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

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What is the current threat

Risk of doing things as done 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?

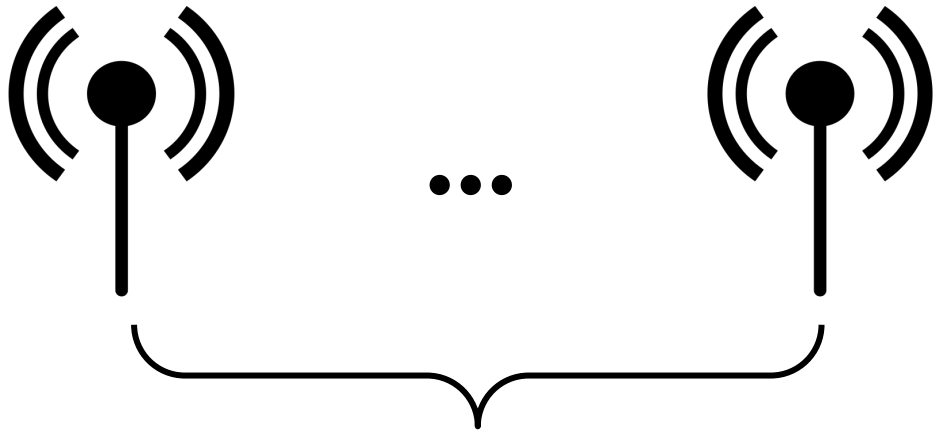
Strategy to improve 802.11 routers?

- Increase Bandwidth (2x)

160 MHz
(802.11ax)

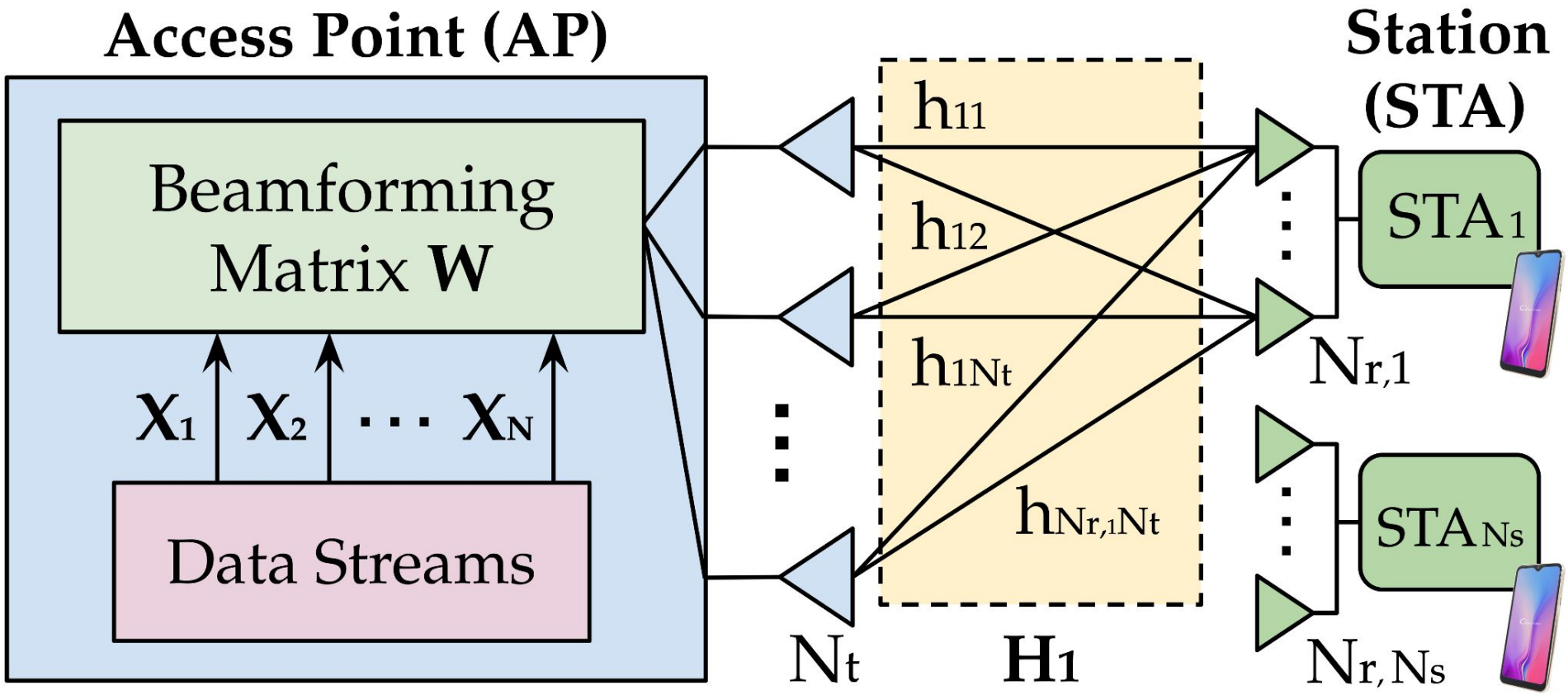
320 MHz
(802.11be)

- Increase Spatial Streams (2x)



- Does it come for free?
- 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**

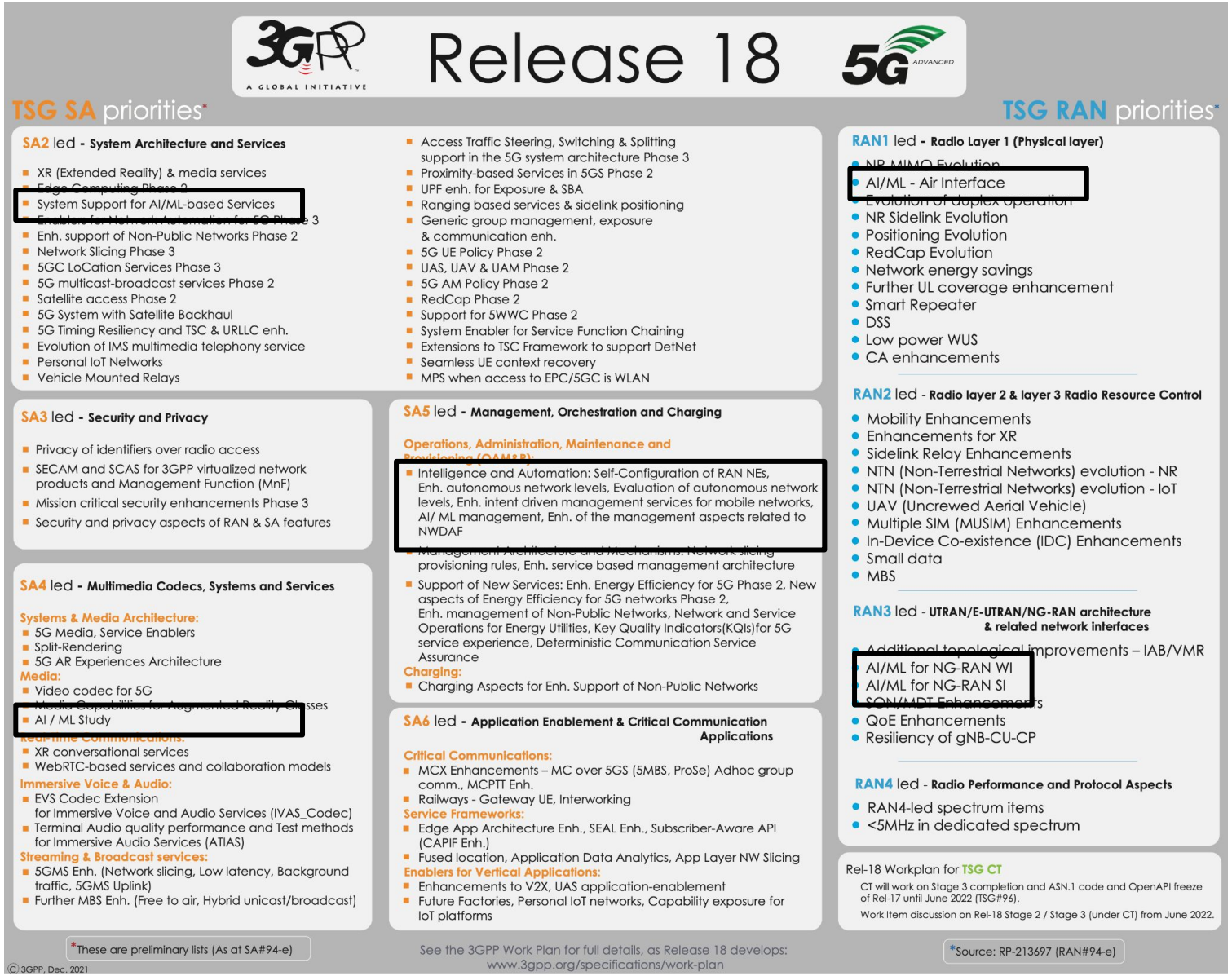
- **Increasing complexity**
- **Makes cost go UP!**

- 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

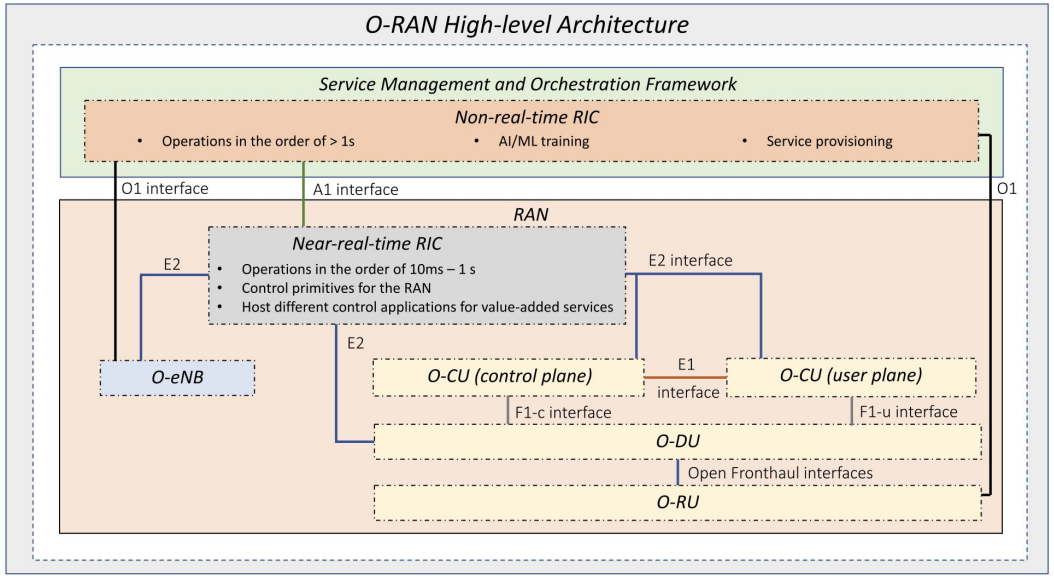
What's going on in the 5G/Cellular Community?



(1) Decided to study "the benefits of augmenting the air-interface with features enabling improved support of **AI/ML based algorithms** for **enhanced performance** and/or **reduced complexity/overhead**"

https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3983

The Open RAN (O-RAN) Paradigm

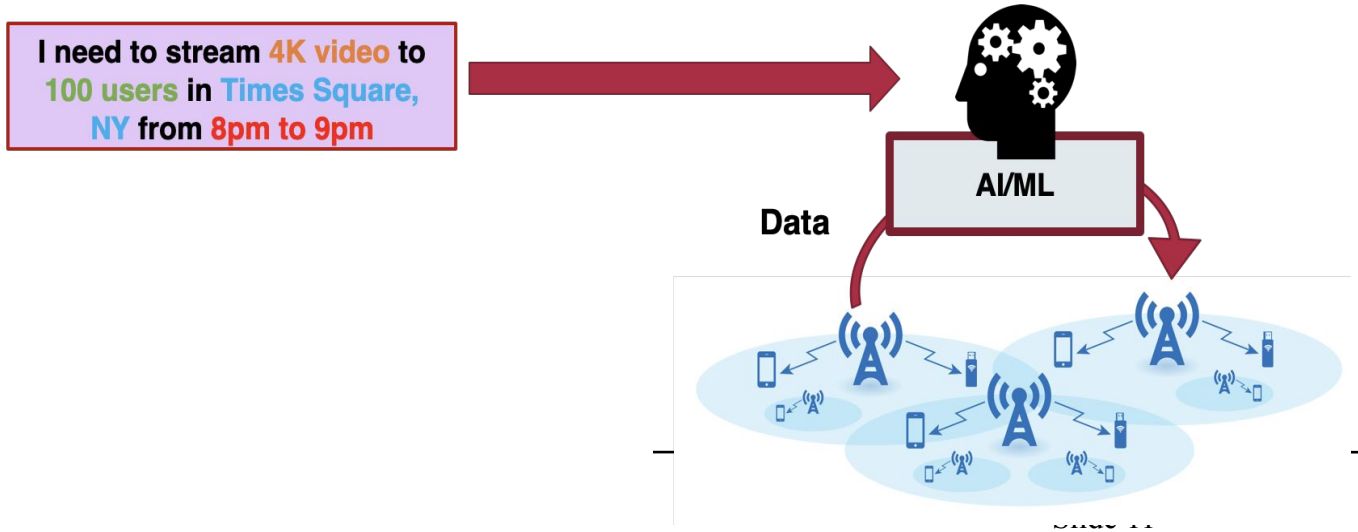


(1) Disaggregation of RAN **hardware** and **software**

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

- 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/

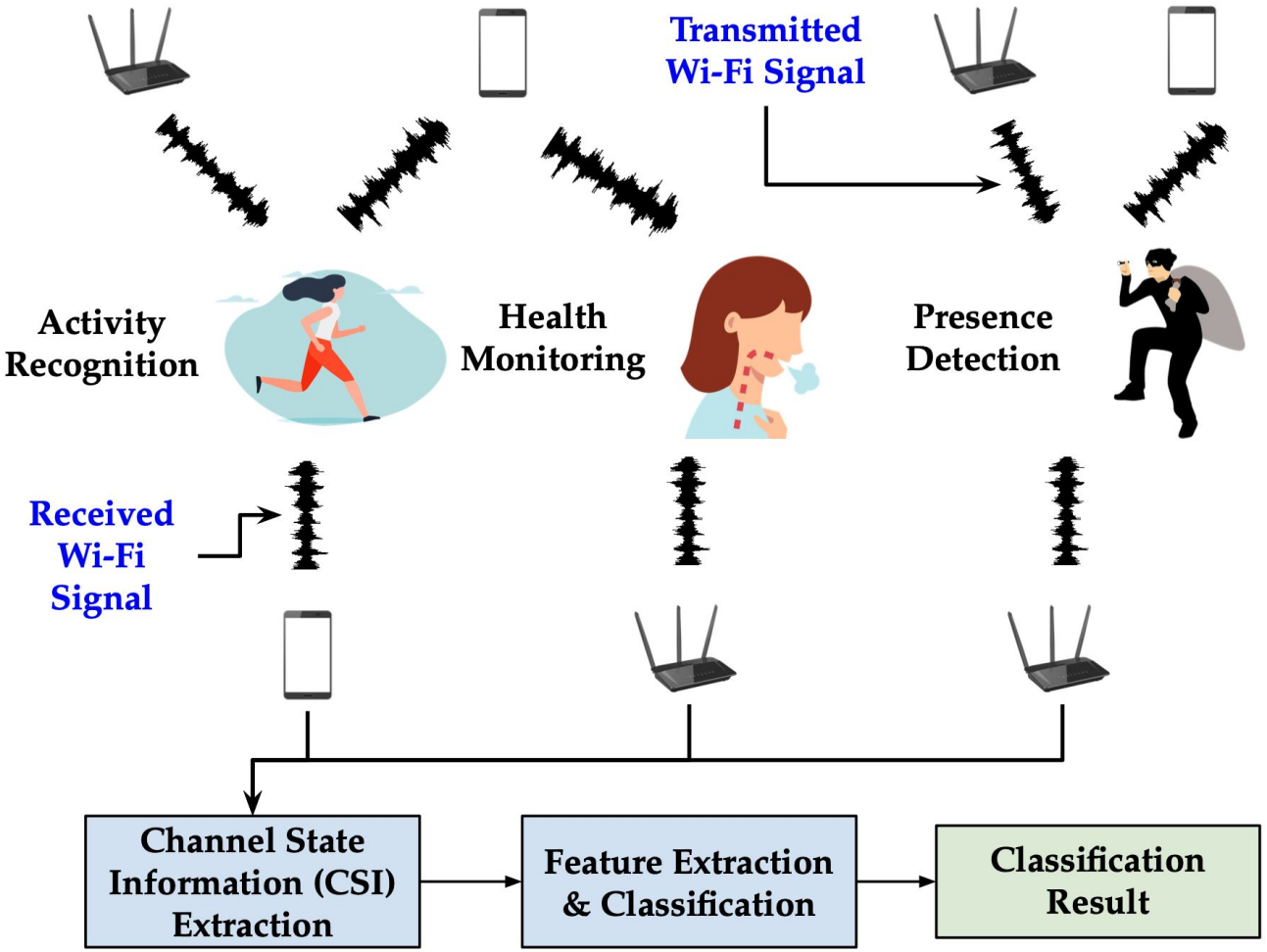
Apply the Same Concepts to Wi-Fi?

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)

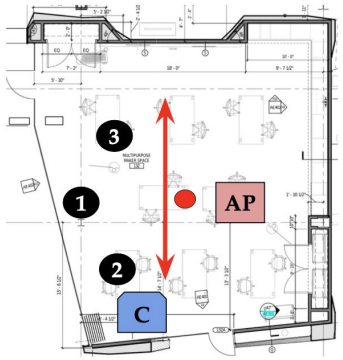
Emerging New Markets

New Market: 802.11bf

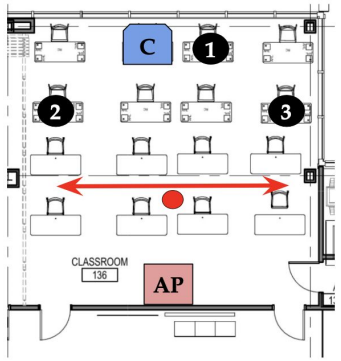


- The research community has worked on these topics for ~10 years
- First "See Through Walls With Wi-Fi!" paper in 2013
- Extreme commercial potential, that's why 802.11bf was created

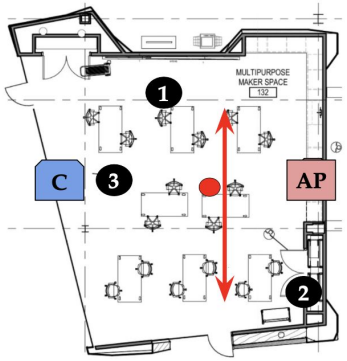
Problems: Generalization, Robustness



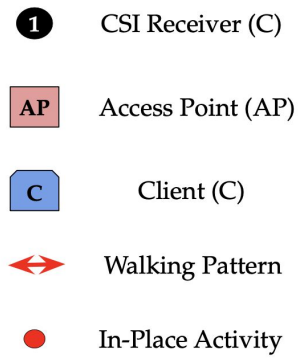
Environment 1 (E1)

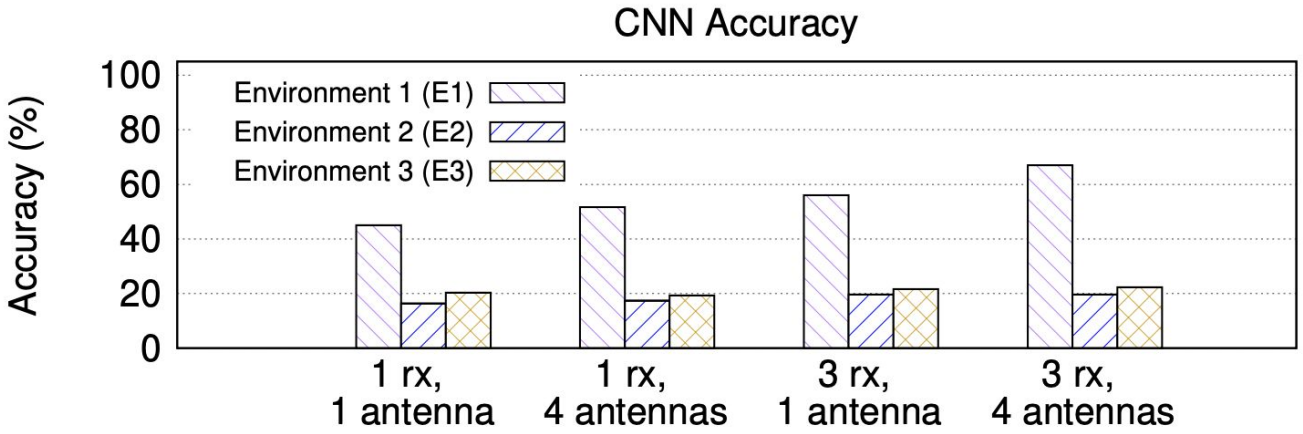


Environment 2 (E2)



Environment 3 (E3)

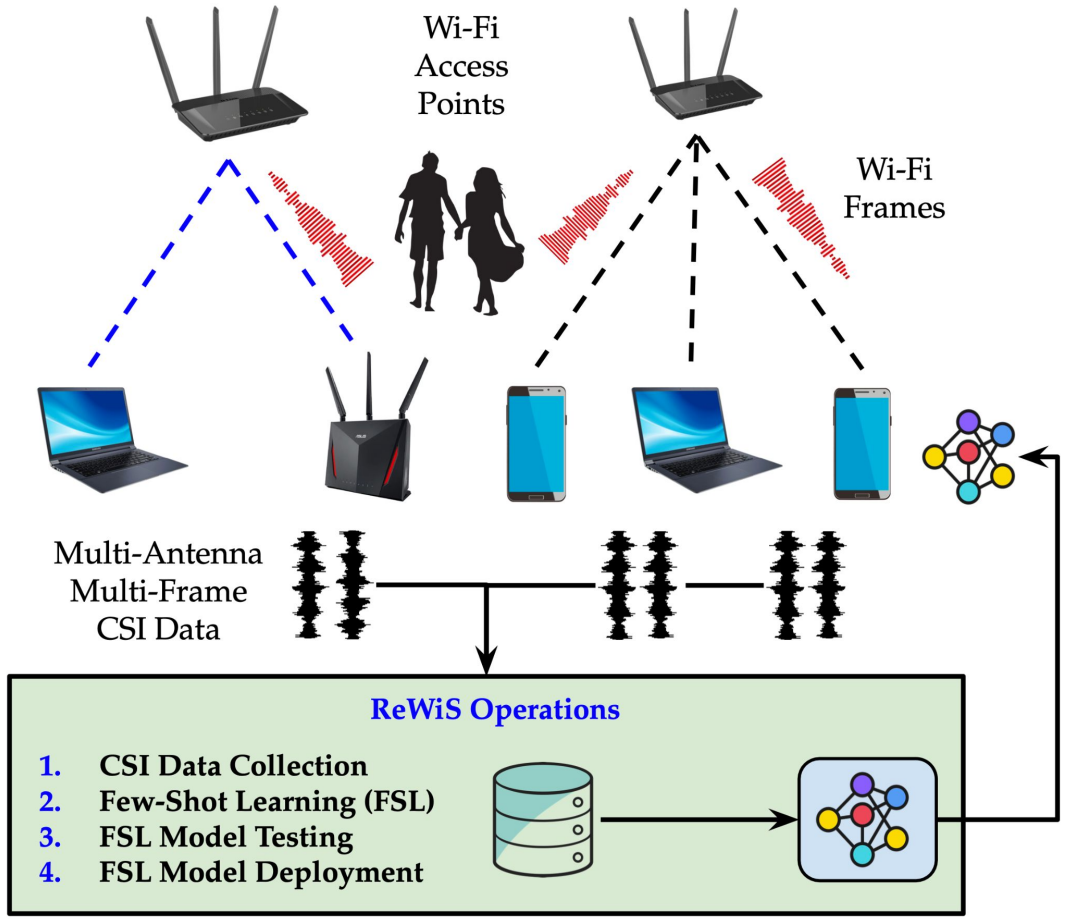


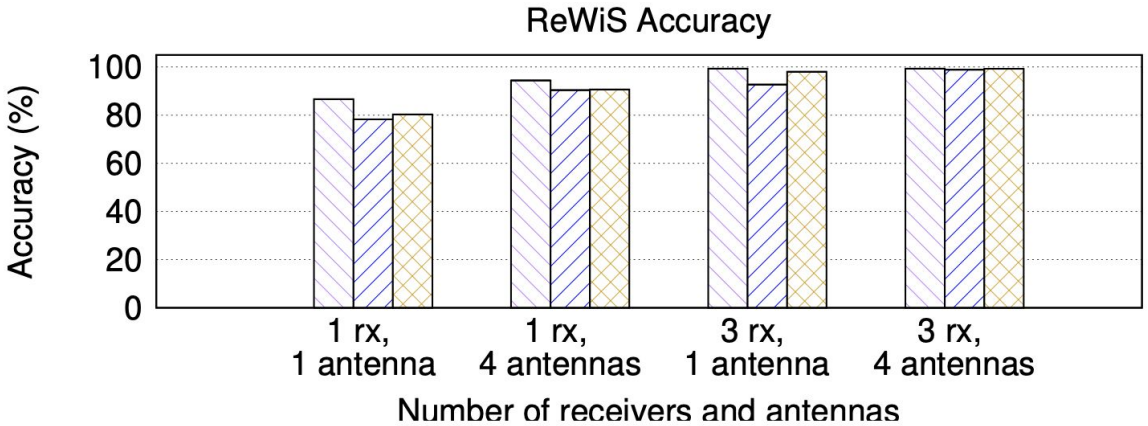


- Trained and tested in different environments
- Performance does not generalize to different environments
- Clients may not like the product
- Some Wi-Fi sensing devices have been shown to experience problems in actual deployments [1]

[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

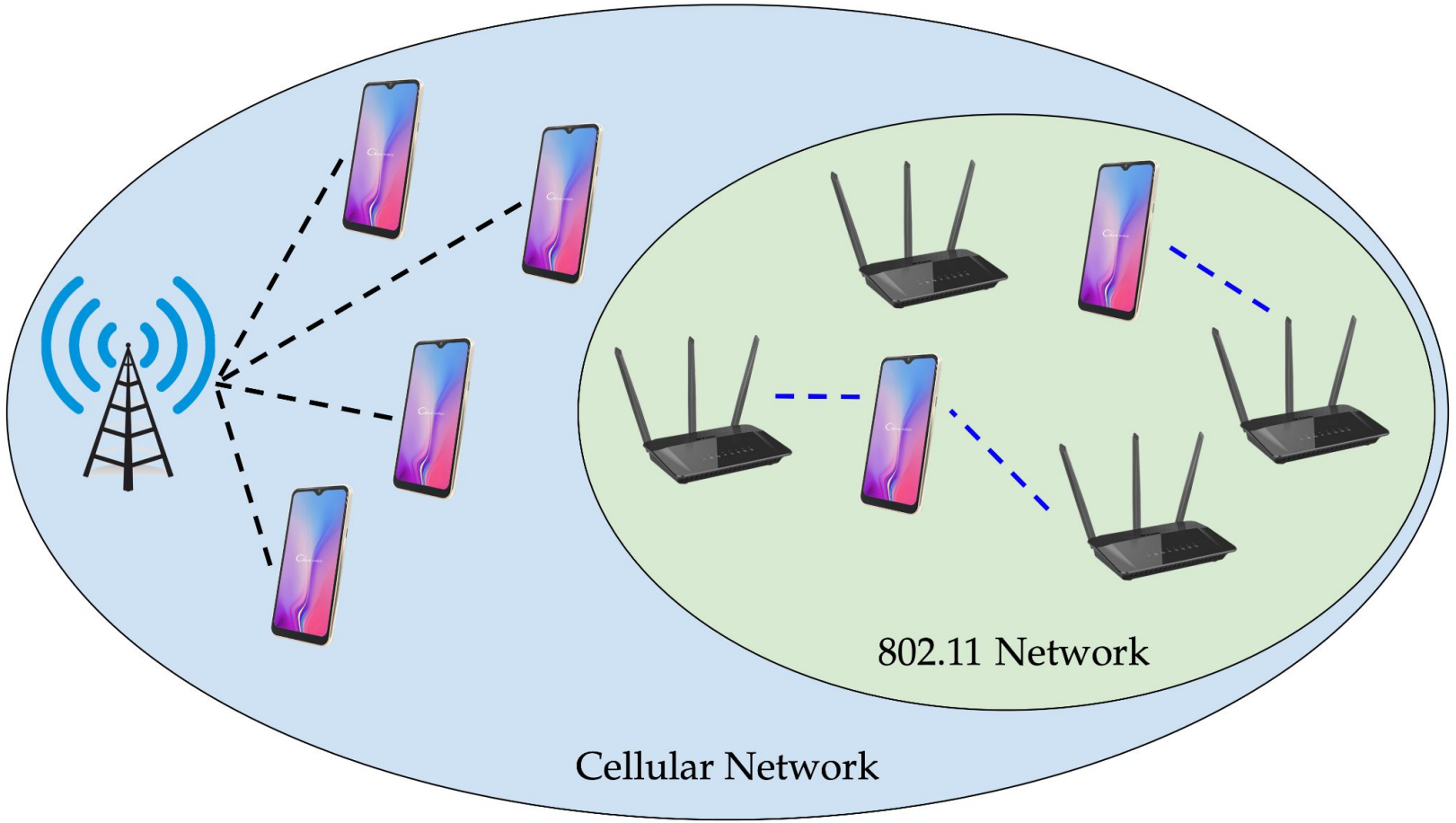
Reality: Today, it's **very hard** to extract CSI from routers

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)

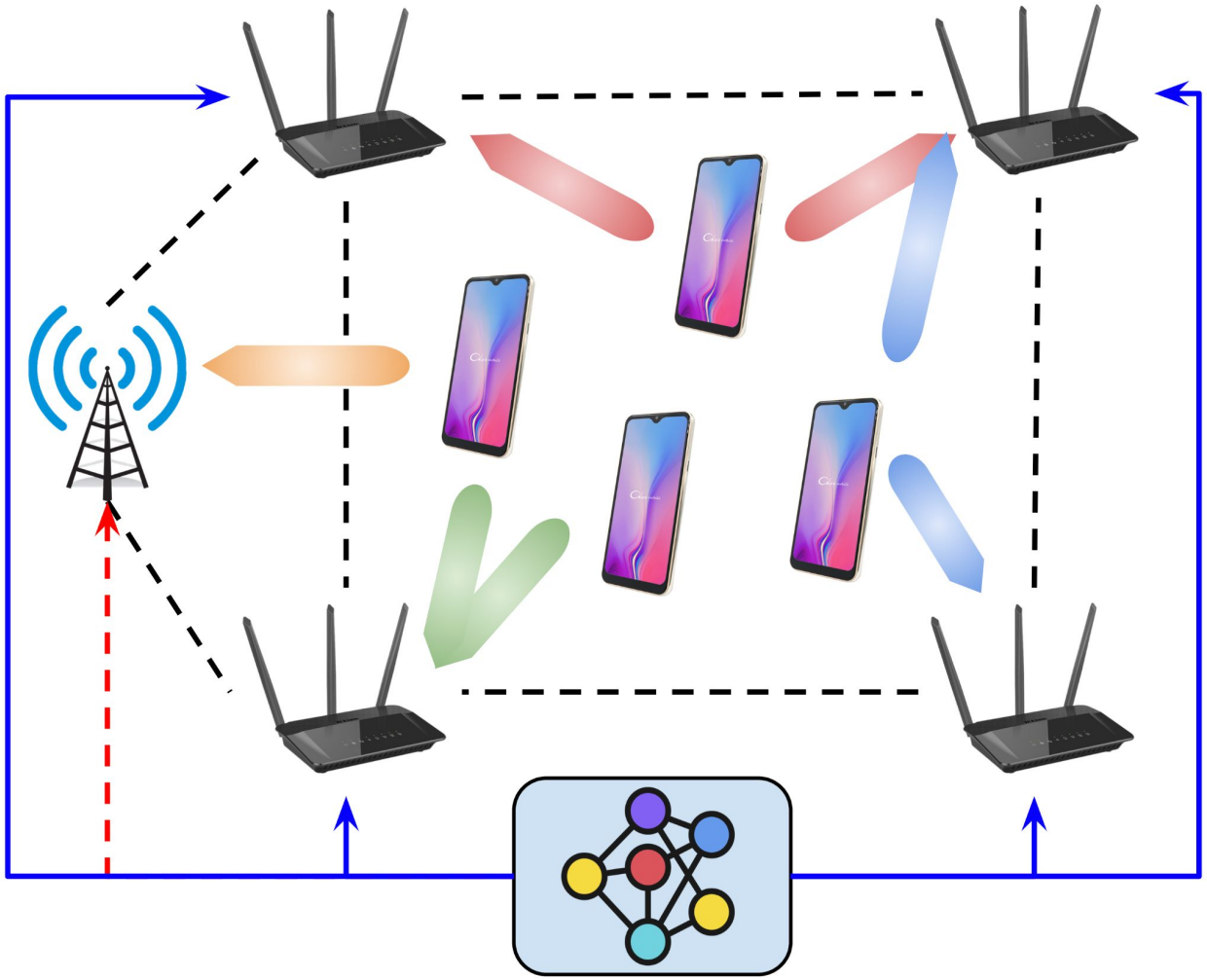
- **Killer use cases:**
  - Shopping Malls
  - Stadiums
  - Concerts
  - ...
  - Crowded Places

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** is 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

Straw Poll

Do you support the creation of a TIG to:

a. describe use cases for AI/ML applicability in 802.11 systems

b. investigate the technical feasibility of "features enabling support of AI/ML based algorithms in the 802.11 MAC/PHY"

Thanks!
Questions?