

Making the Case for Open, Softwarized, Data-Driven 802.11 Networks

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What is the current threat

Risk of doing things the way it is now

**How a softwarized, data-driven 802.11 architecture
may drive costs down**

Emerging new markets

Enhancement of existing 802.11 business models

Creation of new 802.11 business opportunities

What is the current threat?

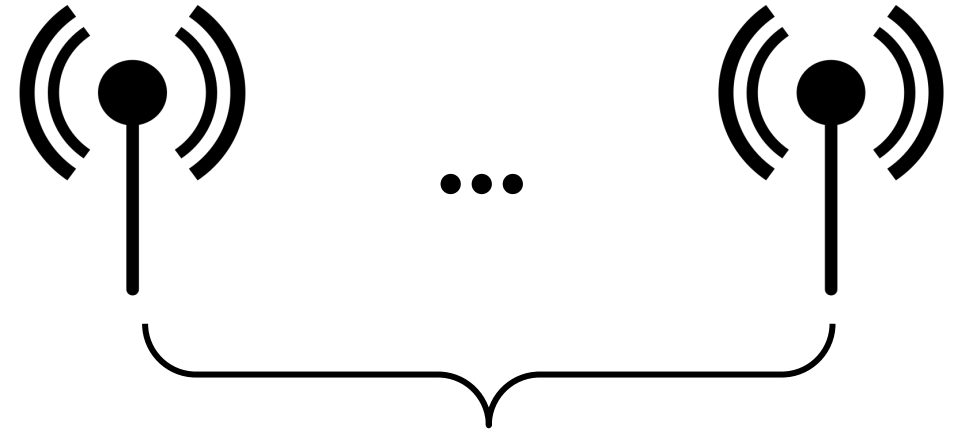
Strategy to improve 802.11 routers?

- Increase Bandwidth (2x)

160 MHz
(802.11ax)

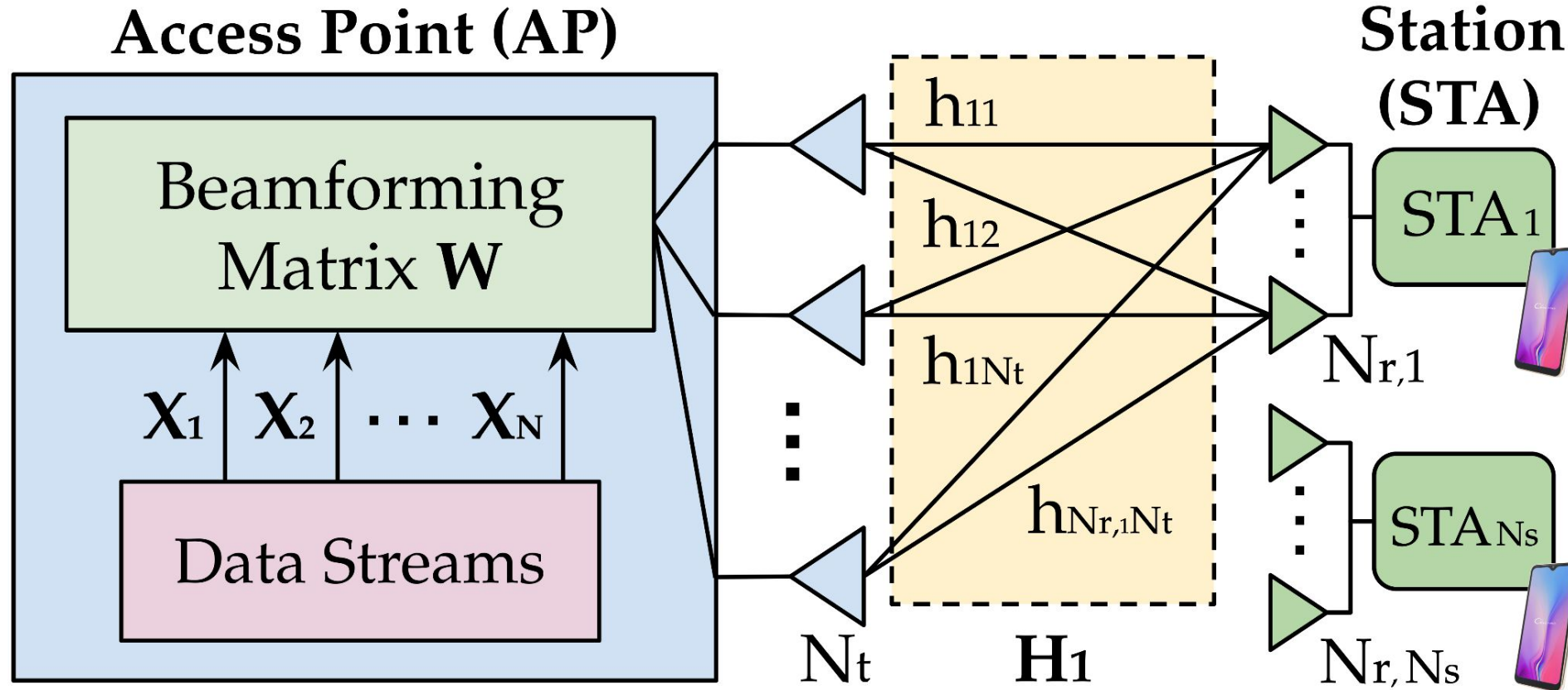
320 MHz
(802.11be)

- Increase Spatial Streams (2x)




- For better performance? Is it really needed?
- No 802.11ac routers that do 8x8 MIMO! Why?

Complexity of MIMO in Wi-Fi Systems



8 x 8 @ 160 MHz, BM report is (486 subcarriers x 56 angles/subcarrier x 16 bits/angle) ~ **54.43 KB**

If BM reports are sent back every 10 ms, the airtime overhead is **435,456 / 0.01 ~ 43.55 Mbit/s**

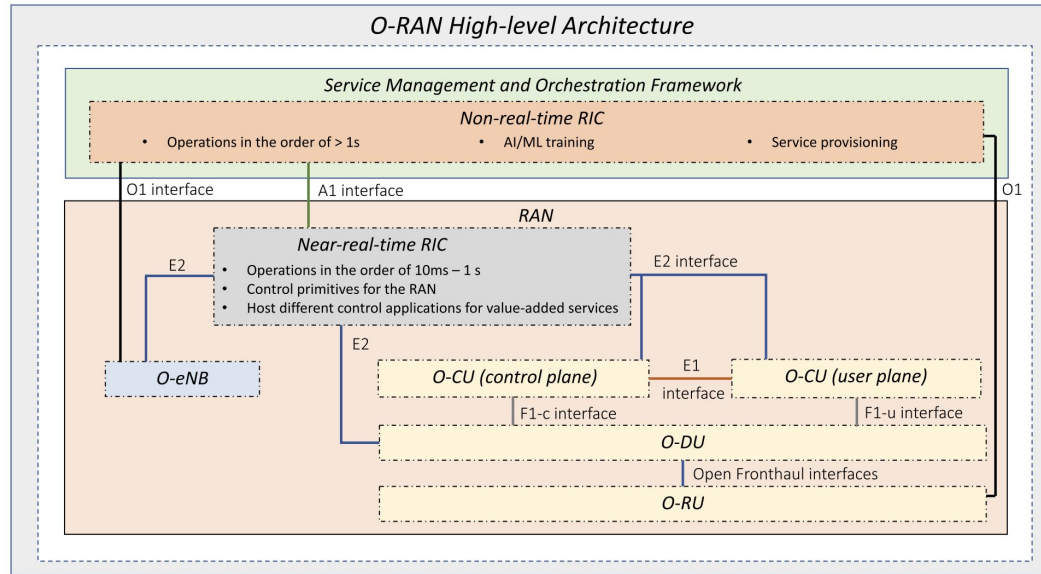
- **Increasing complexity**
 - **Makes cost go UP!**
 - **Routers are becoming very expensive**
 - **With respect to a 802.11ac router**
 - **A Wi-Fi 6E router is ~6x more expensive**
 - **A tri-band Wi-Fi router is ~15x more expensive**
- 

Ry Christ (CNET). Wi-Fi 6E routers are here, and we're not ready for them
<https://www.cnet.com/home/internet/wi-fi-6e-routers-are-here-and-were-not-ready-for-them/>

Threat:
**Fewer People Buy the
New, Fancy, Expensive Routers**

What's going on in the 5G/Cellular Community?

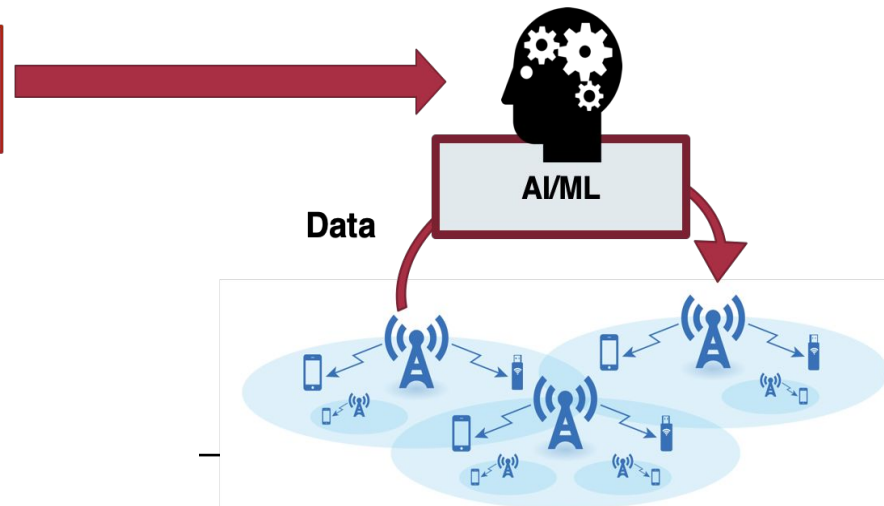
The Open RAN (O-RAN) Paradigm



(1) Disaggregation of RAN **hardware** and **software**

(2) **RAN Intelligent Controller (RIC)** operating at different granularity levels

I need to stream **4K video** to **100 users** in Times Square, NY from **8pm to 9pm**



- Control is **hardware-** and **vendor-agnostic**, so software runs in any O-RAN compliant network
- Zero-touch AI-based control is **natively supported**,
 - best performance
 - self-adaptation

Advantages of Open, Virtualized Networks

- 1. Interoperability reduces CAPEX (60%)**
- 2. Future-proof – no rip and replace infrastructure**
- 3. Easier maintenance results in reduced OPEX (65%)**
- 4. Faster deployments, higher throughput, coverage and capacity**

O-RAN market is estimated to attain a revenue of USD 419.51 Million in 2021 and USD 21,371.47 Million in 2028, CAGR of 83.1%

<https://www.researchnester.com/reports/open-radio-access-network-market/2781>

Parallel Wireless, “OpenRAN – 7 vital benefits for MNOs,” <https://www.parallelwireless.com/blog/openran-7-vital-benefits-for-mnos/>

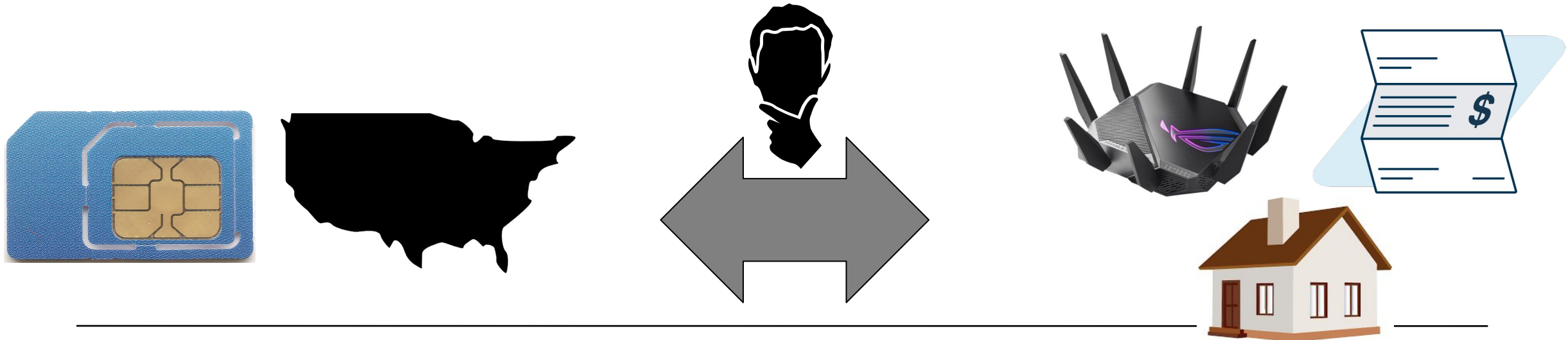
Apply the Same Concepts to Wi-Fi?

**Do more with less antennas and BW
(SW vs HW), yet more devices (unlicensed
bands!)**

**Router costs can be contained
(why? less complexity,
less maintenance costs)**

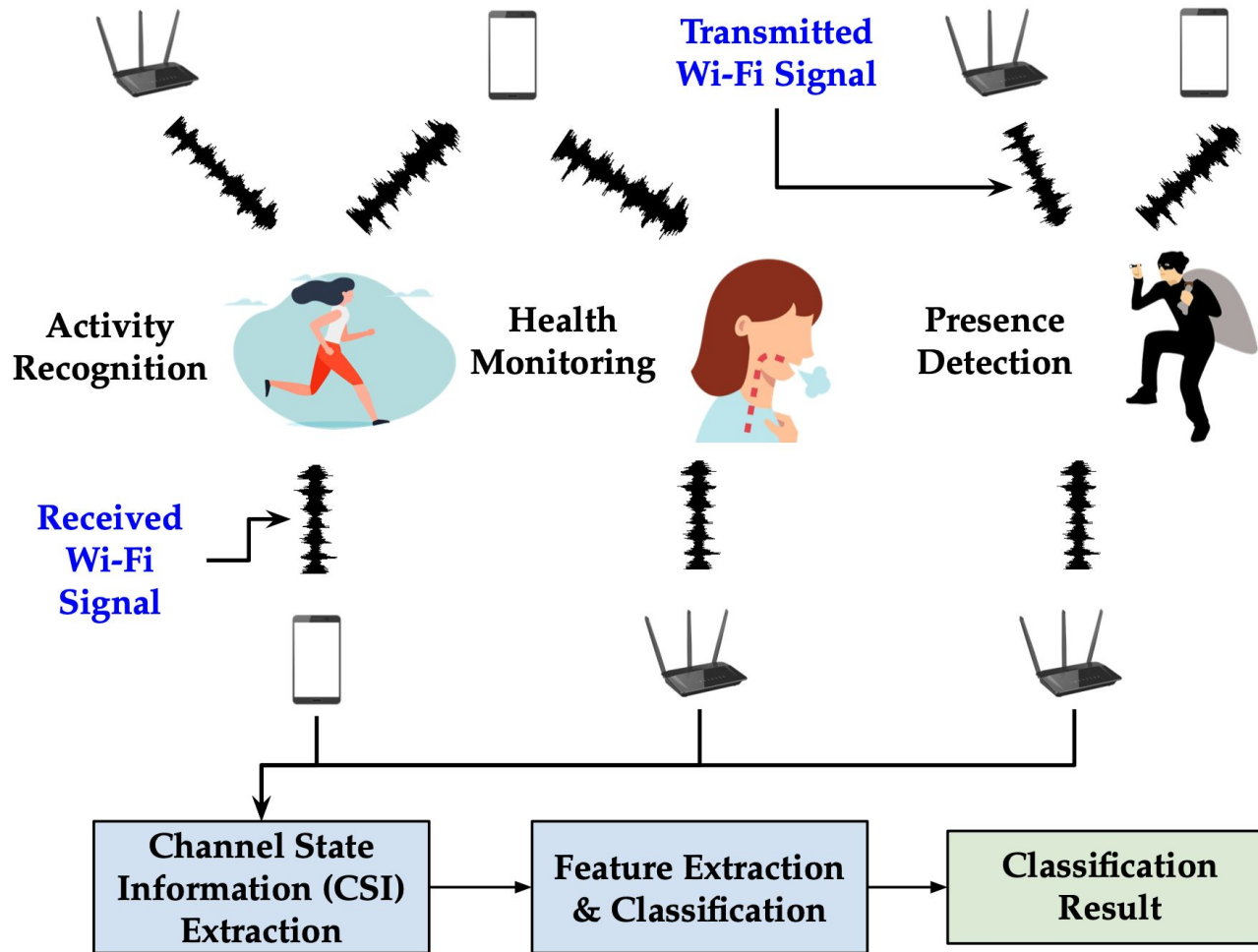
Apply the Same Concepts to Wi-Fi?

Good performance with less costs!
(People will choose 802.11
and not 5/6G networks)



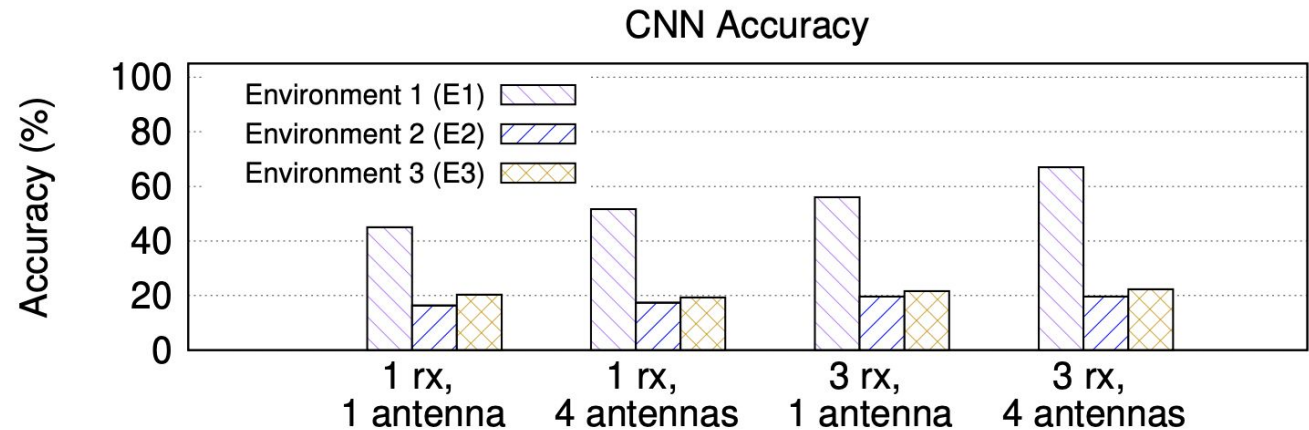
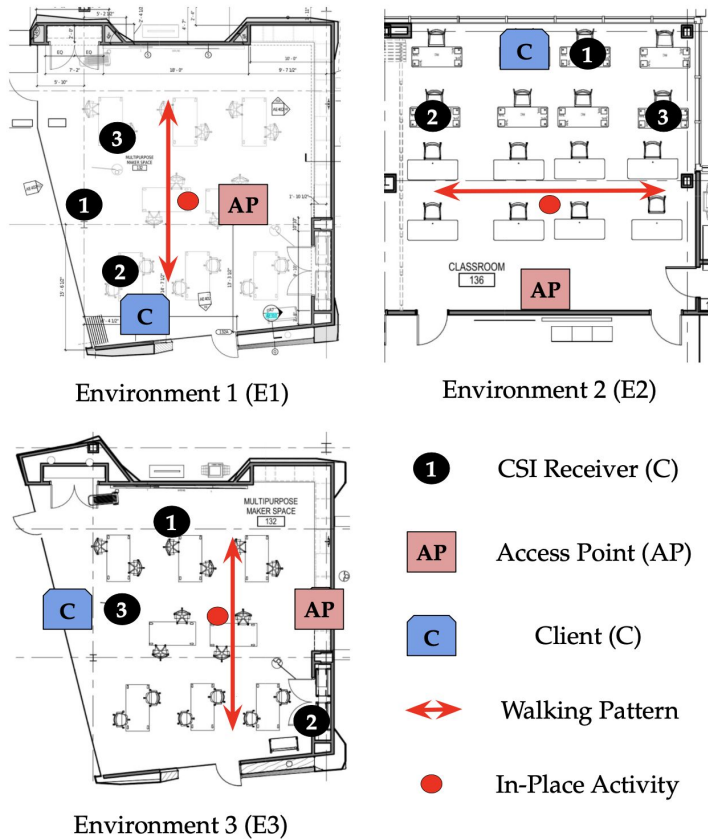
Emerging New Markets

New Market: 802.11bf



- The research community has worked on these topics for ~10 years
- First “See Through Walls With Wi-Fi!” paper in 2013
- Extreme commercial potential, that’s why 802.11bf was created

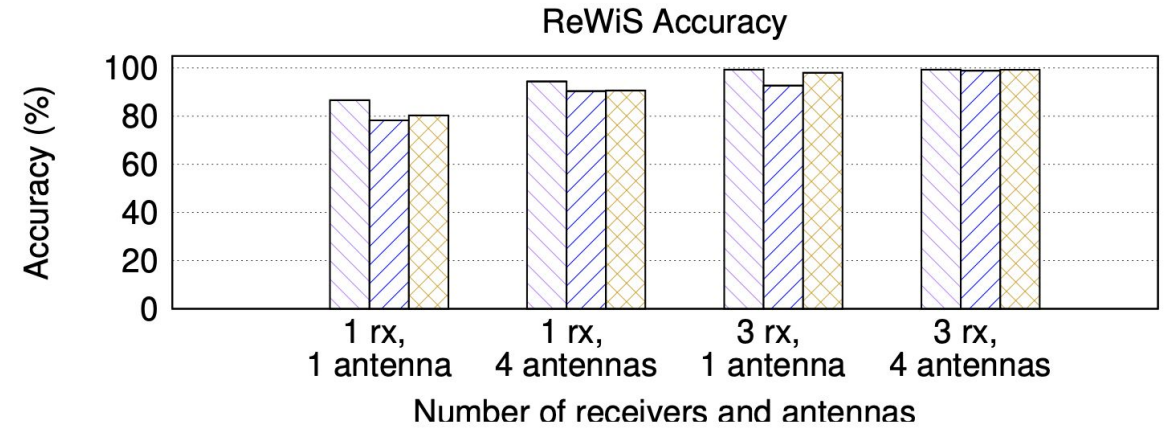
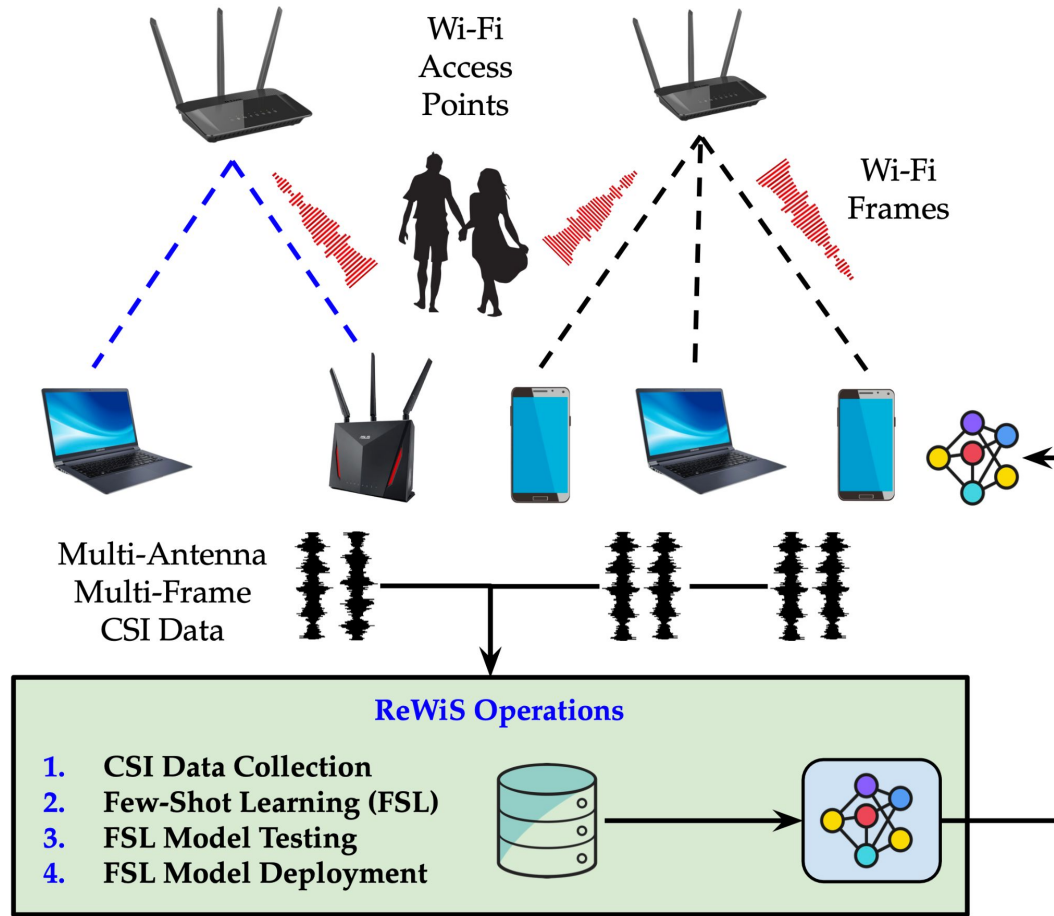
Problems: Generalization, Robustness



- **Trained and tested in different environments**
- **Performance does not generalize to different environments**
- **Clients may not buy the product if it's a one-trick pony**
- **Some Wi-Fi sensing devices have been shown to experience problems in actual deployments [1]**

[1] Christopher Null (TechHive). "Aura review: This home monitoring system is more trouble than it's worth." <https://www.techhive.com/article/583109/aura-review.html>, December 27, 2017.

Better Performance Through Cooperation



- **Through CSI fusion, we are able to generalize among different environments**
- **Ultimately, more sales because the product satisfies the customer better!**

N. Bahadori, J. Ashdown, and F. Restuccia, “**ReWiS: Reliable Wi-Fi Sensing Through Few-Shot Multi-Antenna Multi-Receiver CSI Learning,**” to appear in IEEE WOWMOM 2022. Preprint available at <https://arxiv.org/abs/2201.00869>

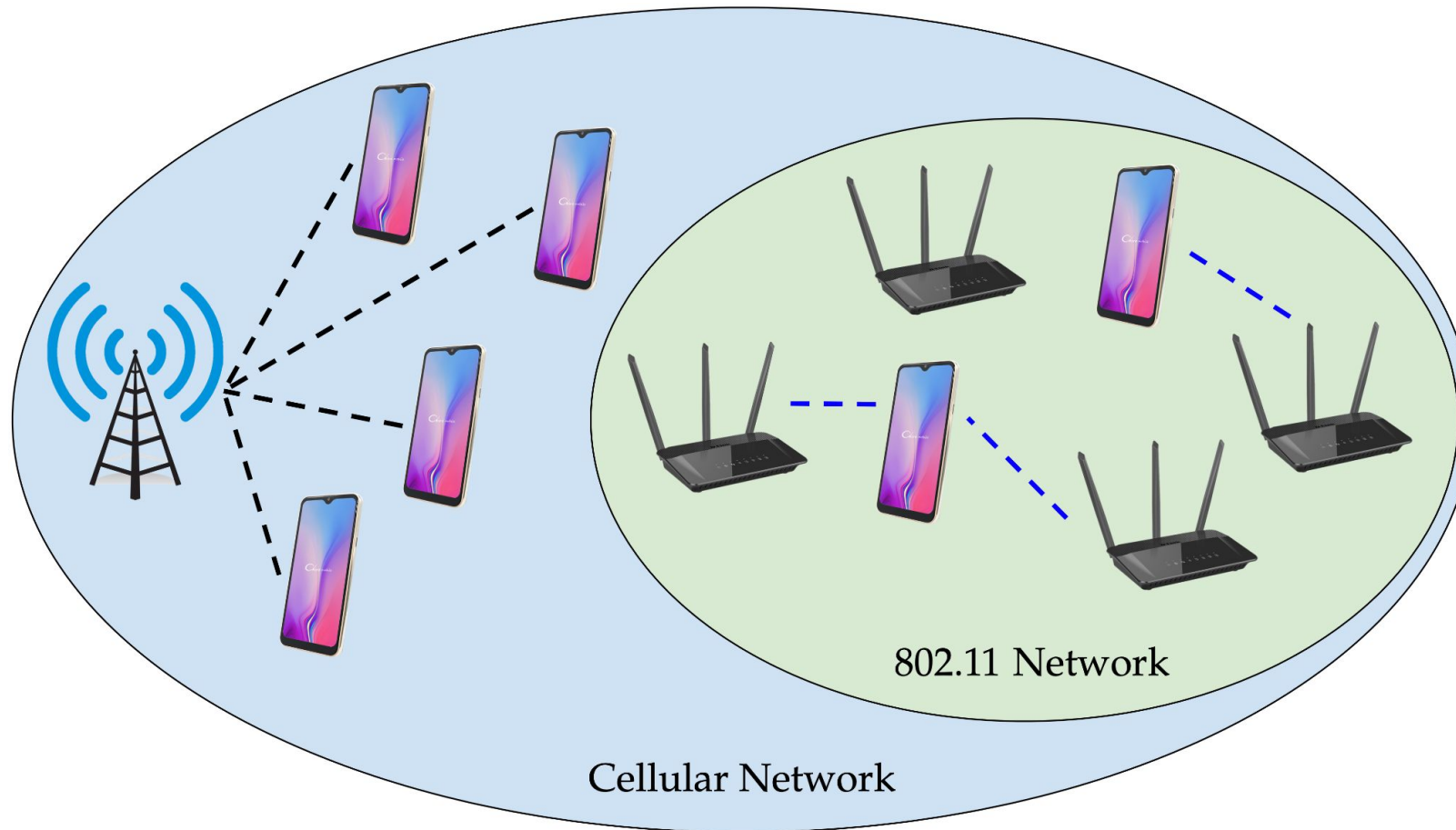
Today, it's **very hard**
to extract CSI from routers

Tool	IEEE Std	Data points/CSI
CSI Tool [4]	802.11n	30
Atheros CSI Tool [8]	802.11n	56
Nexmon CSI [3]	802.11ac	up to 4096
AX-CSI [2]	802.11ax	up to 32768

CSI fusion techniques
are not supported by today's
802.11 standards

New companies that can be centered
around CSI sensing are **hindered**

New Market: AI-Driven Wi-Fi Offloading



- 5G will offload a whopping **71%** of its traffic to Wi-Fi by 2022
- Reduces **costs** for providers, and ultimately, for customers
- Improves service, so more **customer experience** and less **churning**

Claus Hetting, Cisco VNI predicts bright future for Wi-Fi,
<https://wifinowglobal.com/news-and-blog/new-cisco-vni-numbers-predict-bright-future-for-wi-fi-towards-2022/>

New Market: AI-Driven Wi-Fi Offloading

- **Exciting business opportunity**
 - Much cheaper for MNOs than deploying femtocells
 - Wi-Fi APs are ubiquitous in indoor settings
 - Networking-as-a-Service (NaaS)

- **Killer use cases:**

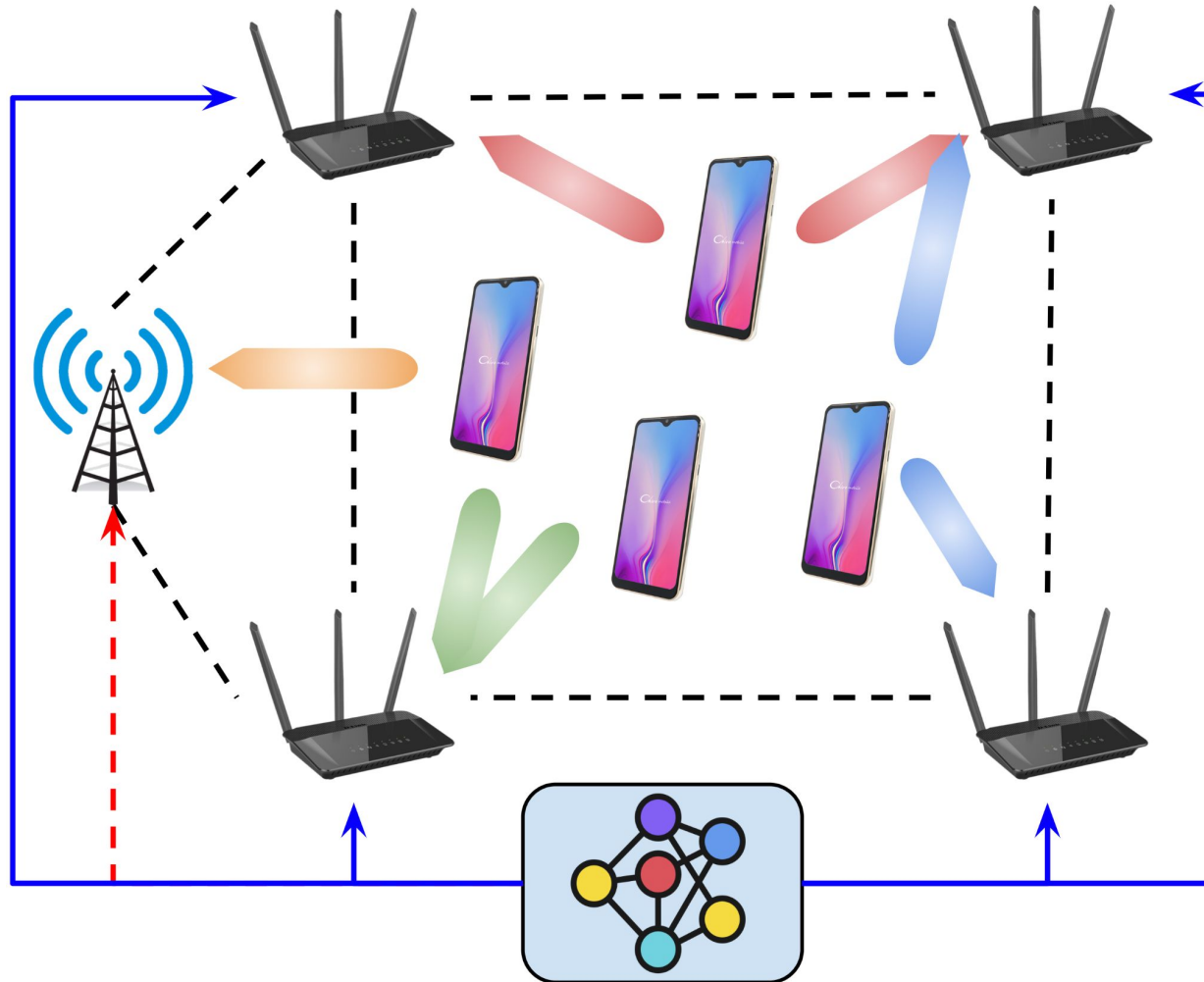
- Shopping Malls
- Stadiums
- Concerts
- ...
- Crowded Places



Problem: Wi-Fi at Scale

- **Wi-Fi is not made for many users**
 - DL MU-MIMO is limited to **8** users in 802.11ax, **4** in 802.11ac
 - Maximum of **4** SS/user in 802.11ax, **2** SS/user in 802.11ac
- **Not scalable for these applications!**
 - More antennas, more BW is **not** the solution!
 - We cannot transform an **AP in a femtocell!**
 - We need **cost-effective** solutions

Solution: Cooperative AI-Driven Wi-Fi Offloading



- Cheaper APs, but smarter (AI) and cooperative!
- Target: deploy more APs, bring complexity (and costs down)
- Sharing **spectrum** and **network information** with 5G networks

To Summarize

802 networks should adopt **open, softwarized, AI-driven strategies to remain competitive**

802 networks should learn to coexist with other technologies and **embed AI by design into their architecture**

How can the 802 RM evolve?

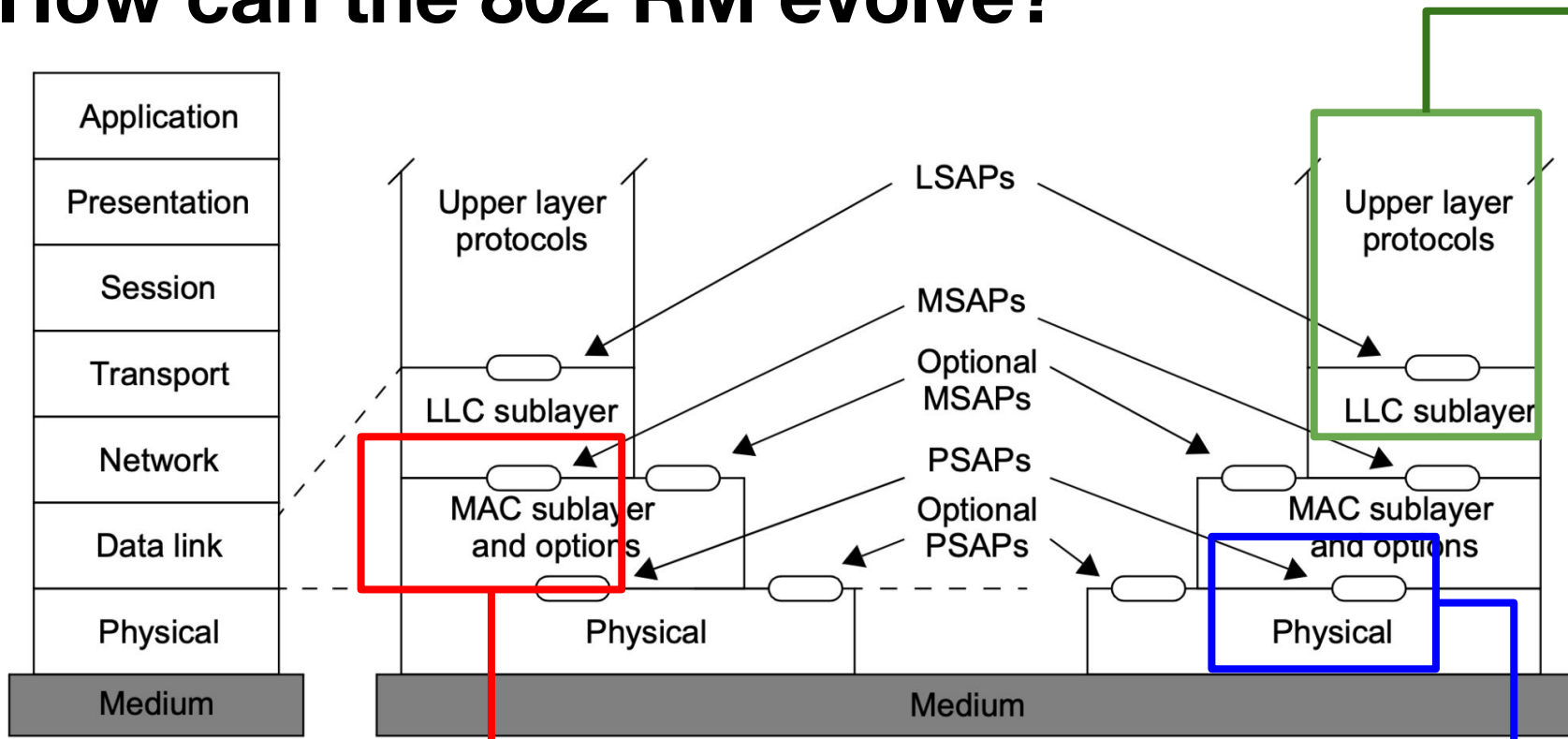


Figure 3—IEEE 802 RM for end stations

Modules and Interfaces

- **Interfaces** for MAC control & monitoring (beams, modulation, coding, etc) and channel control (CSI)

- **Modules** for distributed & centralized control of MAC/PHY,
 - for current 802 network
 - across 802 networks
 - different networks (e.g., O-RAN)
- If **centralized**, interfaces from/to central controller (e.g., AP in Wi-Fi)
- **Interfaces** for radio control & monitoring (e.g., beams, modulation, coding, etc) and channel control (e.g., CSI)

Thanks!
Questions?