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

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<tbody>
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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)

  ![Diagram showing two antennas]

- 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) \sim 54.43 \text{ KB}
If BM reports are sent back every 10 ms, the airtime overhead is \frac{435,456}{0.01} \sim 43.55 \text{ 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 $\sim 6x$ more expensive
  • A tri-band Wi-Fi router is $\sim 15x$ 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”

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

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 like the product
- Some Wi-Fi sensing devices have been shown to experience problems in actual deployments

[1] Christopher Null (TechHive). “Aura review: This home monitoring system is more trouble than it’s worth.”
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!
Reality: Today, it’s very hard to extract CSI from routers

<table>
<thead>
<tr>
<th>Tool</th>
<th>IEEE Std</th>
<th>Data points/CSI</th>
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<tbody>
<tr>
<td>CSI Tool [4]</td>
<td>802.11n</td>
<td>30</td>
</tr>
<tr>
<td>Atheros CSI Tool [8]</td>
<td>802.11n</td>
<td>56</td>
</tr>
<tr>
<td>Nexmon CSI [3]</td>
<td>802.11ac</td>
<td>up to 4096</td>
</tr>
<tr>
<td>AX-CSI [2]</td>
<td>802.11ax</td>
<td>up to 32768</td>
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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

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.
How can the 802 RM evolve?

- **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)

**Modules and Interfaces**

*Figure 3—IEEE 802 RM for end stations*
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?