Advisory

Converging WiFi6 Signals: Arms-Length Transactions Establish Royalty Ranges

A Comprehensive Market-Based Analysis of a Series of Transactions Reflecting the Value Created Via Wide-Spread Innovation and Standardization Efforts

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Tech+IP, an independent market maker in IP transactions (www.techip.cc), conducted a market-based analysis of the economic value of Wi-Fi 6. We followed the same transparent, in-depth approach as in our prior reports on 4G/5G, ADAS, MPEG-H 3D Audio, HEVC, and other Standard Essential Patent ("SEP") technologies, working for the past 12 years with leading patent owners, implementers, institutes, investors, and their advisors.

Wi-Fi 6 (IEEE 802.11ax) represents a significant technological advancement, enabling the creation of billions of dollars in new market value. Licensing its use warrants a corresponding fair valuation to be paid to the inventors. Additional conclusions include:

- Wi-Fi 6 represents a significant technological improvement over previous versions, especially Wi-Fi 4, and is a leap forward in terms of throughput, operation in "dense" environments, networking, and quality of user experience, all critical for today's consumer and enterprise demands.
- The depth and breadth of Wi-Fi 6's stakeholder support, market adoption, and dramatic daily usage globally is incontrovertible evidence of its overall value to the ecosystem.
- The development of Wi-Fi 6 followed the traditional multi-party, multi-year process but featured significantly deeper innovation, more contributors, and broader technical debates than any previous generation. This resulted in both fundamental and incremental advancements. While most of the technology development is complete, the patent estate for Wi-Fi 6 continues to evolve and expand, as is the case in any standardized technology.
- There is a noticeable recent trend where large implementers often advocate for new technology adoption early on, but later resist paying fair royalties to inventors. They increasingly use post-hoc attacks on the innovation's depth and patent enforceability to underpay those who developed the technology. This frequently leads to "fabricated" disputes, adoption delays, and higher costs, which ultimately reduce investment in future innovations. In the end, this inefficiency affects all stakeholders, with consumers bearing the brunt through higher costs and delayed access to new technologies.
- Market-based analysis of Wi-Fi 6 value is possible even though there is no universally accepted methodology for counting the number of patents in the Wi-Fi 6 "SEP patent stack" across the industry. Royalty rates across transactions converge, despite many conflicting publicly available patent landscape reports. They each, separately, likely overestimate or underestimate the total SEP stack. But the market discovered the vaAs one lue.
- We estimate that the **aggregate royalty value** for the universe of SEPs to implement the full capabilities of Wi-Fi, including up to Wi-Fi 6/6E is **not less than $6.40 per device.**
- One of the several reasonableness checks we conducted **compared cellular technology with Wi-Fi** and concluded that the aggregate royalty value for Wi-Fi, given the similarities and complementary use cases, could reasonably be **at least $7.00 per consumer end device (e.g., smartphone).**
- Our findings further suggest that our calculated aggregate royalty value correlates with device types, included functionalities and prices.

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Economic Analysis of Wi-Fi 6 Market and Arms-length Transaction Data:

In the case of Wi-Fi 6 today, after much licensing delay and posturing by some large implementers, the market has evidenced a converging series of independent, arms-length transactions and litigation outcomes globally. These data points serve as a more reliable, post-hoc, price-discovery mechanism for reasonable royalties than most theoretical economic analyses.

In general, our analysis re-evaluated existing patent landscapes and economic assessments, followed by an in-depth analysis of relevant market and transaction data from multiple perspectives.

We first estimated the range of royalty stack values for Wi-Fi 6 using a "bottom-up" approach, starting with publicly available data from licensing agreements, damages awards, and patent pools. This approach aimed to determine the patent royalty value for different types of devices. Next, we adjusted implied rates for real-world factors such as FRAND constraints, existence of non-monetized patents, and others as typically negotiated between licensors and licensees.

Next, we looked at the role of Technical Standards in:

- Technology improvement: Evaluating contributions, key features, and implementers' marketing, as well as public statements regarding standards as evidence of value for implementers.
- Meeting market demand: Analyzing market adoption, trends, forecasts, and price trends to show value from the end users' perspective.

Finally, we performed a series of "reasonableness checks" which we define as:

- Applying royalty rates to the potential Wi-Fi 6 patent landscape.
- Examining Wi-Fi standards patents expiration data.
- Doing a comparison to 4G/5G technology.
- Considering the impact of shifting IEEE IPR policies.

We followed our standard, "best practices" framework for determining value, checking the reasonableness of our estimates, and providing helpful industry context, which includes:

1) Technical observations
2) Market analysis observations
3) Royalty rate analysis
4) Wi-Fi economic value based on a "bottom-up" approach
5) Reasonableness check using a "top-down" approach
6) Shifting IEEE intellectual property rights policies

1) Technical Observations

The development of the IEEE 802.11ax standard was a highly collaborative, extended, and synergistic process between academia and industry, resulting in greater contributions and involvement compared to previous IEEE 802.11 standards, with the number of contributions to this standard nearly matching the combined contributions of the previous two Wi-Fi versions.

Technological advancements and market needs have propelled the development of Wi-Fi 6. Notably, certain solutions that were originally implemented in cellular technology have now been integrated into Wi-Fi 6. Wi-Fi 6/6E represents a significant leap from previous generations. Features

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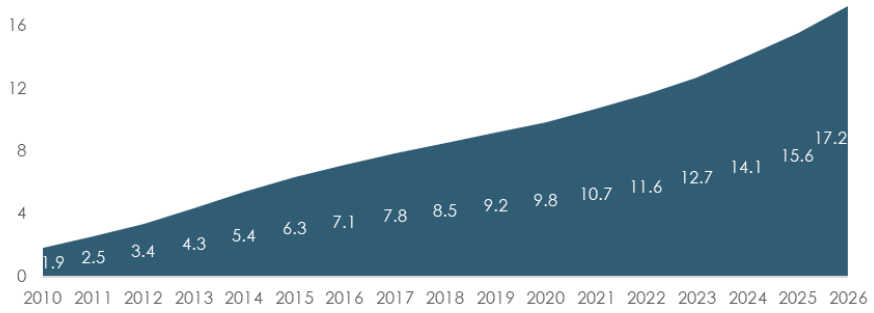
such as UL MU-MIMO, TWT (target wait time), 1024 QAM, OFDMA, per symbol overhead, BSS coloring, are not present in legacy technologies (i.e., Wi-Fi 4 and Wi-Fi 5), and were adopted by the latest standard to enable services in high density environments. The Wi-Fi patent stack at the moment remains indeterminate, in part because IEEE permits blanket declarations without requiring the disclosure of specific patents and the lack of a standard method for determining which patents are SEPS, leading to varying estimates across reports, including these two examples (see below):

Report	Total Wi-Fi 6 Granted Families
CAICT, "Global Wi-Fi 6 Technology Innovation and Standard Essential Patent Analysis Report (2022)"	606
NGB Corporation, "Data analysis: essentiality report on Wi-Fi 6 patents 2021"	645
Unified Consulting, "Wi-Fi Economic Report"	4,876
IPlytics, "Who's ahead in the Wi-Fi 6 patent race?"	~6,150
LexisNexis, "Who Is Leading the Wi-Fi 6 Patent Race?"	7,319

2) Market Analysis Observations

- **Surge in Wi-Fi Device Shipments:** Wi-Fi device shipments have grown 7 times over the past decade, driven by rising demand for multimedia content, social connectivity, and enhanced user experiences.
- **Impact of IoT, Videoconferencing, and Smart Homes:** The growth of IoT, videoconferencing, and smart home technologies has expanded Wi-Fi adoption across diverse sectors.

Wi-Fi Connected Devices in Use (in B)



*The number of Wi-Fi enabled devices in use has seen ~7.0x growth since 2010 (ABI Research, Internet of Everything Market Tracker - 1Q 2023)

- **Exponential Growth in Internet Use and Bandwidth Requirements**: Since the Wi-Fi 4 release in 2009, global internet use and bandwidth demand have surged, with monthly IP traffic rising from 20 exabytes in 2010 to 495 exabytes in 2023. Average household bandwidth consumption has increased 72-fold, driven by streaming, gaming, and remote work, underscoring the need for robust Wi-Fi networks (see below).

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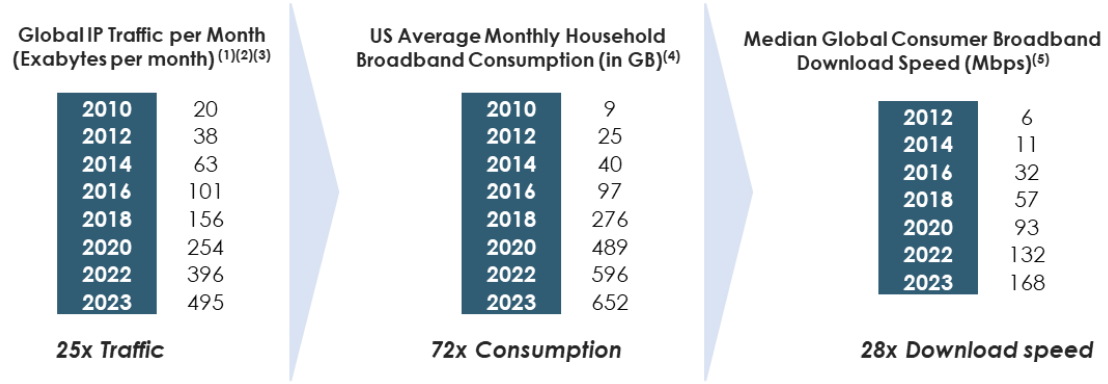
Growth in Traffic, Consumption, and Broadband Speed



- **Challenges in Dense Wireless Environments**: Dense wireless environments, where multiple devices connect to the same access points, often suffer from reduced throughput. Legacy standards like Wi-Fi 4 struggled to maintain performance in such high-density settings, including offices, apartments, and public spaces.
- **Wi-Fi 6 as a Market Solution**: Wi-Fi 6 networks provide up to 20x the throughput compared to earlier versions, addressing the growing need for higher data rates, lower latency, but with emphasis on delivering data with greater network efficiency.
- **Market Growth and Pricing Trends**: We observe that each new generation of Wi-Fi has introduced improvements that enhance connectivity and performance, leading to a price premium for pioneering devices. For instance, when first released, Wi-Fi 6 routers and access points were priced around $150 higher than pioneering Wi-Fi 4 devices from the same company. Price premium is also observable in other, non-pioneering, AP's and routers supporting different Wi-Fi generations.

3) Royalty Rate Analysis

Tech+IP analyzed real-world licensing data, damages awards, and public patent pool rates to estimate Wi-Fi 6 royalty rates across consumer and enterprise devices. This included public rates from licensors and pools like Sisvel, Huawei, Sol IP (ETRI), AXWireless, and others. We also examined Atlas Global Technologies' licensing wins, including settlements with Samsung and a group of wireless networking companies like D-Link, Zyxel, Sercomm, and others, as well as its verdict against TP-Link.

Atlas vs. TP-Link: The case led to an implied US royalty rate of $0.79 per router/AP, with a $37.5 million award for infringing five patents. Patent portfolio geography adjustment is used to account for patent portfolio geographical coverage strength and its relation to infringing products sale geography.

Atlas vs. Samsung: A licensing agreement valued at ~$51 million (Acacia 10-K 2021 and 10-Q Q3-2021) established an implied rate of $0.10 per end device based on Samsung Wi-Fi 6 enabled smartphones, tablets and TVs sales historically and in the future. Adjustments included first-mover discounts, sales geography, and regional patent coverage.

4) Wi-Fi Economic Value Based on a "Bottom-Up" Approach

Tech+IP conducted a comprehensive analysis of publicly announced and implied royalty rates related to all generations of 802.11 technology. This analysis aimed to help estimate the implied aggregate royalty stack value for all generations of the Wi-Fi standards, with a particular focus on Wi-Fi 6.

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In estimating the royalty value for 802.11ax (Wi-Fi 6), we applied several key adjustments and considered the following:

- By drawing analogies from cellular royalty stack valuations, we concluded that newer standards generally hold more market value than their predecessors. Specifically, we estimate that Wi-Fi 6 could account for 50% of all Wi-Fi royalties, with the remaining 50% attributed to legacy standards, thus assigning a 50% share of royalty as Wi-Fi 6 premium.
- The implied aggregate royalty value was estimated using 600 patent families, which represents the lower end of publicly available data on the total Wi-Fi 6 SEP count, based on reports from CAICT, NGB Corporation, Unified Patents, and IPLytics/Lexis Nexis. To validate this selection, we conducted a sanity check by comparing it to the Wi-Fi 4 SEP count established in the Innovatio case (2013), taking into account that Wi-Fi 6 contributions are approximately double those of Wi-Fi 4. **Our analysis indicated that even at this conservative estimate, the total Wi-Fi, including up to Wi-Fi 6/6E aggregate value exceeds $6.40 per device.**
- Not all patent owners will monetize their Wi-Fi 6 portfolios, as some use them for defensive purposes or cross-licensing. As a result, the **actual royalty burden for licensees is estimated to be about 50% of the theoretical total**. This reflects the difference between the "licensable stack" (patentees likely to license) and broader pool of all patent holders.
- Additionally, we analyzed the selling prices of consumer routers and enterprise access points implementing Wi-Fi 6 technology. Our analysis concluded that a higher implied “bottom-up” aggregate royalty burden tends to correlate with enhanced functionality and greater capacity, without excessively burdening the final cost to consumers as seen through their respective selling prices.
- We recognized the risk of “stacking issues” in bottom-up aggregate royalty calculations, where cumulative royalty burdens could become excessively high and impact implementer profitability. However, our analysis and estimation of the aggregate royalty burden for Wi-Fi 6 indicates that this is not a concern, as the estimated royalties do not lead to excessive stacking. At this stage, the Wi-Fi 6 SEP stack is considered largely “closed”, with no significant changes anticipated that would substantially alter the aggregate royalty burden.

5) Reasonableness Check Using a “Top-Down” Approach

Tech+IP also performed a “top-down” approach to validate findings from the “bottom-up” analysis. While generally treated separately, Wi-Fi 6 shares significant similarities and complementary use cases with 4G/5G technology, as highlighted by the Wireless Broadband Alliance. Wi-Fi is ubiquitous in homes, offices, and public spaces, serving billions of devices for high-speed internet access, often surpassing cellular usage.

Many telecom operators use “Wi-Fi offloading” methods to re-route smartphone traffic from cellular stations to access points. Data sources covering this topic indicate that over 70% of telecom data traffic is actually Wi-Fi traffic (e.g., voice over Wi-Fi is another form of Wi-Fi offloading). Reports from Wi-Fi Alliance and GSMA estimated Wi-Fi's global economic value at $3.5 trillion in 2023, compared to $5.7 trillion for cellular, underscoring Wi-Fi's significant contribution to global GDP.

Given their functional similarities and complementary use cases, we observe that the value of Wi-Fi (i.e., end-devices) could reasonably be positioned closer to the lower end, what is **at least ~$7.00**, of the observable data on cellular technology royalty value for smartphones.

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6) Observation on Shifting IEEE Intellectual Property Rights Policies

Many licensing market observers have noted that certain implementers, directly and through their networks, throughout the last decade have been actively undermining the value and importance of Wi-Fi technology. These activities have been focused mostly on various changes of IEEE IPR policies from 2015 and related DOJ Business Review Letters from 2015 and 2020. Some of the actual 2015 policy changes and/or interpretations regarding them that were misused to undermine the Wi-Fi value are:

- Focusing on SSPPU ("Smallest Saleable Patent-Practicing Unit") as an approach for royalty base estimates
- "License to all" requirement
- Top-down-only valuation approach
- Restriction to the freedom to seek injunctive relief
- Restriction to using comparable licensing evidence derived from situations where the threat of an injunction was present

The 2023 IEEE policy introduced language further clarifying "Reasonable Rate" and "Prohibitive Order", while at the same time not addressing "License to all" leaving room for further issues and misunderstanding. Also, the 2023 IEEE policy introduced updated policies around Letters of Assurance (LoAs) required from contributors to IEEE standards. This shifting policy landscape sent mixed signals to the broader market and led to several different interpretations by licensors and licensees, thus delaying dealmaking.

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