Wireless Technology Overview

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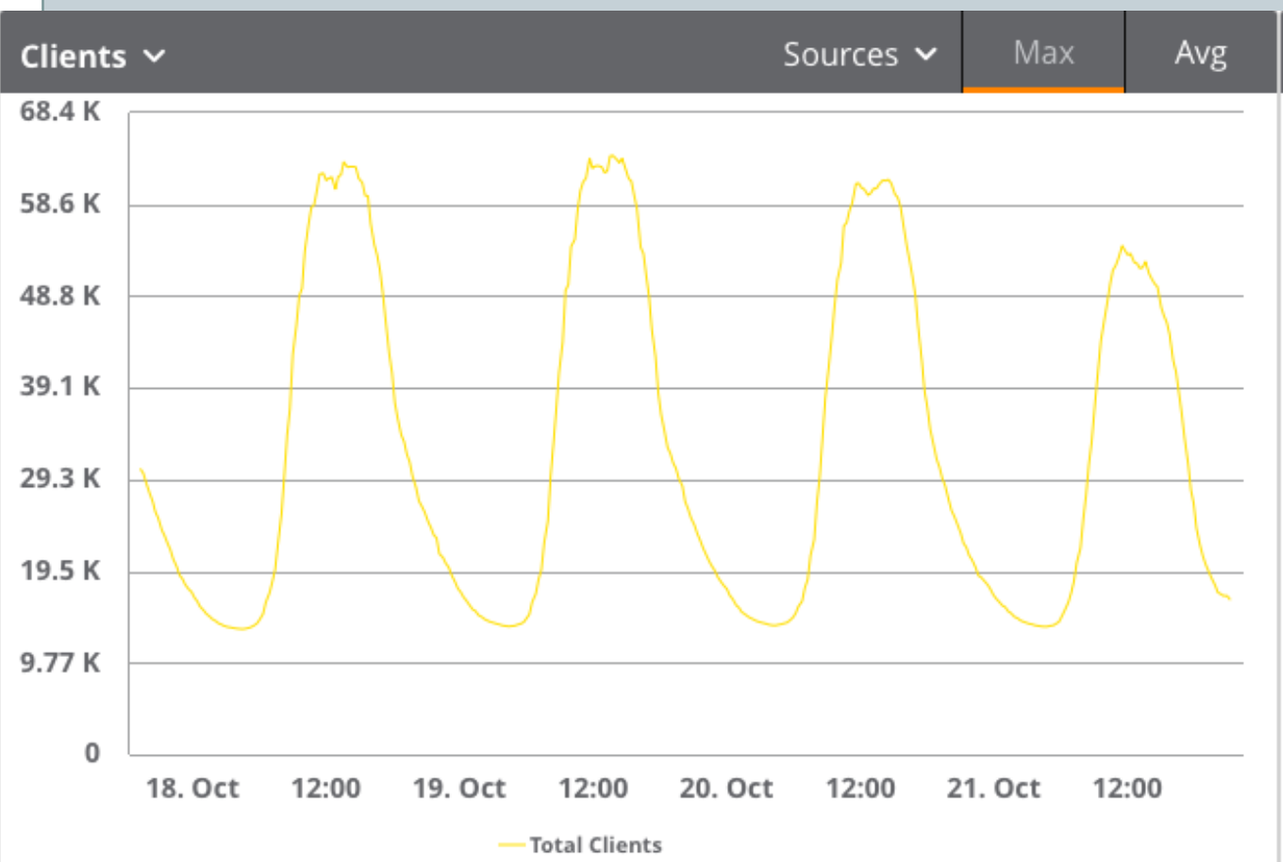
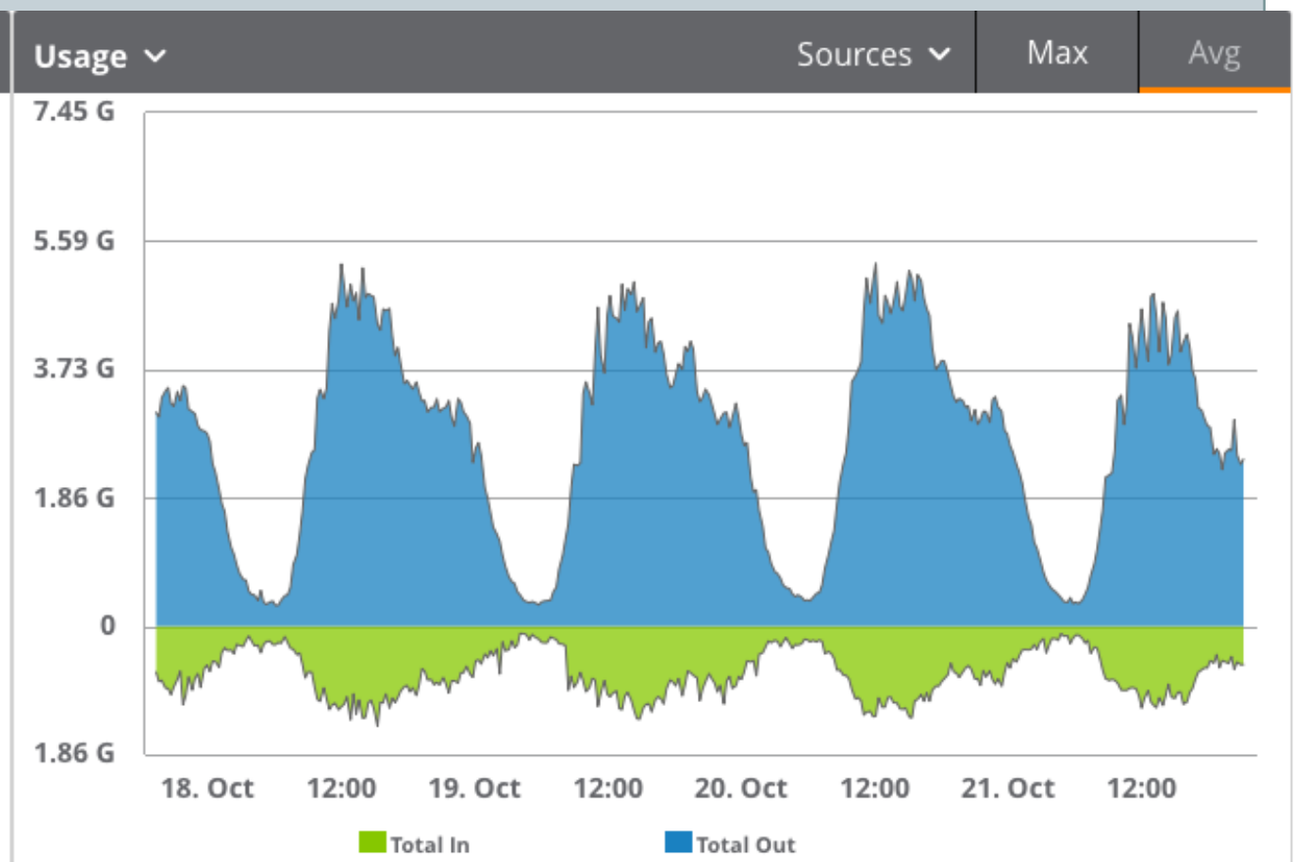
My Background

- Developed one of the first nationwide Voice over IP (VoIP) carrier networks
- Vice President & Principal Engineer Open Telecommunications (US & Australia)
- Lead development of the largest, nationwide Wi-Fi networks
- Participated in development of first inter-carrier Wi-Fi roaming protocols (WISPr)
- Development team Unlicensed Mobile Access (UMA) a/k/a Wi-Fi Calling

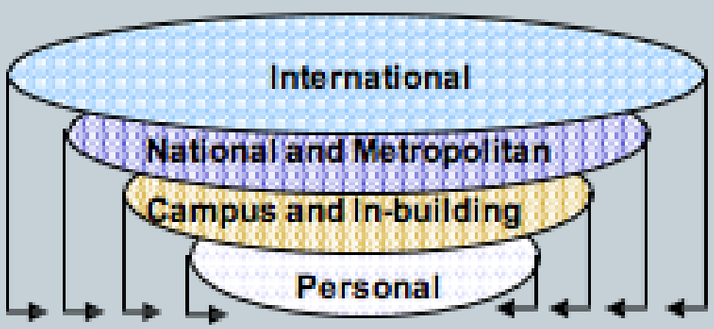
UW Wi-Fi network

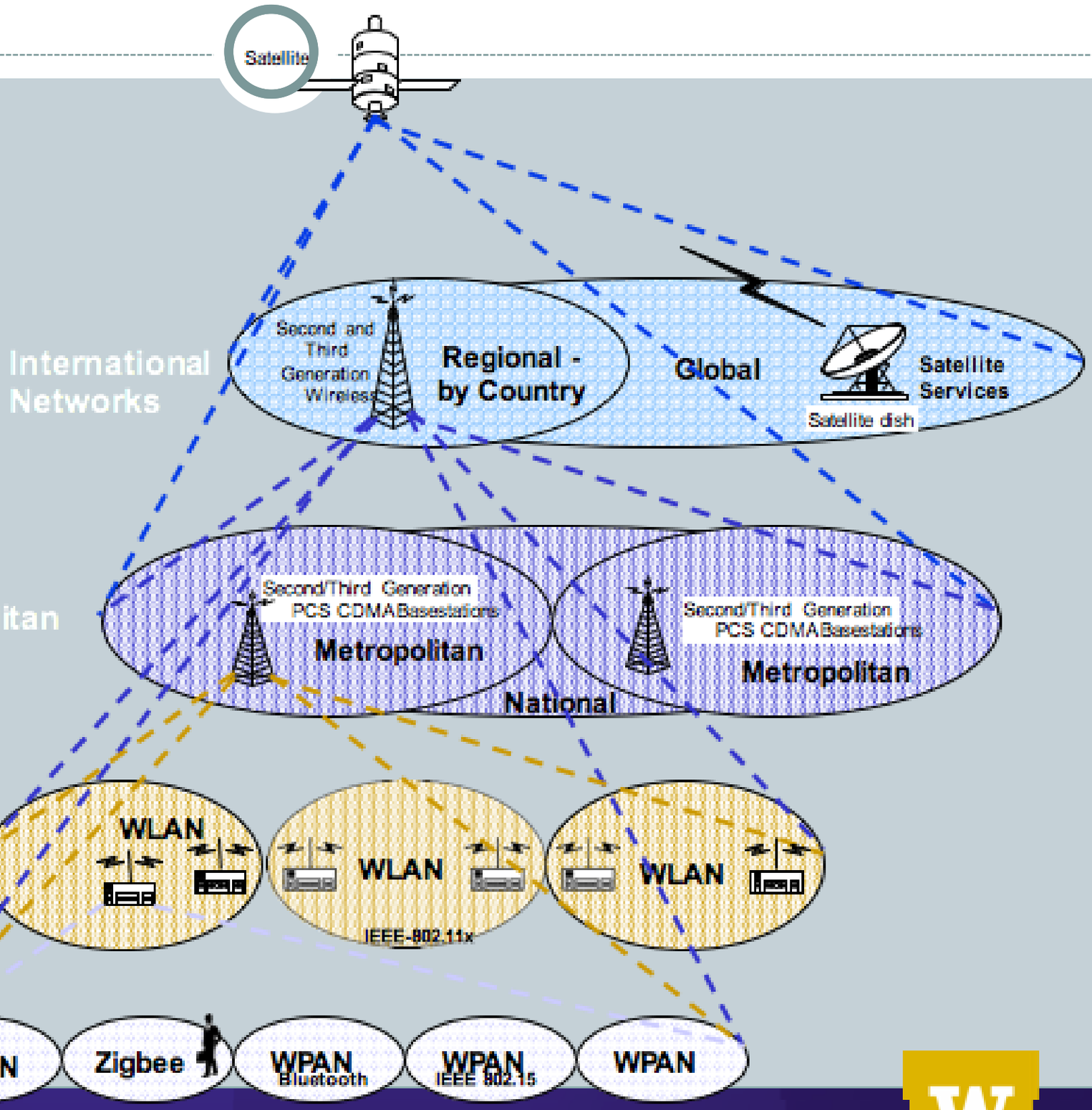
UP	DOWN	ROGUE	CLIENTS	VPN SESSIONS	VPN USERS	ALERTS
10805	21	8	63215	0	0	1561





Wireless Technology Overlay





US Frequency Map

UNITED

STATES

Radio Spectrum

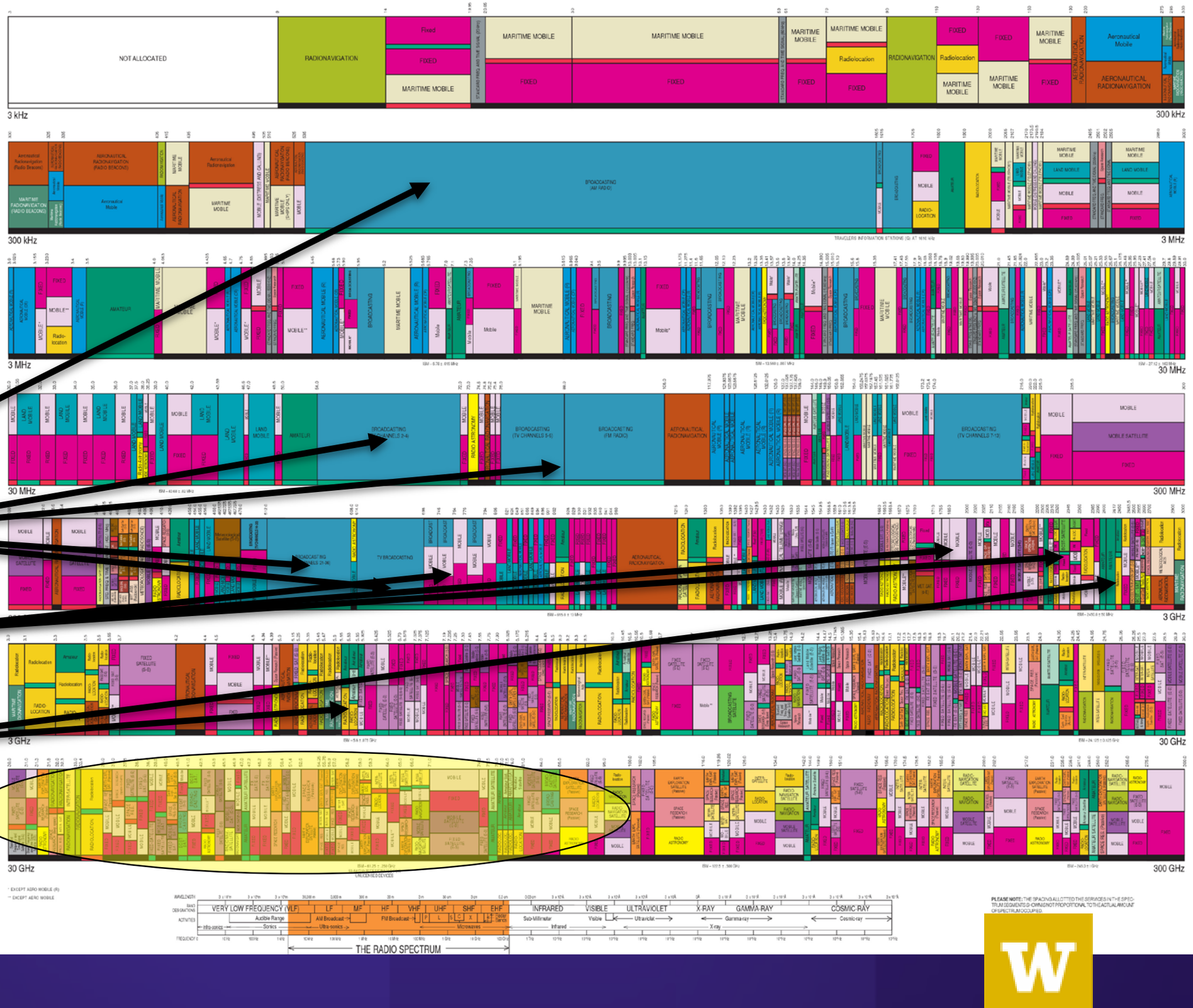
AM Radio

TV/FM

Cellular

Wi-Fi

New &
Interesting



Cellular

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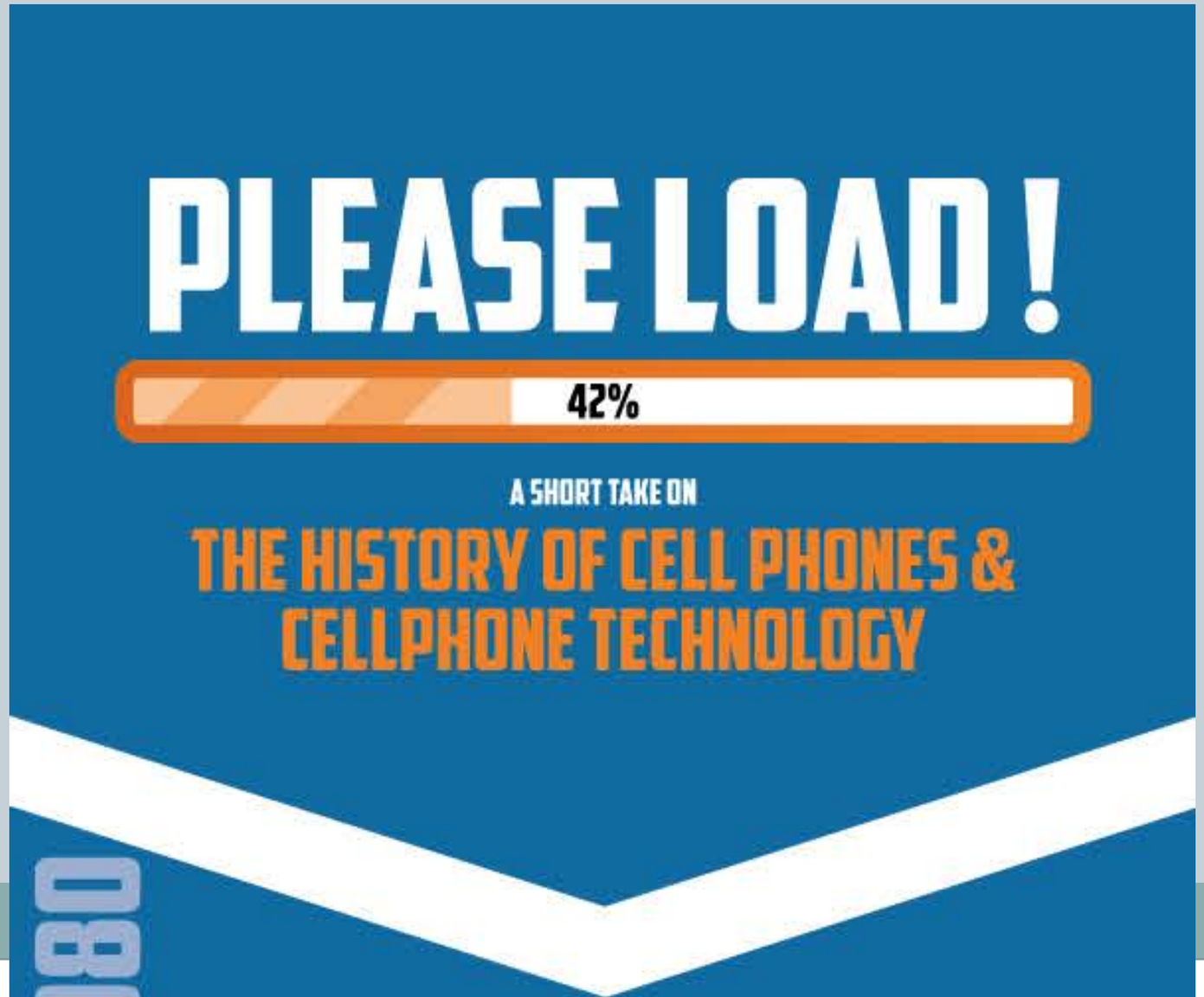
A/K/A

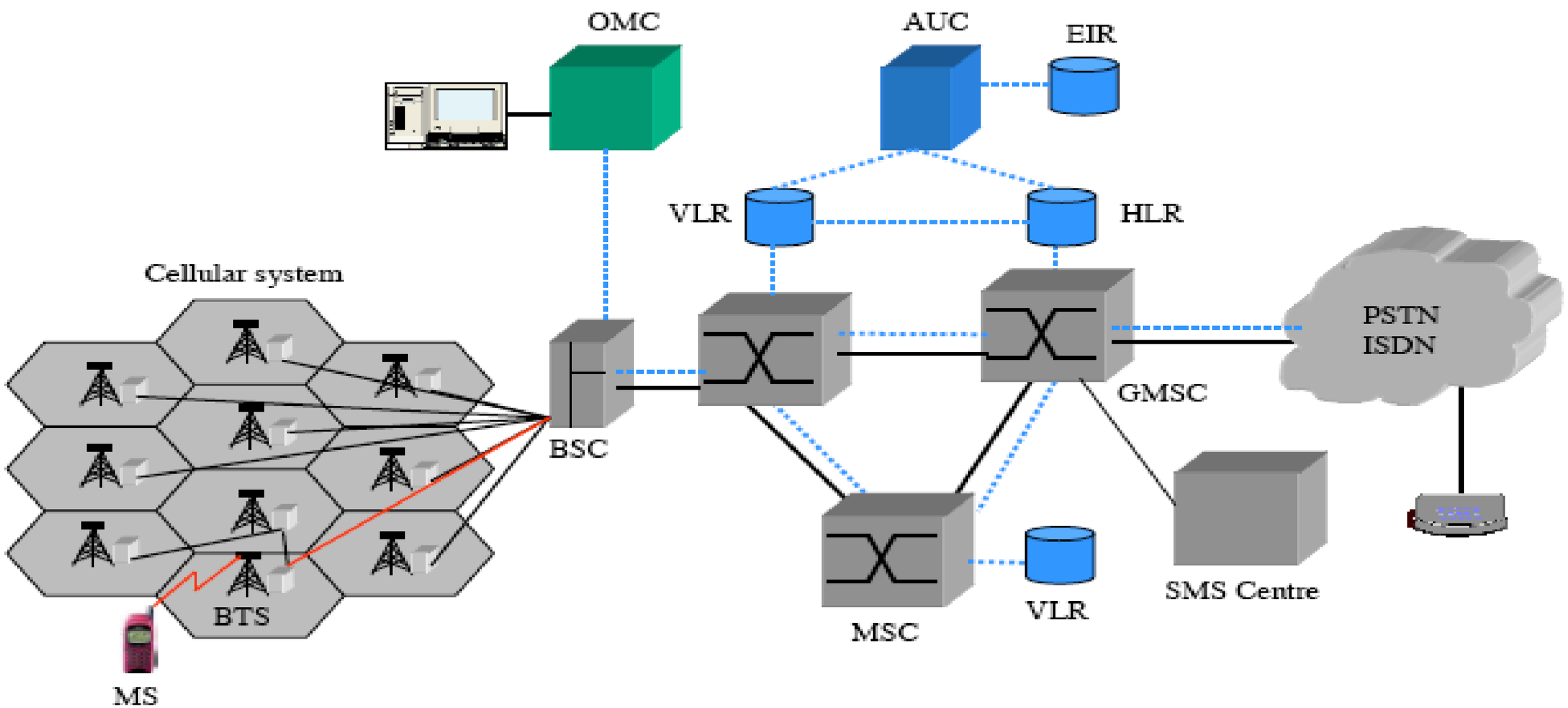
WIRELESS WAN

A brief history of cellular



Source: Lyca Mobile

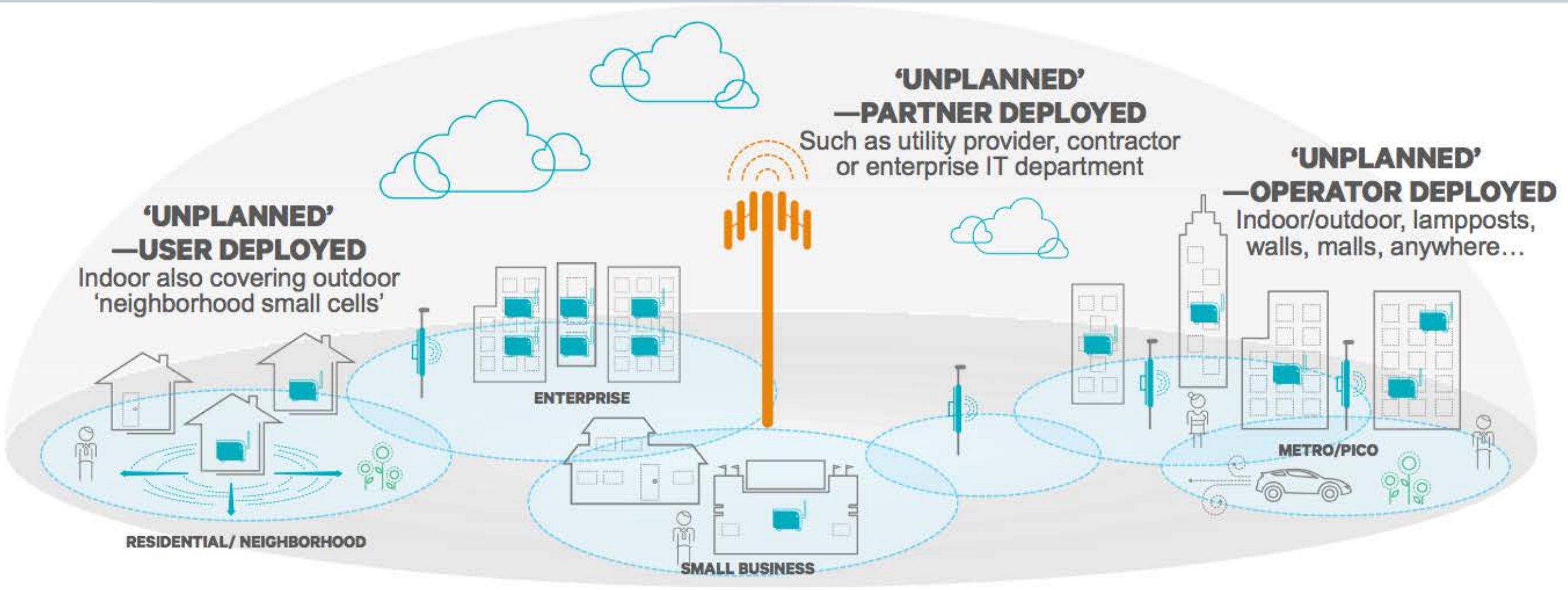
Anatomy of a Cell System



Cellular today and beyond

- Networks are moving closer to users
- Big cell sites are provide wide coverage
- Other options provide capacity/bandwidth
  - Distributed Antenna Systems (DAS)
  - Small cells
  - Metro/ small/ micro cells

Metro/ small/ micro cells



Viral, ad-hoc, 'unplanned', e.g. where backhaul exists—more like Wi-Fi	**Plug & play, self organizing, coordinated small cells**	**Managed by operator in licensed spectrum**

Source: Lyca Mobile

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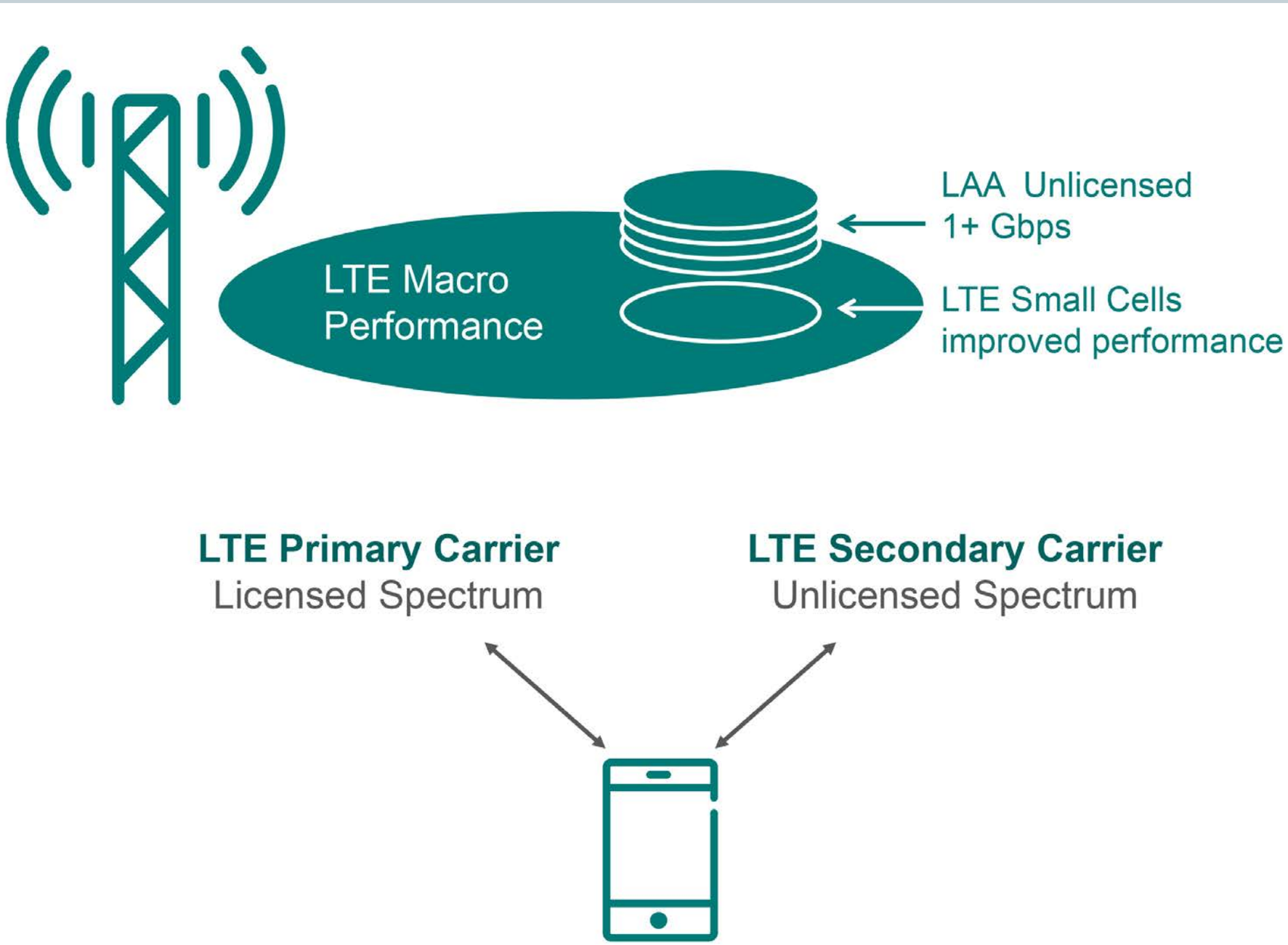
  - LTE-License Assisted Access

LTE-License Assisted Access



Source: Erikson

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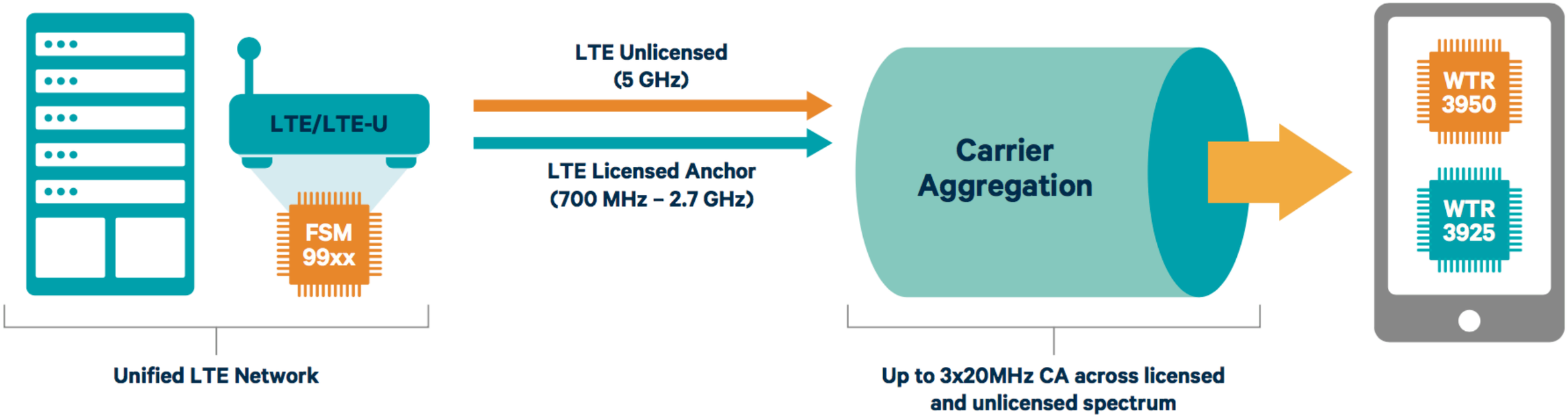
LTE-Unlicensed



Key Benefits:

- Enhanced user experience with licensed anchor for control and mobility
- Better capacity and range compared to Wi-Fi
- A good neighbor to Wi-Fi, going beyond minimum requirements to ensure fair coexistence
- Unified LTE network with common management of licensed and unlicensed spectrum

Source: Qualcom

Wi-Fi

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A/K/A

WIRELESS LAN

Wi-Fi Standards*

Standards are defined by the IEEE

Interoperability tested & devices certified by the Wi-Fi Alliance

- ×1997 - 802.11 — 2 Mbps max, 2.4GHz band
- ×1999 - 802.11a — 5 GHz band, 54 Mbps max
- ×1999 - 802.11b — 2.4 GHz band, 11 Mbps Max
- ×2003 - 802.11g — 2.4 GHz band, 54 Mbps max, Same rates as 11a

Wi-Fi Standards*

Standards are defined by the IEEE

Interoperability tested & devices certified by the Wi-Fi Alliance

- 2007 - incorporated standards
  802.11 a, b, d, e, g, h, i, j
  *d, e, h, i, & j add capabilities

- 2009 - 802.11n 2.4 & 5 GHz
  increased speeds
  54 - 600 Mbps
  wider channels

- 2012 - incorporated standards
  802.11 k, r, y, n, w, p, z, v, u, s
  to 802.11-2007 base

Wi-Fi Standards*

Standards are defined by the IEEE

Interoperability tested & devices certified by the

Wi-Fi Alliance

- 2013 - 802.11ac 5 GHz only
  increased speeds
  wider channels
- 2016 - 802.11ac “wave2”
  wider channels
  multiple transmit
- 2010 - 802.11ad first product now
  60 GHz band +

Future Wi-FI

Next up...

- 802.11ax release late 2017-2018
  - top speeds of 10 Gbps targeted*
  - improved efficiencies
  - targeted for dense environments

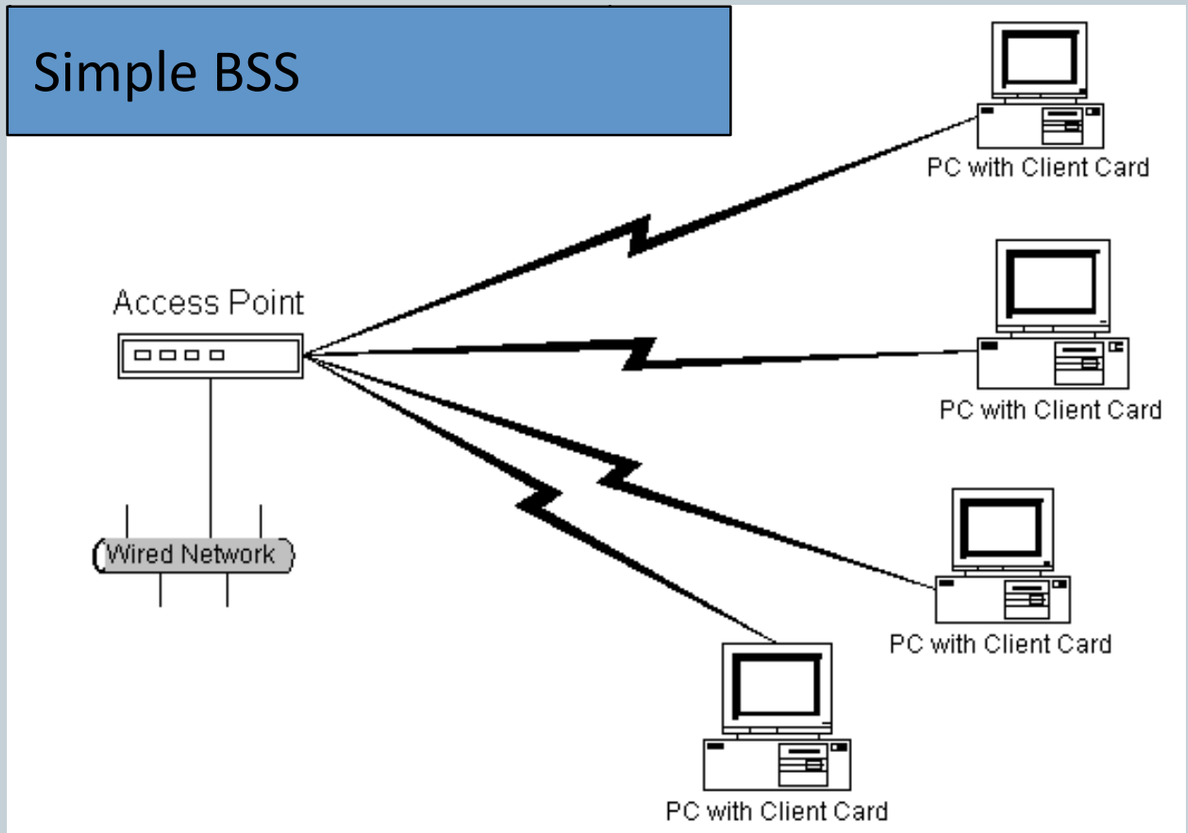
Wi-Fi service sets

Service Set Identifier (SSID)	Independent Basic Service Set (IBSS)
× identifies network	× Direct computer to computer Wi-Fi
× aka network name	× aka Adhoc Wi-Fi

Wi-Fi service sets

Basic Service Set (BSS)

Simple BSS

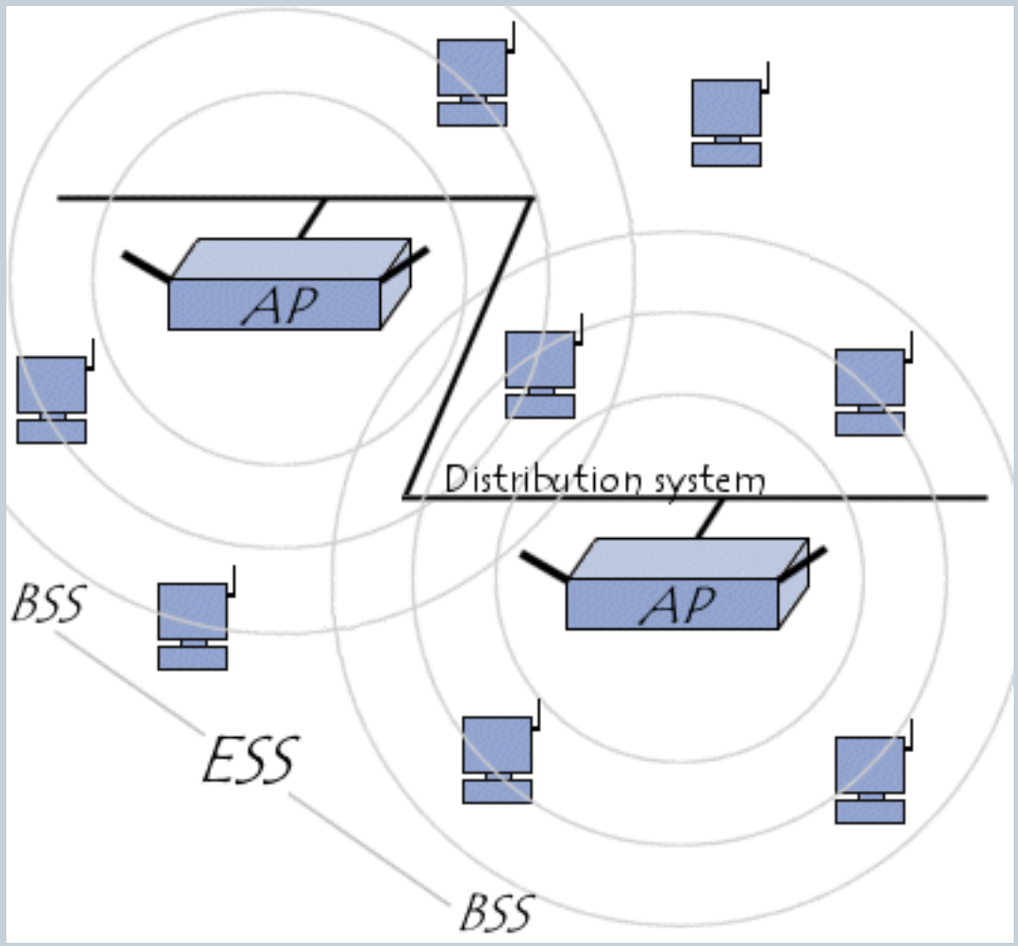


- Wi-Fi through an access point
- Home & coffee shop Wi-Fi is usually this flavor

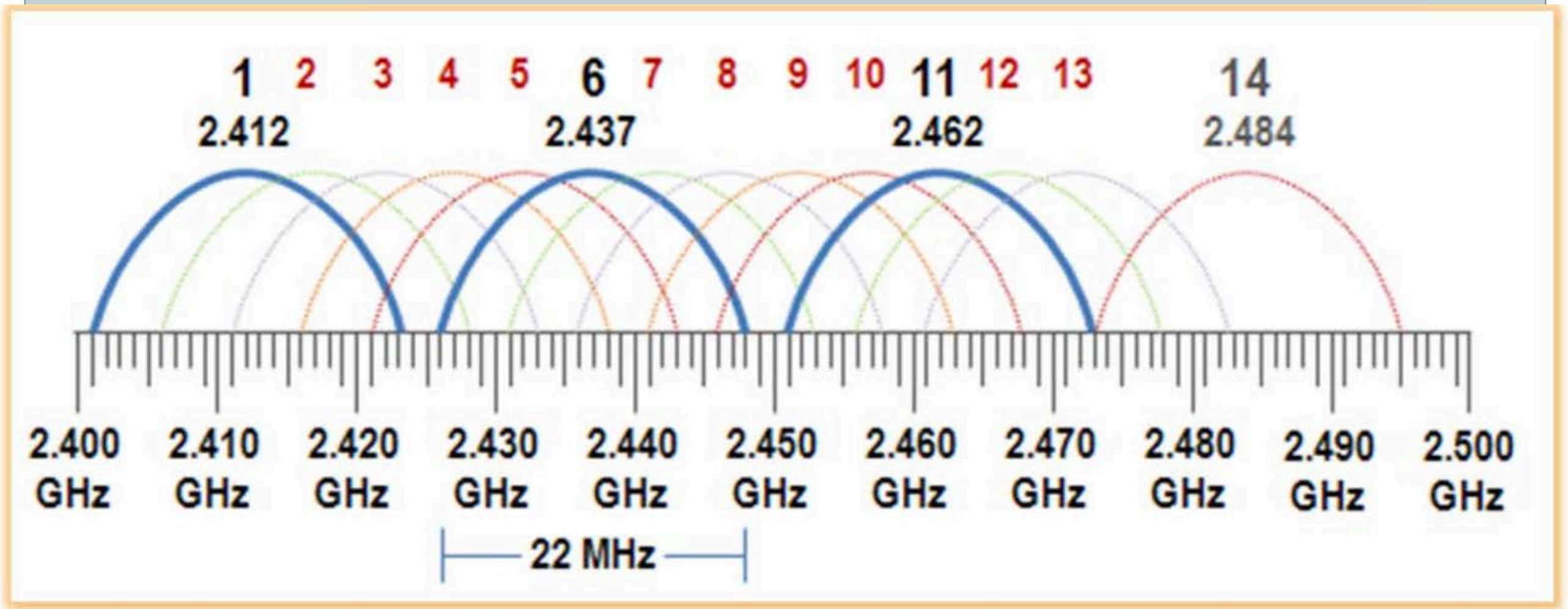
Wi-Fi service sets

Extended Service Set (ESS)

- Access points with single SSID working together to form a single network
- Enterprise is this flavor

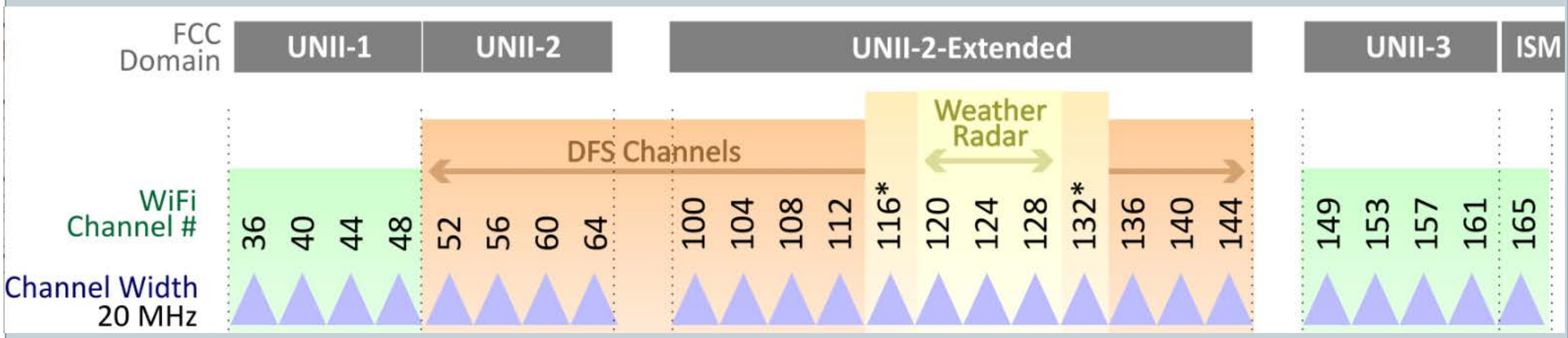


Wi-Fi Channels - 2.4 GHz



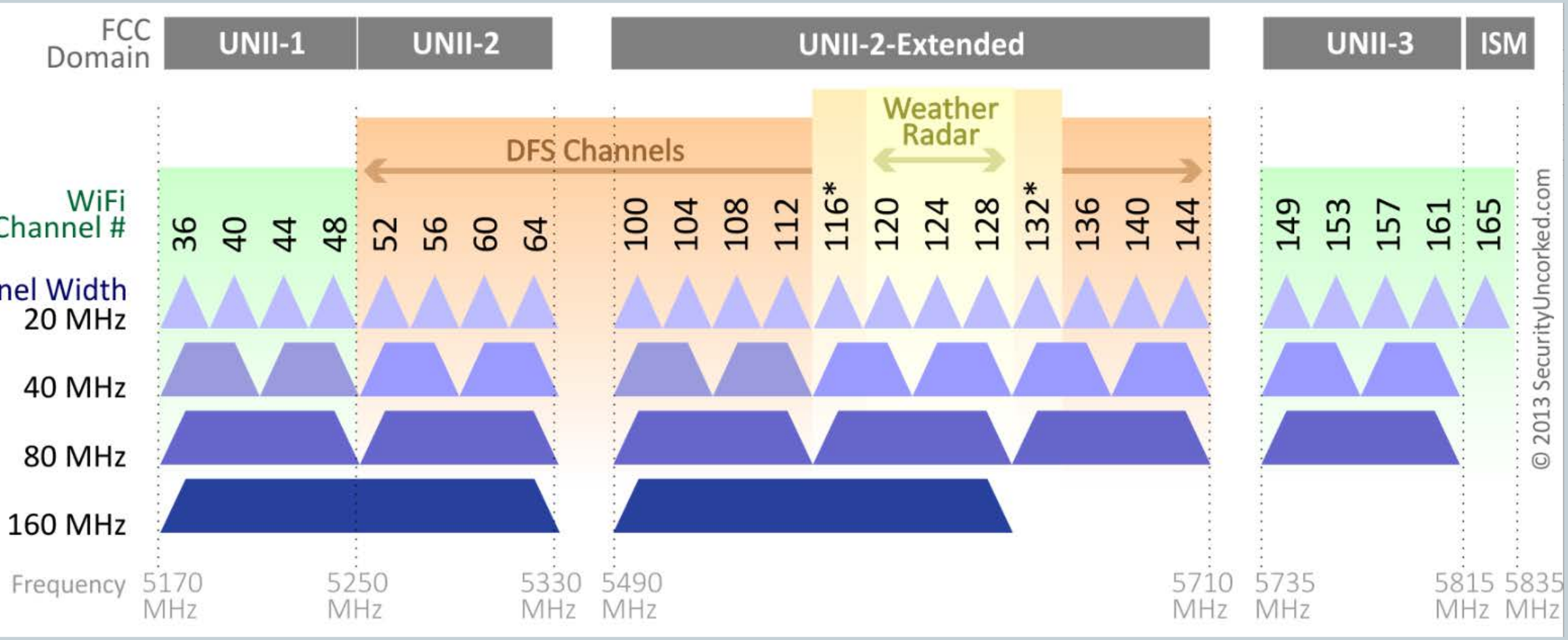
- 3 non-overlapping channels (1-6-11)

Wi-Fi Channels - 5 GHz



- More channels
- More complicated
- 9 non-overlapping regular channels
- Dynamic Frequency Selection (DFS) + 15 more

Wider Channels

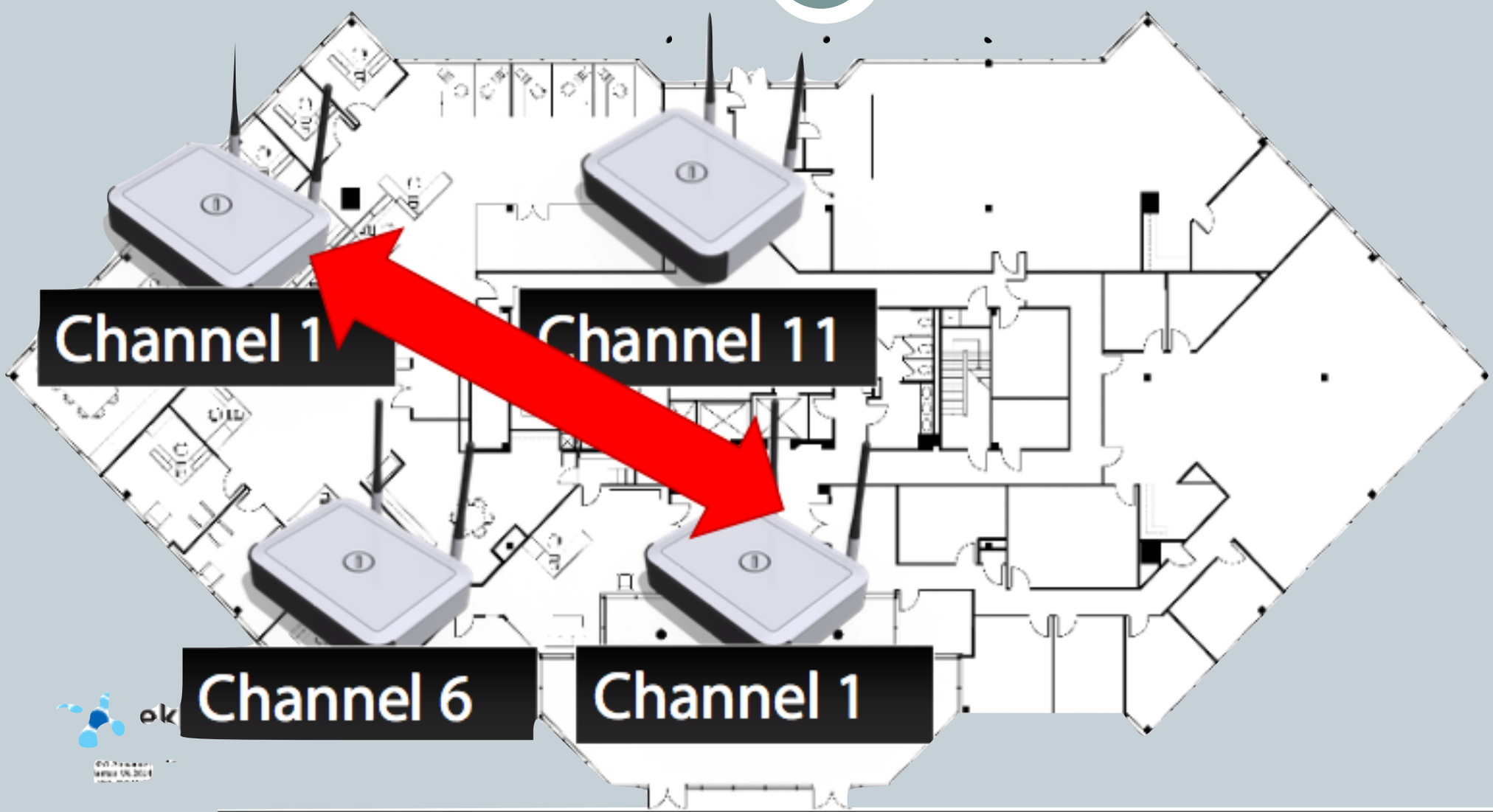


- 40 MHz added in 802.11n
- 80 MHZ added in 802.11ac
- 160 MHz added in 802.11ac “wave 2”

Why do we care?

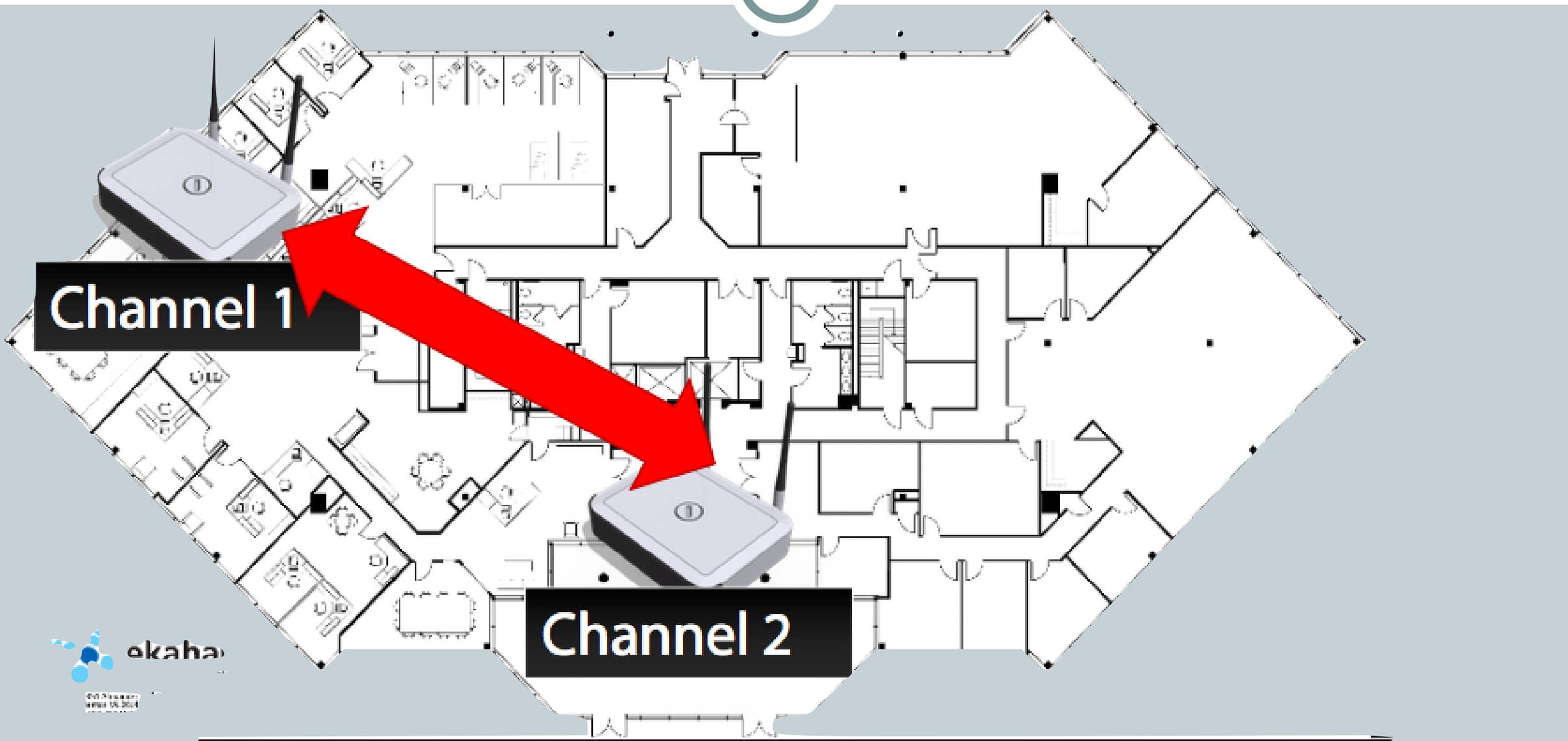
- Wide channels = more speed
- I like faster networks

Co-channel interference



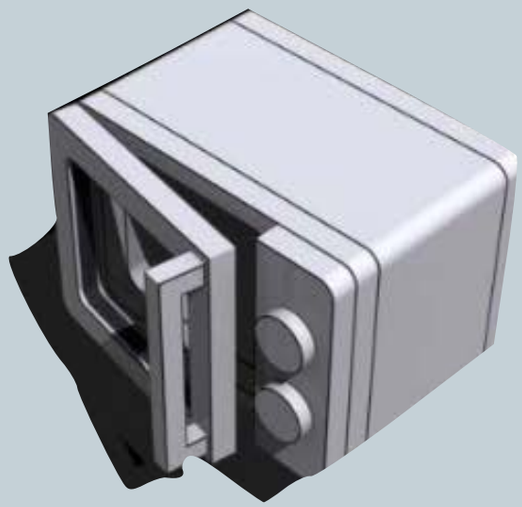
Co-Channel interference:
More than one AP audible per frequency

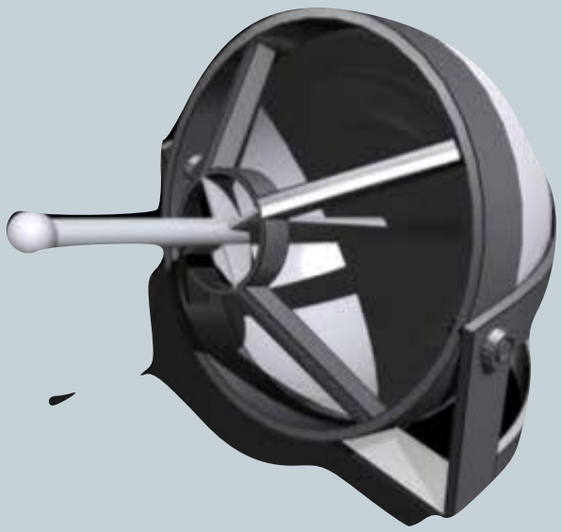
Adjacent-channel interference



Non-Wi-Fi interference

Non-Wi-Fi Interference
= The guys that don't play it nice



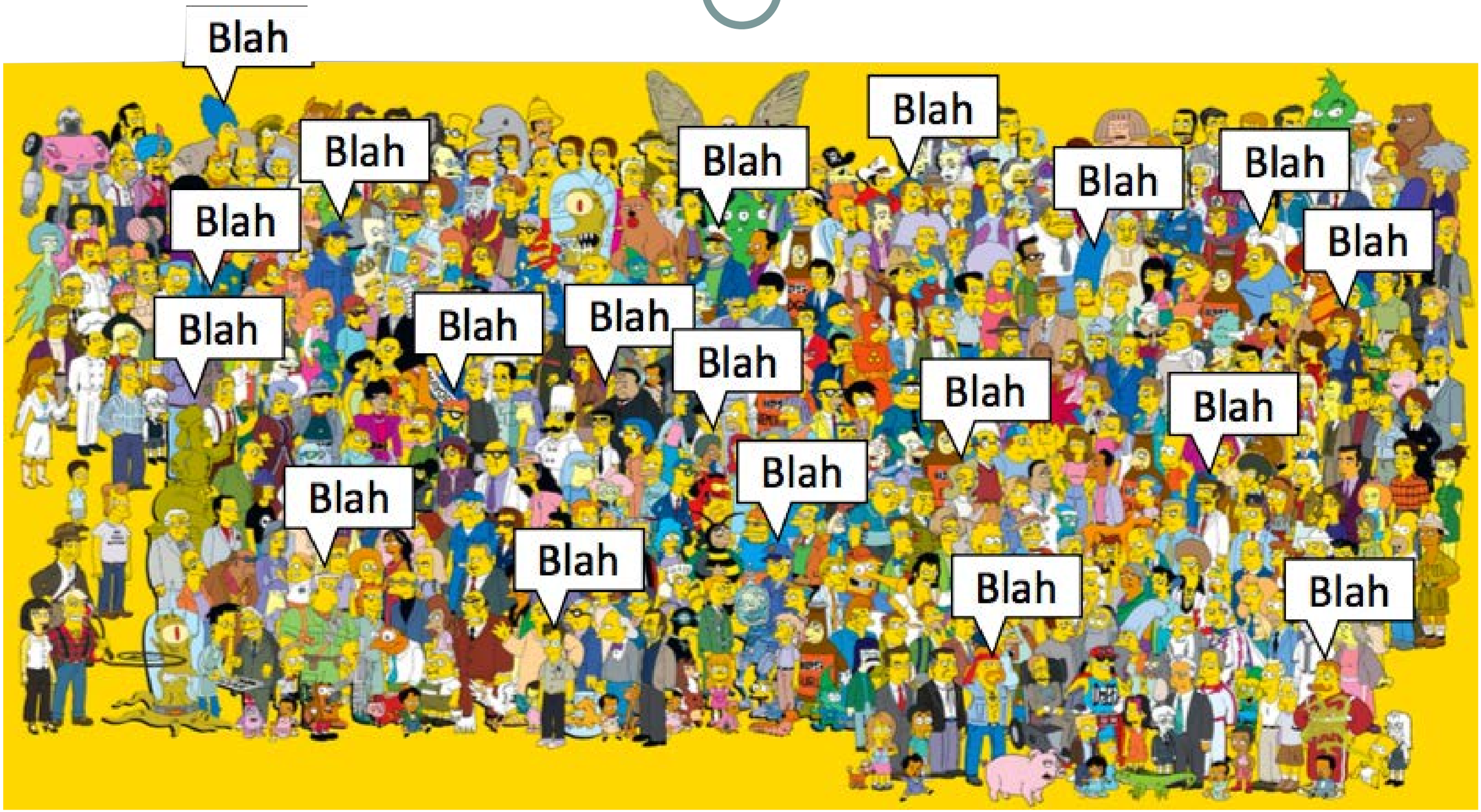


Enterprise Wi-Fi is complicated

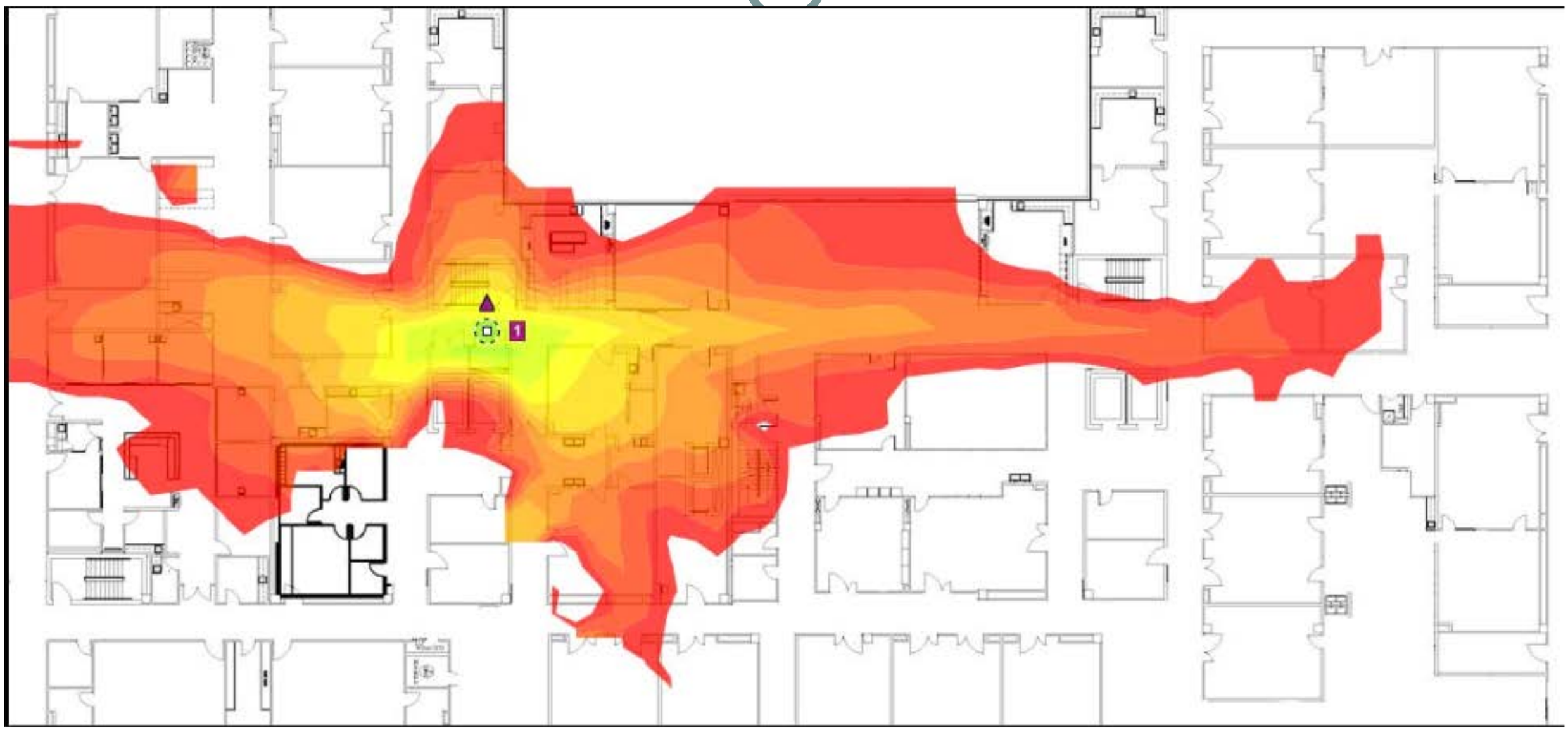
CSMA/CA

- Carrier sense multiple access with collision avoidance
- Listen
- if quiet, then talk
- if busy, back off random timer
- Listen again

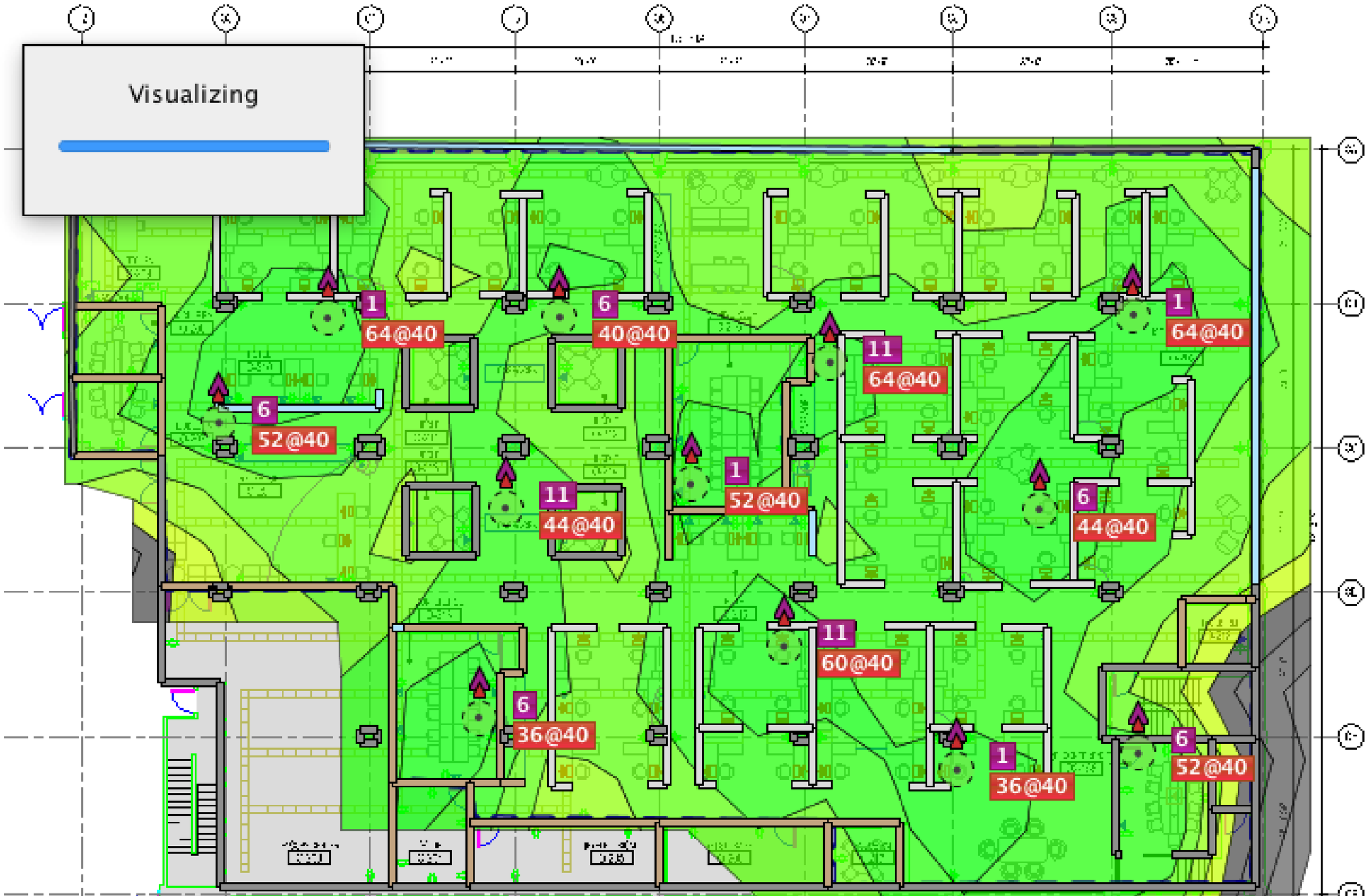
More users, more stuff = challenges



Planning for Wi-Fi coverage



Planning for Wi-Fi capacity



DEMO

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