Evolution of Sharing in 6 GHz

Monisha Ghosh

It has been more than three years since the U.S. Federal Communications Commission (FCC) issued the Report and Order (R&O) and Further Notice of Proposed Rulemaking (FNPRM) for the 6 GHz (5.925–7.125 GHz) band on April 24, 2020, permitting unlicensed use on a shared basis [1]. Since then, many countries have followed the U.S. lead in allowing unlicensed use over the entire 1.2 GHz band, while others have permitted unlicensed use in the lower half, 5.925–6.425 GHz, while evaluating options for the upper 6 GHz, 6.425–7.125 GHz [2]. Agenda item 1.2 on the International Telecommunication Union's (ITU) World Radiocommunication Conference (WRC-23), to be held in November 2023, will discuss allocating the upper 6 GHz for International Mobile Telecommunications (IMT) applications, with a possibility of a primary allocation for mobile [3]. Nations, such as the U.S., who have already allocated the entire band for unlicensed use will recommend "No change" [4], since there is an expanding ecosystem of Wi-Fi 6E devices that operate in the full band. Furthermore, on September 28, 2023, the FCC announced a Second R&O and FNPRM permitting the use of a new class of devices, Very Lower Power (VLP), in 6 GHz [5] and the U.K.'s regulatory agency Ofcom's consultation exploring a new, hybrid-sharing mechanism, closed on September 15, 2023 [6], indicating that sharing in the band could be extended beyond current rules. However, there continue to be concerns from incumbents that expanding unlicensed use in the 6 GHz band will lead to harmful interference. All of these recent developments lead to new research problems related to spectrum sharing in 6 GHz.

Incumbents in 6 GHz and FCC Rules

Existing incumbents in the 6 GHz bands include fixed microwave links, cable television relay services (CTRS), satellite, and mobile Broadcast Auxiliary Services (BAS) [1]. While some countries have only allocated the lower 500 MHz on an unlicensed basis reserving the upper portion for possible future auctions and licensing [2], the large number of incumbents in the band (> 48,000) made the prospect of relocating incumbents prior to licensing a major challenge for the U.S. Hence, the most expedient way of making this band available for commercial applications was to develop rules for unlicensed devices to use this band while sharing with incumbents. Since a large percentage of wireless traffic is handled by Wi-Fi, allocating this band for unlicensed use also relieves the growing congestion in the existing 2.4 GHz and 5 GHz unlicensed bands.

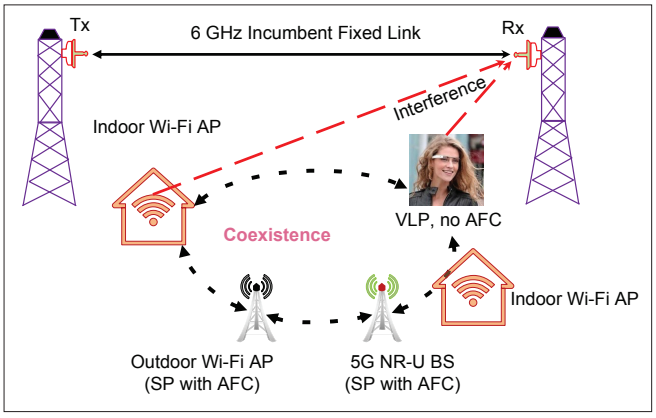

Figure 1. Caption.

The 6 GHz band in the U.S. encompasses four U-NII (Unlicensed National Information and Infrastructure) bands, U-NII-5 (5.925–6.425 GHz), U-NII-6 (6.425–6.525 GHz), U-NII-7 (6.525–6.875 GHz), and U-NII-8 (6.875–7.125 GHz) with specific incumbents in each: the majority of fixed links are deployed in U-NII-5 and U-NII-7, while mobile services, such as Electronic News Gathering (ENG) are in U-NII-6 and U-NII-8. The U.S. rules protect incumbents via two sets of rules that unlicensed devices must follow: low power indoor (LPI) and standard power (SP). LPI operation is permitted across the entire 6 GHz band without the need for an Automated Frequency Coordination (AFC) system, but access points (APs) must be installed indoors. LPI APs are restricted to a Power Spectral Density (PSD) of 5 dBm/MHz and a total EIRP of 30 dBm: this permits 27 dBm of transmit power over the 160 MHz channel bandwidth specified in Wi-Fi 6E and the full 30 dBm in the 320 MHz bandwidth that Wi-Fi 7 will support. SP APs can be installed anywhere, but are limited to operate only on U-NII-5 and U-NII-7 bands and require an AFC to avoid interference with incumbents. In both cases, client devices are permitted to transmit 6 dBm lower power than the AP. LPI devices have been available since 2020, soon after the R&O was issued, but SP devices are yet to be deployed since the AFC has not been certified by the FCC. The second R&O permitting VLP devices at −5 dBm/MHz and maximum EIRP of 14 dBm will spur the development of new applications and devices, such as smart glasses. It should be noted that the 6 GHz band can also be used by 3GGP specifications, such as LTE-LAA [7] and 5G NR-U [8] which implement listen-before-talk (LBT) and other sharing mechanisms that are required for operation in the band. Hence, while it is an unlicensed band, cellular systems can also benefit from the available spectrum by utilizing carrier aggregation. On the other hand, a licensed allocation would rule out other uses of the band. Figure 1 summarizes the various coexistence scenarios that exist in the 6 GHz band in relationship to incumbent fixed links.

Interference Concerns in 6 GHz

Incumbents who operate point-to-point fixed links in the 6 GHz band remain concerned about the potential harmful interference from both LPI and SP devices as 6 GHz unlicensed deployments proliferate. The increase in deployments also provides opportunities for conducting real-world measurements to quantify the interference potential instead of narrow experiments that analyze worst-case situations. For example, the University of Michigan has updated their infrastructure and deployed approximately 16,000 Wi-Fi 6E APs, operating under LPI rules, throughout their campus. This deployment was studied in detail in [9], using measurements of the beacon Received Signal Strength Indicator (RSSI) to develop a statistical understanding of the outdoor signal strength resulting from a dense indoor deployment. Median outdoor RSSI's were measured between −75 dBm and −85 dBm: these will not present a risk of harmful interference to fixed links in the vicinity of the deployment. In the upper 6 GHz bands, satellite links (Earth-to-space) could face aggregate interference if the upper 6 GHz were to be shared with high-power, outdoor, IMT applications. In addition to fixed links, mostly in U-NII-5 and U-NII-7, incumbents, such as ENG deploy mobile equipment in U-NII-6 and U-NII-8 and since an AFC cannot protect such itinerant services, SP deployments are not permitted in these two bands. For the same reason, the Second R&O and FNPRM [5] permits VLP only in U-NII-5 and U-NII-7 at a PSD of −5 dBm/MHz but seeks

input on permitting deployment in U-NII-6 and U-NII-8 as well as raising the PSD to 1 dBm/MHz if geofencing is implemented, using incumbent information from the FCC's databases to prevent VLP devices from operating in the vicinity of incumbent receivers. Both proposals require further analysis to determine if incumbents will continue to be protected with the expanded rules.

Hybrid Sharing in the Upper 6 GHz

An innovative proposal from Ofcom [6] suggests that a new approach for the upper 6 GHz may be feasible; sharing not only between new entrants and incumbents, but between low-power unlicensed and high power licensed outdoor, and using managed databases and advanced dynamic spectrum sensing. The goal is to maximize the utility of the band; allocating for only one type of service perhaps may not be the best option for efficiency. While this is an innovative approach, it remains to be seen as to how best such a proposal can be implemented. It should be noted that the U.K. also recommends "No Change" on Agenda item 1.2 for WRC-23. Further, the rules for the upper 6 GHz band in the U.S. will not be modified, but if such a scheme shows promise, it may be a viable approach for future shared bands, for example, in the 7.125–24 GHz, which is the focus of future spectrum sharing as studied in [10].

Conclusions

The 6 GHz band offers new opportunities for applications and devices, and also research problems for the academic community to pursue, such as interference management, novel sharing mechanisms, and propagation analysis. The sharing methodologies proposed in this band could also be applied in future shared bands with similar incumbents.

References

[1] Report and Order and Further Notice of Proposed Rulemaking, Unlicensed Use of the 6 GHz Band; https://www.fcc.gov/ecfs/document/0424167164769/5.
[2] Wi-Fi Alliance, "Countries Enabling Wi-Fi in 6 GHz (Wi-Fi 6E); https://www.wi-fi.org/countries-enabling-wi-fi-in-6-ghz-wi-fi-6e.
[3] Agenda of the World Radiocommunication Conference (WRC-23); https://www.itu.int/dms_pub/itu-s/md/20/cl/c/S20-CL-C-0069!C1!MSW-E.docx.
[4] Draft Proposals For The Work Of The Conference, Agenda Item 1.2; https://www.fcc.gov/sites/default/files/uspp_ai_1_2_67ghz.docx.
[5] Second Report and Order, Second Further Notice of Proposed Rulemaking, and Memorandum Opinion and Order, Unlicensed Use of the 6 GHz Band; https://docs.fcc.gov/public/attachments/DOC-397315A1.pdf.
[6] Ofcom Consultation on Hybrid Sharing: Enabling Both Licensed Mobile and Wi-Fi Users to Access the Upper 6 GHz band; https://www.ofcom.org.uk/__data/assets/pdf_file/0031/263776/condoc-upper-6ghz-review-june23-v2.pdf.
[7] V. Sathya, M. I, Rochman and M. Ghosh, "Measurement-Based Coexistence Studies of LAA & Wi-Fi Deployments in Chicago," *IEEE Wireless Commun.*, Nov. 2020.
[8] M. Hirzallah *et al.*, "5G New Radio Unlicensed: Challenges and Evaluation," *IEEE Trans. Cognitive Commun. and Net.*, vol. 7, no. 3, pp. 689–701.
[9] S. Dogan-Tusha *et al.*, "Evaluating the Interference Potential in 6 GHz: an Extensive Measurement Campaign of A Dense Indoor Wi-Fi 6E Network," accepted to ACM WiNTECH 2023, Oct. 6, 2023; https://arxiv.org/pdf/2307.00235.pdf.
[10] FCC Technological Advisory Council Report, "A Preliminary View of Spectrum Bands in the 7.125 - 24 GHz Range; and a Summary of Spectrum Sharing Frameworks;" https://www.fcc.gov/sites/default/files/SpectrumSharingReportforTAC%20%28updated%29.pdf.