969,968 (9.17%)  
**WEP:** 27,815,788 (12.16%)  
**????:** 43,297,442 (18.94%)  
**None:** 19,132,440 (8.37%)

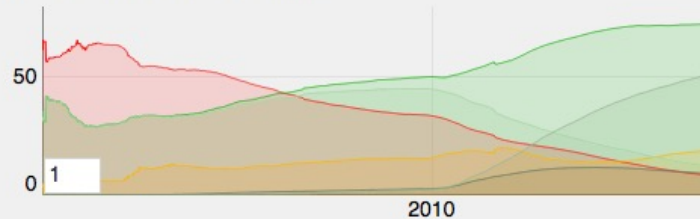


## WiFi Networks Over Time



[Full-screen Graph]

## WiFi Encryption Over Time



[Full-screen Graph] [2 Years only Graph]

Mouse-over graphs to interact with data. Select a range to zoom in, double click to zoom back out. Modify the number in the corner to smooth over multiple days. Full-screen graphs available!

Source: wige.net

system.de



Login ▾

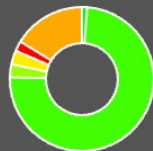
# Statistics

- General
- Personal
- Groups
- Android
- SSID/Manufacturers
- Octet/Channel/File
- Geographic
- Processing

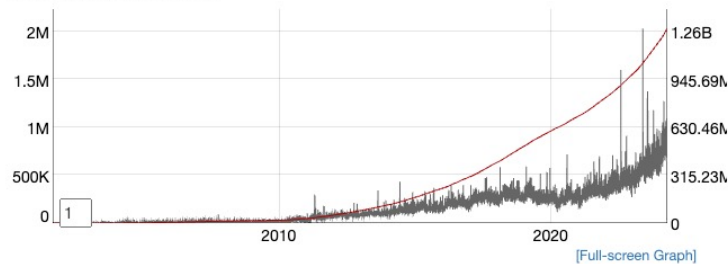
Unique WiFi networks in DB:	1,295,533,217
Unique networks w/ location:	1,280,540,206
Unique WiFi locations in DB:	17,570,653,623
Unique BT Devices in DB:	2,458,168,848
Unique BT w/ location:	2,407,269,170
Unique Cell towers in DB:	23,014,354
Unique Cells w/ location:	22,723,924
Registered Users:	531,111
Networks with default SSID:	18,484,777 (1.43%)
New unique networks today:	152,928
New today with location:	151,465
New yesterday with location:	756,557
Total Files parsed:	5,969,596
Files uploaded today processed:	404
Files 1 day ago / 2 days ago:	2,410 / 3,007
Files queued to process:	29

## Wireless Encryption

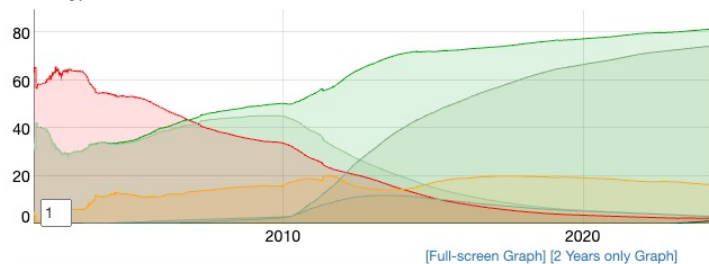
- WPA3: 15,135,132 (1.17%)
- WPA2: 962,284,604 (74.28%)
- WPA: 37,744,125 (2.91%)
- WEP: 40,449,845 (3.12%)
- ?????: 211,155,902 (16.30%)
- None: 29,460,254 (2.27%)



## WiFi Networks Over Time



## WiFi Encryption Over Time



Mouse-over graphs to interact with data. Select a range to zoom in, double click to zoom back out. Modify the number in the corner to smooth over multiple days. Full-screen graphs available!



Username: Admin  
Password: Admin



# Security best practices

- WPA2 is the bare minimum
- WPA2 Personal (PSK) is for... personal (!)
- WPA2 Enterprise (802.1x) for businesses
- WPA3 more and more supported and new default
- Use a Wireless Intrusion Prevention (wIPS) solution
- Use VPN on Public Wireless Connections

Simple Rule:

*„Security is a  
Process, not a  
Product“*



# Fail 5: Hype versus Reality



When 802.11ac  
Wave 2  
was announced...



4x4:4

Much More  
Bandwidth  
>2 Gig

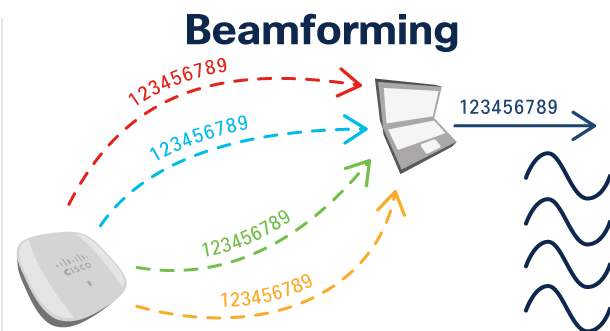
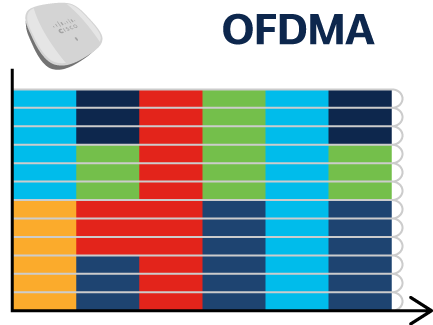
256  
QAM

It was all about...

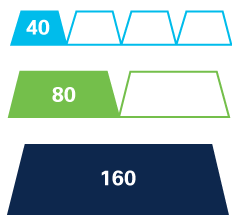
160 MHz  
wide  
channels

Multi  
User  
MiMo

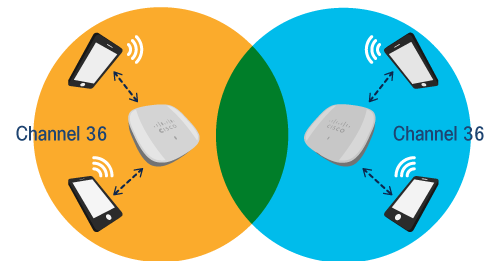
But now...



## 160 MHz Channels



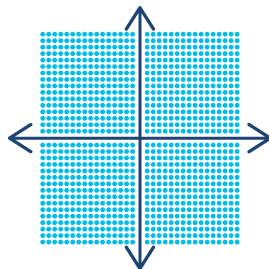
## BSS Coloring



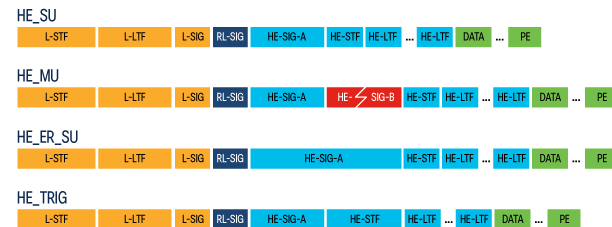
## Target Wake Time



## 1024-QAM



## Longer Symbol Time





Simple Rule:

*“Now more than  
ever,  
  
you need the  
smartest Chipset”*

Fail 6:  
Listen to the  
Architect...



So I am told...

Access Points are ugly....

And what do you do with things that are ugly?



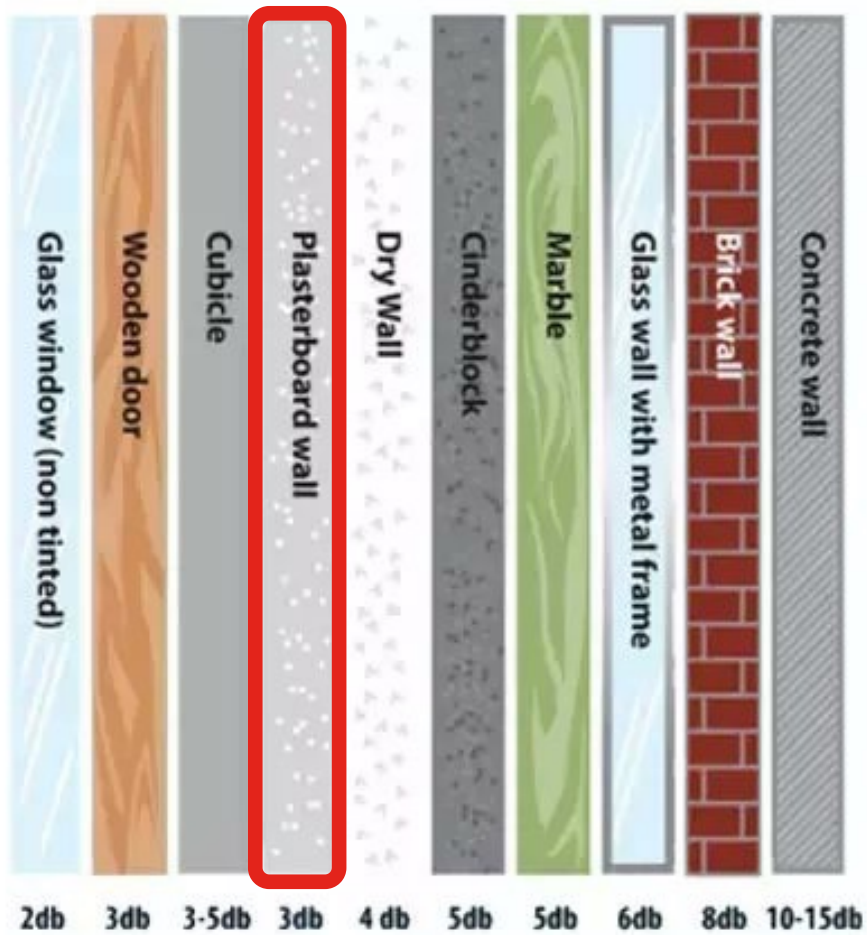


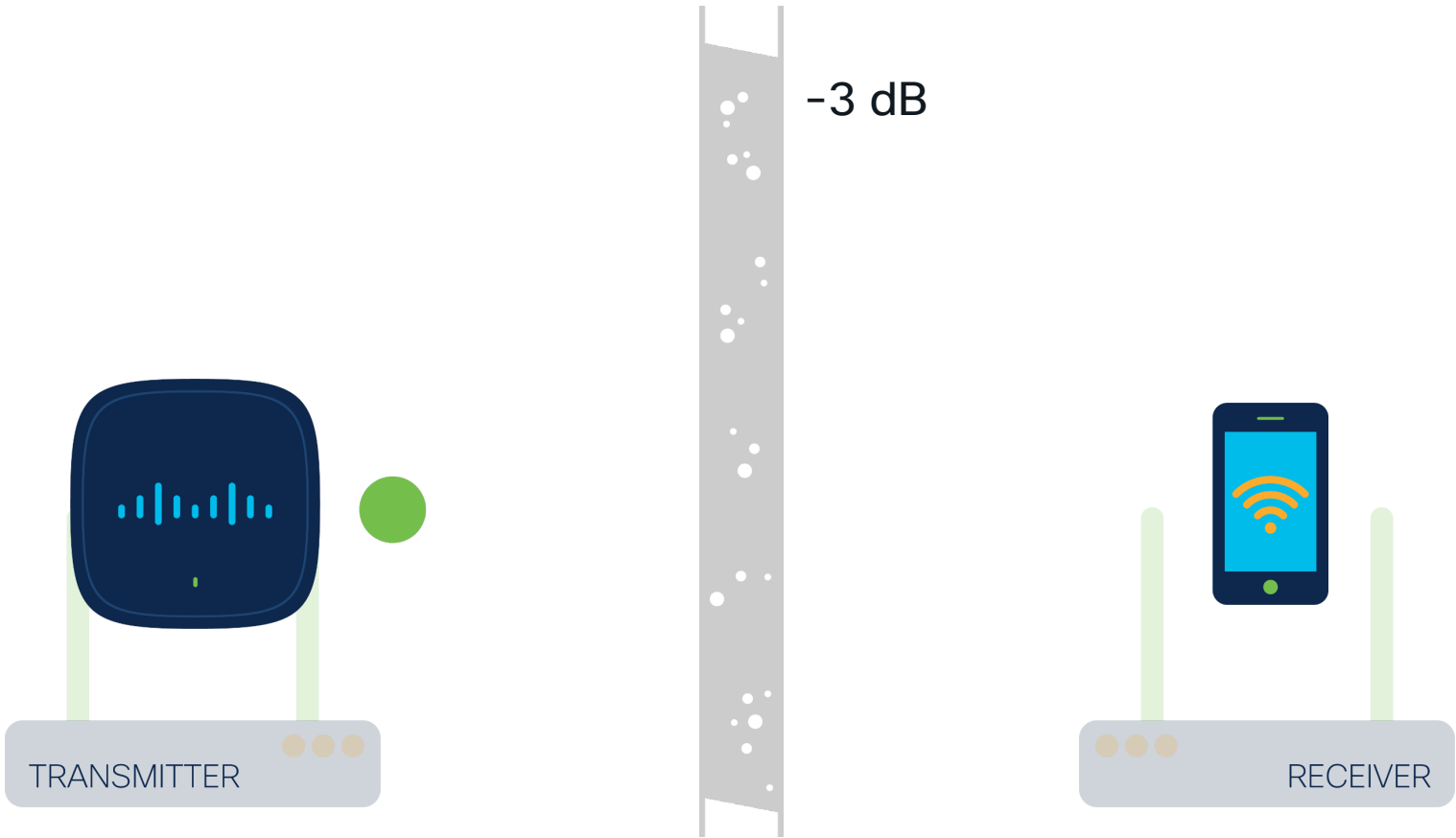


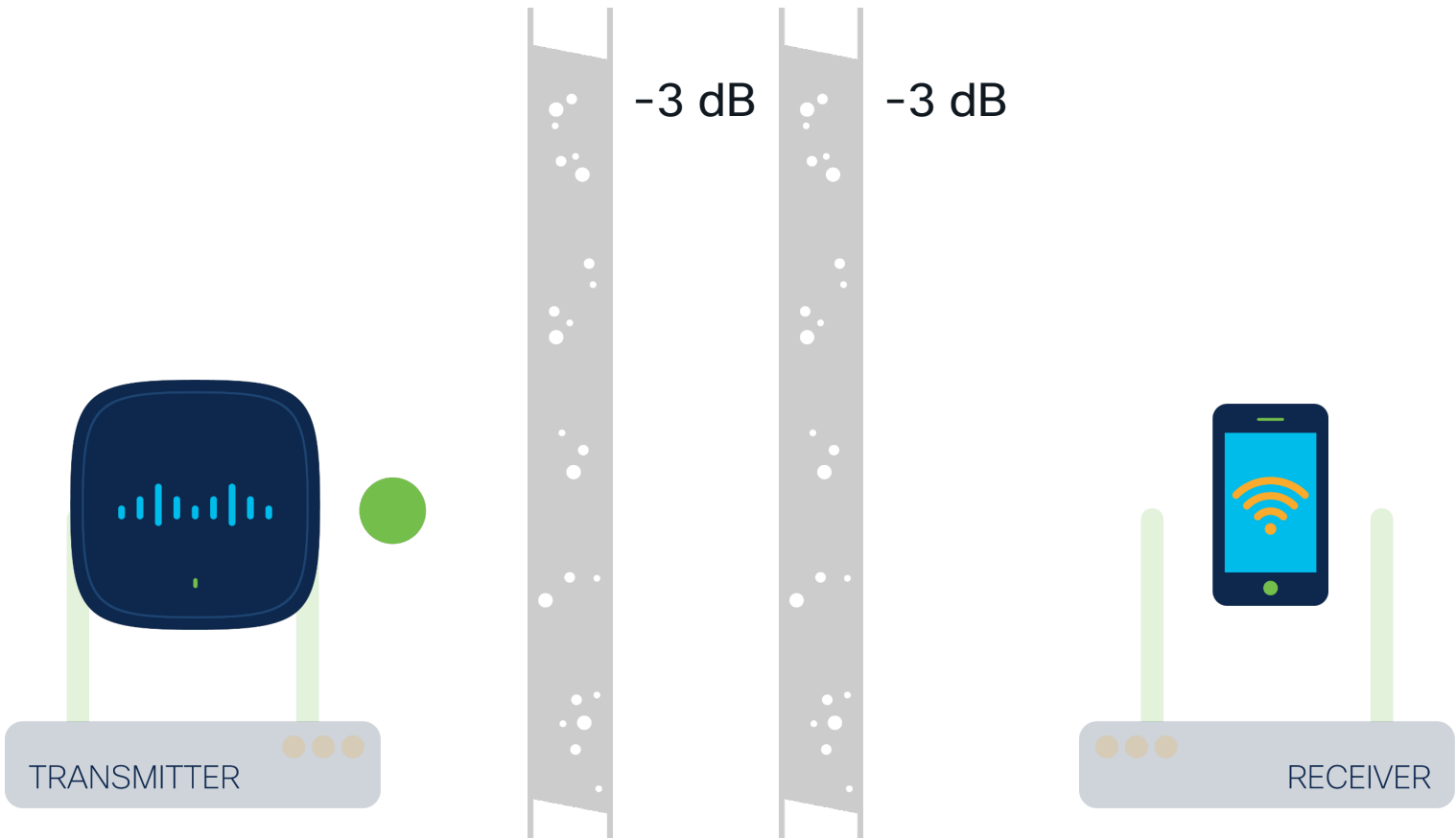
With Wi-Fi...

Put your AP's where your clients are











70% of the clients  
in a network are?



Maximum transmission on Wi-Fi?

$25 \text{ mW} = 14 \text{ dBm}$

# So...

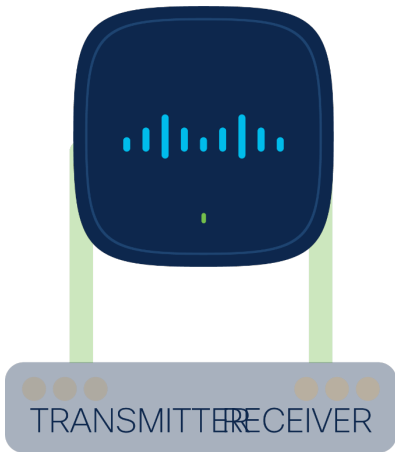
(RF Mathematics continued...)

Max ETSI transmission is 100 mW.  
that is 20 dBm

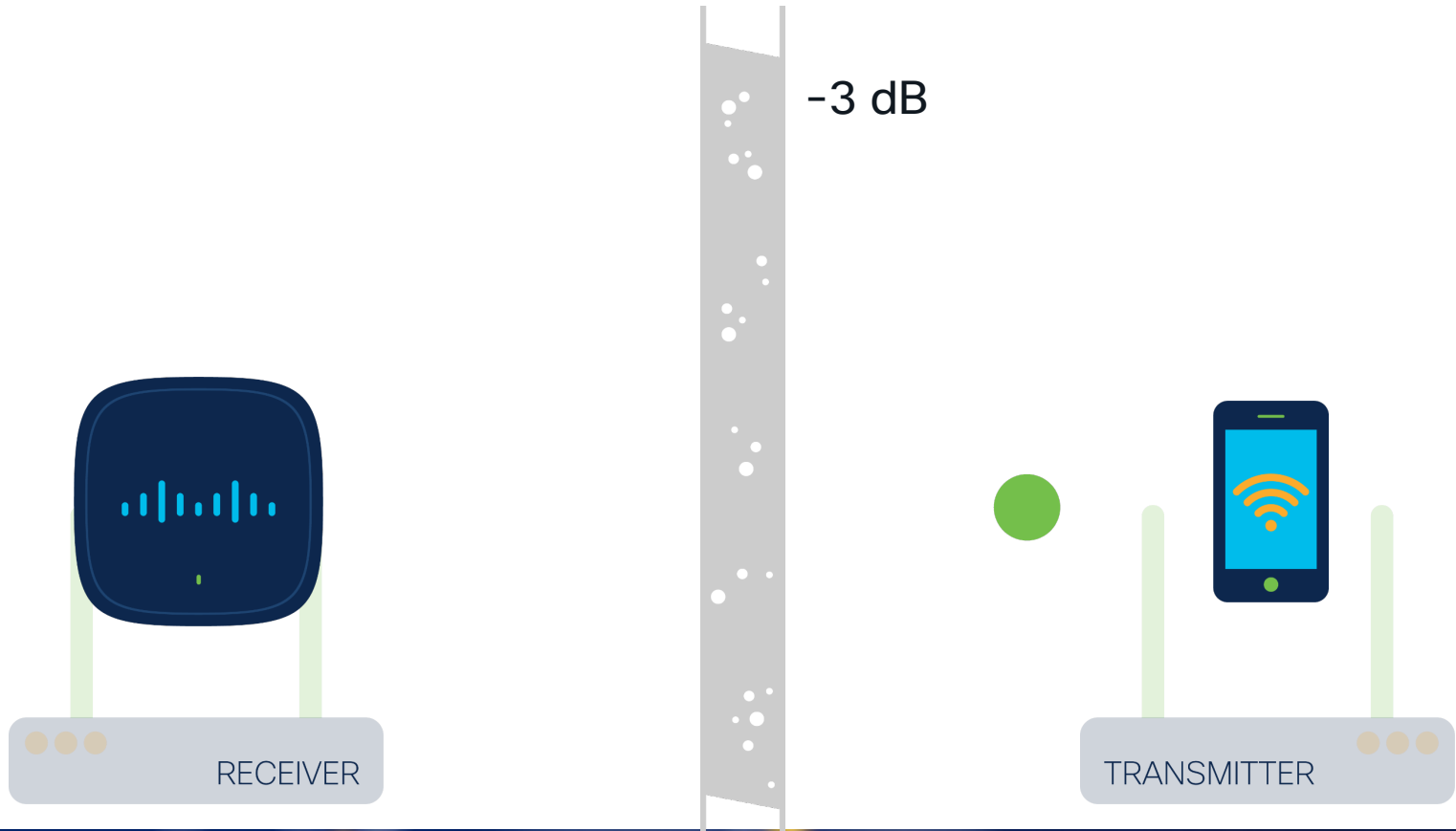
20 dBm	100 mW
17 dBm	50 mW
14 dBm	25 mW
11 dBm	12.5 mW
8 dBm	6.25 mW
5 dBm	3.12 mW
2 dBm	1.6 mW
0 dBm	1 mW













What about these?

Why don't you hide them?

“Then they don't work...”

AHA!

Introducing...

The  
“Peep Hole AP”













# Oberon Model 3032 NetPoint™ Wi-Fi Bollard



Simple Rule:

”Can you  
read the logo?”

Then you are  
probably good to

Fail 7:

I'll wait  
for the  
Next Upgrade





# Wi-Fi 6 - This is the fastest transition ever



Simple Rule:

“don't wait till  
tomorrow  
  
with what  
you can do today...”



You have learned 7 things to look at  
When you want to be an expert  
&  
You have learned 7 things to look at  
When you *hire* an expert

And  
Remember...

IF YOU  
... **THINK** ...  
HIRING A  
**PROFFESIONAL**  
— IS —  
**EXPENSIVE**  
WAIT 'TILL  
• **YOU HIRE** •  
— **AN AMATEUR** —

But if you search well....

There's always someone willing to do it cheaper...



Thank you!

# Ihre Ansprechpartner

## Die Ausbildung der Fachkräfte von morgen ist wichtig!

Wir möchten unseren Beitrag leisten und die Lehre mit unserem IPv6-Wissen unterstützen. Auf Anfrage stellen wir sehr gerne IPv6-Schulungsunterlagen zur Verfügung, die Sie in Ihre Unterrichte einbinden können. Die Unterlagen sind aber nicht Teil der Cisco Networking Academy.

### Lukas Thiem

Network Support Engineer  
Trainer

T +49 30 290 23 15-244

E [lthiem@system.de](mailto:lthiem@system.de)



### Jens Schneider

CTO

M +49 170 461 85 31

T +49 30 290 23 15-220

E [jschneider@system.de](mailto:jschneider@system.de)



### Peter Schulte

Geschäftsführer/ CEO

M +49 171 776 30 36

T +49 30 290 23 15-210

E [pschulte@system.de](mailto:pschulte@system.de)



Der system.de-Geschäftsführer Wilhelm Boeddinghaus hat über IPv6 und Netzwerkvirtualisierung zwei Online-Seminare bei Open HPI (Hasso Plattner Institut) aufgenommen, die ebenfalls einen Mehrwert für Ihre Schüler bieten können.

<https://open.hpi.de/courses/ipv6-2018?locale=de> und <https://open.hpi.de/courses/virtnet2019>

**system.de** – System & Project GmbH, [www.system.de](http://www.system.de), AG Berlin Charlottenburg HRB 537 40  
Knesebeckstr. 96, 10623 Berlin - Neuer Wall 10, 20354 Hamburg - Alter Holzhafen 19, 23966 Wismar