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ITU-APT Foundation of India (IAFI)[1]

# UPDATE TO WORKING DOCUMENT TOWARDS A PRELIMINARY DRAFT NEW APT REPORT ON SHARING OF NEW WIFI SPECTRUM IN UPPER AND LOWER 6GHZ

**[Editor's Note: Contributions are invited from APT members for consideration at the AWG-29. Presently this report is planned to be completed for AWG-29]**

**Table of Contents**

1) Scope
2) Proposal
3) Introduction
4) References
5) Abbreviations and acronyms
6) Regulatory information
7) Overview of Sharing of New Wi-Fi spectrum in upper and lower 6Ghz
8) Summary

## 1. Scope

Development of a new APT Report on sharing of new WIFI spectrum in upper and lower 6Ghz bands since WIFI is a major enabler of connectivity in the home, at work, and in public spaces, Wi-Fi is fueling economic growth and societal development.

## 2. Proposal

Given the fact that this a preliminary document and has not been introduced yet and this will be the first draft of the update as a temp document, additions proposed in attachment are in track change mode. The aim of the draft is to provide with a report on sharing of new Wi-Fi spectrum in both upper and lower 6 GHz bands.

## 3. Introduction

Wi-Fi is often the most cost-effective way to get online, enabling extensive use of Internet-based applications and services without incurring the hefty connectivity charges associated with cellular contracts. Low-cost reliable connectivity makes citizens more productive. Wi-Fi

[1] ITU-APT Foundation of India (IAFI) is a new Affiliate member of APT. Details of IAFI can be seen at itu-apt.org

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has become a lifeline for connecting people, enhancing digital technology and the global proliferation of Wi-Fi access is important for both established and developing economies. The flexibility and benefits Wi-Fi brings to digital economies have proven to provide essential benefits during the COVID-19 pandemic and the increasing demand for Wi-Fi means that the regulators need to assign much larger unlicensed spectrum for Wi-Fi. Due to such expected growth, which is followed by the expectations of consumers that is ever increasing requirement being fueled by fast connectivity, low latency and maximization of connections in more and more devices. Wi-Fi networks congestion at the access point level is becoming an issue because access to license-exempt mid-band spectrum creates an artificial spectrum shortage; since the World Radiocommunication Conference in 2003 no new mid-band spectrum has been made available for Wi-Fi despite the exponential growth in data traffic. Furthermore, the current Wi-Fi spectrum doesn't offer sufficiently wide channels for newer applications and services.

Wi-Fi 6 or new spectrum for WIFI will enable new use cases for industrial IoT, smart homes and support for high-density deployments, to name a few, but access to wider channels is needed to support these new use cases. The new 6GHz Wi-Fi band will lead to opening up of up to seven new 160 MHz channels. The 6 GHz band could potentially serve as a multi-lane superhighway for the latest Wi-Fi devices. The 6 GHz band comprises frequencies from 5.925 to 7.125 GHz, and the V band from 57 to 71 GHz. The bands support new Wi-Fi versions, Wi-Fi 6E and WiGig, respectively, which offer much higher data speeds and shorter range than previous versions of Wi-Fi.

## 4. References

## 5. Abbreviations and acronyms

| | |
|---|---|
| AP | Access Points |
| AR | Augmented reality |
| LAN | Local Area Network |
| MU-MIMO | Multi-User Multiple-Input Multiple-Output |
| OFDMA | Orthogonal Frequency-Division Multiple Access |
| TWT | Target-Wake-Time |
| VR | Virtual reality |

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## 6. Application of new spectrum in upper and lower 6ghz

**Wi-Fi 6** (2.4 GHz and 5 GHz) and **Wi-Fi 6E** (6 GHz) is the successor of 802.11ac. It is also known as *High Efficiency* Wi-Fi, for the overall improvements to Wi-Fi 6 clients under dense environments. The main goal of this standard is to enhance access to spectrum which is critical to enable a better user experience and enable innovation.

Wi-Fi can be used in the 2.4 and 5GHz bands throughout most of the world. In the UK, 83MHz is available for Wi-Fi use at 2.4 GHz and 585MHz at 5GHZ. However, there are variations between countries in the supported frequencies and the ways in which devices can connect. For instance, in the 5.8 GHz band there is more available spectrum but this is because **it has been made available in the UK,** even though the bands are not available for similar Wi-Fi services and applications throughout Europe.


**Figure 1: Wi-Fi channels in the 2.4 GHz band.**

The higher number of connected devices within existing bands, and the limited number of Wi-Fi channels can lead to congestion when several devices attempt to use the same Wi-Fi channel.

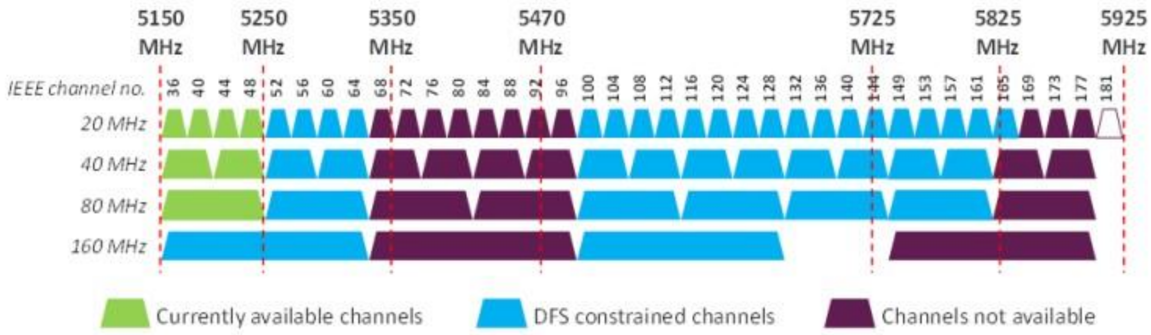



**Figure 2: Example Wi-Fi channel plan used in the 5 GHz band**

Therefore, it can be agreed that more than one Wi-Fi channel is needed for mesh technologies to provide different multimedia platforms throughout the home, and this demand for higher throughput mesh technologies in the home will increase in the future. Opening new Wi-Fi bands, and removing DFS requirements in the 5.8 GHz band, will offer a higher number of wider channels needed.

In order to see this in a growing demand the latest development in the Wi-Fi is the Wi-Fi 6 and other RLAN technologies. It is agreed that Wi-Fi 6 will improve battery life, allow a higher density of wireless devices.

The 5.8 GHz band (5725-5850 MHz) is very lightly used due to the requirement to implement DFS in this band. As a result, we have considered removing the DFS requirement in this band to enable more efficient use of it.

In light of increasing demand for wireless connectivity and the new Wi-Fi technologies being capable of providing the capacity needed for low latency multimedia applications, we proposed to open up access to new spectrum in the lower 6 GHz band (5925- 6425 MHz) and to remove the DFS requirements for the lower power indoor3 use of Wi-Fi in the 5.8 GHz band.

Enterprises users rely on W-Fi for most corporate connections, using mesh-based systems to coordinate fast internet access for a large number of users;

**Technical improvements**

The 802.11ax amendment brings several key improvements over 802.11ac. 802.11ax addresses frequency bands between 1 GHz and 6 GHz. Therefore, unlike 802.11ac, 802.11ax will also operate in the unlicensed 2.4 GHz band. To meet the goal of supporting dense 802.11 deployments, the following features have been approved.

In the previous amendment of 802.11 (namely 802.11ac), multi-user MIMO has been introduced, which is a *spatial* multiplexing technique. MU-MIMO allows the access point to form beams towards each client, while transmitting information simultaneously. By doing so, the interference between clients is reduced, and the overall throughput is increased, since multiple clients can receive data at the same time. With 802.11ax, a similar multiplexing is introduced in the *frequency domain*, namely OFDMA. With this technique, multiple clients are assigned with different Resource Units in the available spectrum. By doing so, an 80 MHz channel can be split into multiple Resource Units, so that multiple clients receive different types of data over the same spectrum, simultaneously. In order to have enough subcarriers to support the requirements of OFDMA, four times as many subcarriers are needed than by the 802.11ac standard. In other words, for 20, 40, 80 and 160 MHz channels, there are 64, 128, 256 and 512 subcarriers in the 802.11ac standard, but 256, 512, 1,024 and 2,048 subcarriers in the 802.11ax standard. Since the available bandwidths have not changed and the number of subcarriers increases by a factor of four, the subcarrier spacing is reduced by the same factor, which introduces four times longer OFDM symbols: for 802.11ac the duration of an OFDM symbol is 3.2 microseconds, and for 802.11ax it is 12.8 microseconds.

**Figure 3:**

## 6GHz Sharing and Compatibility Studies

**C-band uplink**

| | IMT-Advanced (4G) (5925-6425 MHz) | IMT-2020 (5G) (6425 – 7025 MHz) | WiFi in 6 GHz (5925 – 6425 MHz) |
|---|---|---|---|
| ITU | Report ITU-R S.2367 | To be done under AI1.2 | No studies |
| CEPT | No studies | No studies | ECC Report 302 |

| Sub Bands | Existing Utilisation | Existing / Future Studies |
|---|---|---|
| 5925-6425 MHz: | Globally many countries have identified this band for unlicensed 6 GHz Wi-Fi connectivity, including Europe, Americas, ME, Asia etc | **Existing studies related to IMT-Advanced (Report ITU-R S.2367)** show very little potential for IMT operations while protecting FSS uplinks (indoor use only, EIRP limit necessary).<br>Studies conducted related to Wifi by CEPT **(ECC Report 302)** have demonstrated that FSS sharing with unlicensed WiFi indoor could be more feasible than IMT in this Band. |
| 6425-6725 MHz: | Unplanned band, allocated to the FSS globally (earth-to-space).<br>**Used for uplinks by large numbers of GSO FSS networks covering all Regions.**<br>**Uses includes feeder links for MSS systems including safety services.** | ▪ To conduct further in-band sharing technical studies for the E2S (uplink) operations to examine the results of aggregate interference from IMT B/S studies into receiving FSS space stations;<br>▪ To examine the space to earth satellite operations in-band sharing. |
| 6725-7025 MHz: | **Planned FSS band – subject AP30B**, there are no existing studies with IMT/5G | ▪ Plan contains all national allotments of all countries and needs particular attention due to the super-status of the Plan with regards to the List and other services<br>▪ Subject to the provisions and associated Plan for the FSS of Appendix **30B** of the Radio Regulations. Articles 1 and 2 of Appendix **30B** selected this band in 1985 to guarantee, for all countries, equitable access to the geostationary-satellite orbit in the frequency bands of the fixed-satellite service. |
| 6 700-7 025 MHz | Allocated to the FSS globally (space-to-earth),<br>Limited to feeder links for NGSO – MSS and is subject to coordination under No. **9.11A.** | ▪ Co-existence issues between IMT and receiving FSS earth stations would be similar to those studied in Report ITU-R S.2368, i.e., separation distances and coordination contours would be necessary around receiving FSS earth stations to achieve co-existence |

**Leading to:**

1. **Studies from IMT to FSS satellite receivers (GSO, non-GSO, including App 30B planned systems) – *most critical due international aspect***
2. **Studies from FSS transmitting earth stations to IMT receivers**
3. **Studies from IMT to receiving earth stations (non-GSO MSS feeder downlinks)**

**Use case application**

5.1 Technical improvements

| Features | 802.11ac | 802.11ax | Usage/Application |
|---|---|---|---|
| OFDMA | Not Available | Centrally controlled medium access with dynamic assignment of 26, 52, 106, 242, 484 or 996 tones per station. Each tone consists of a single subcarrier of 78.125 kHz bandwidth. Therefore, bandwidth occupied by a single OFDMA transmission is between 2.03125 MHz and ca. 80 MHz bandwidth. | OFDMA segregates the spectrum in time frequency resource units (RUs). A central coordinating entity (the AP in 802.11ax) assigns RUs for reception or transmission to associated stations. Through the central scheduling stations of the Rus contention overhead can be avoided which increases efficiency in scenarios of dense deployments. |
| Multi-user MIMO (MU-MIMO) | Available in downlink direction | Available in uplink direction | With downlink MU-MIMO an AP may transmit concurrently to multiple stations and with uplink MU-MIMO an AP may simultaneously receive from multiple stations. Whereas OFDMA separates receivers to different RUs, with MU-MIMO the devices are separated to different spatial streams. In 802.11ax, MU-MIMO and OFDMA technologies can be used simultaneously. To enable uplink MU transmission, the AP transmits a new control frame (trigger) which contains scheduling information (Rus's allocation station, modulation and coding scheme (MCS) that shall be used for each station. |
| Trigger-based Random Access | Not available | Allows performing UL OFDMA transmissions by stations which are not allocated RUs directly. | In Trigger frame, the AP specifies scheduling information about subsequent UL MU transmission. However, several RUs can be assigned for random access. Stations which are not assigned RUs directly can perform transmissions within RUs assigned for random access. To reduce collision probability (i.e., situation |

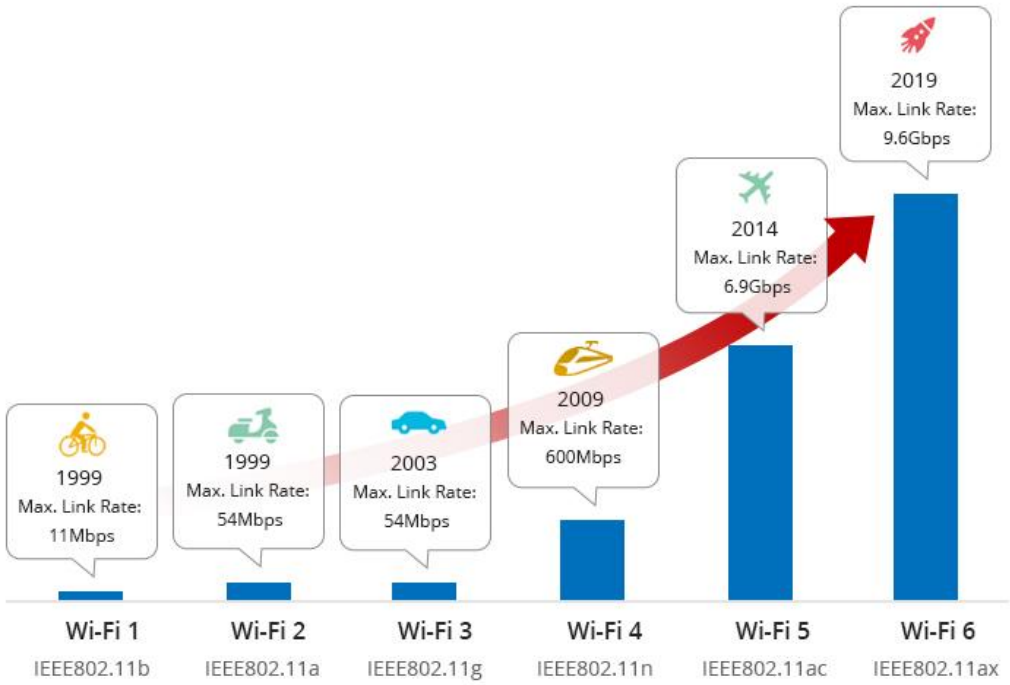
| | | | |
|---|---|---|---|
| | | | when two or more stations select the same RU for transmission), the 802.11ax amendment specifies special OFDMA back-off procedure. Random access is favorable for transmitting buffer status reports when the AP has no information about pending UL traffic at a station |

Two of the most significant changes involve how Access Points support a large number of devices in high density environments. Wi-Fi 6 incorporates features found in 4G LTE cellular networks by upgrading access points to Orthogonal Frequency Division Multiple Access (**OFDMA**) from the older OFDM (minus the Access). OFDMA divides the 802.11 channel (20, 40, 80, 160 MHz wide) into hundreds of sub-channels, also known as Resource Units (RU).

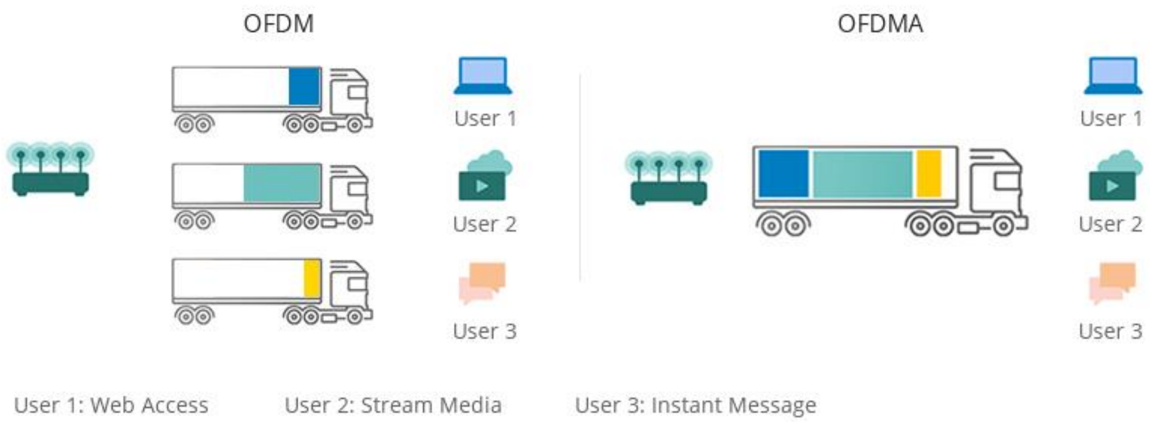
Wi-Fi 6 also enables each Access Point to add a unique color—referred to as "Basic Service Set (BSS) Color"—to each transmitting channel. With 63 different colors available, coloring ensures that neighboring APs can all be assigned unique colors. With each Access Points transmitting a locally-unique color, a device can easily distinguish transmissions coming from its Access Points from that of a neighboring Access Points. This distinction enables a device to ignore a neighboring Access Point's transmission when attempting to transmit. Coloring leads to increased capacity by enabling simultaneous transmissions between Access Points on the same channel.

**Figure 4:**

**Optimize Efficiency with OFDMA Technology**



Orthogonal Frequency-Division Multiple Access (OFDMA) divides available channel bandwidth into several mutual orthogonal subcarriers or resource units (RUs). Furthermore, by subdividing the channel, applications that use small frames can be transmitted to multiple endpoints simultaneously, which cuts down on overhead and congestion at layer two. When multiple connections transmit limited amounts of data, OFDMA will be leveraged at maximum.
Unlike the previous OFDM technology adopted by Wi-Fi 5, OFDMA is flexible to allocate the entire channel to a sub-divide depending on traffic, greatly improving efficiency and reducing latency. The following diagram will further illustrate the working principle differences via analogy. One truck can only send one kind of package to one house at a time previously (Wi-Fi 5 with OFDM), while the same truck is able to carry multiple packages to separate destinations now (Wi-Fi 6 with OFDMA).




OFDMA is like an Access Point-centric methodology enabling an 802.11ax access point to simultaneously communicate with multiple devices by dividing each Wi-Fi channel into smaller sub-channels. That is to say, an AP can choose to allocate the whole channel (all sub-channels within a channel) to a single user in a given time frame, or it may partition the whole channel to serve multiple devices simultaneously. The adoption of this new technology moves Wi-Fi from a contention-based to a scheduled-based service, which helps to stabilize the Wi-Fi performance.

**Increase Throughput With MU-MIMO Technology**

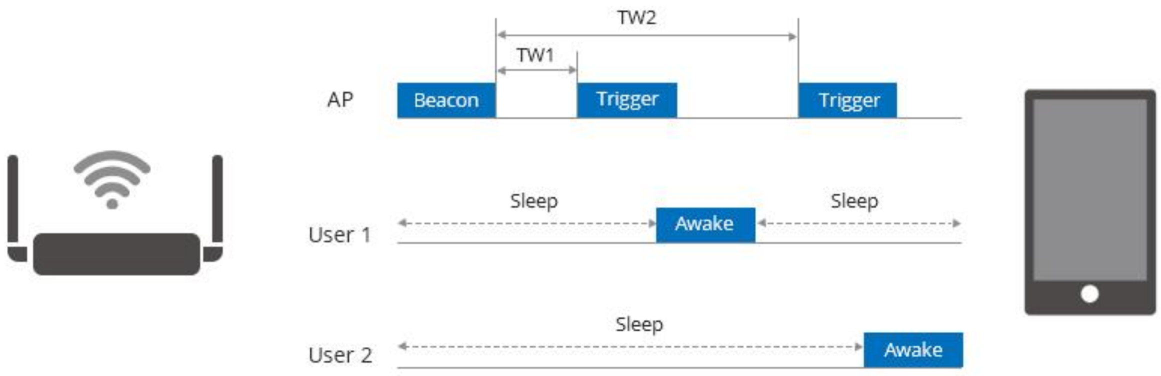
MU-MIMO, short for "multi-user, multiple input, multiple output," allows routers to communicate with multiple devices at the same time rather than communicate successively. Wi-Fi 5 supports this MU-MIMO technology as well, but only working for downloads whereas Wi-Fi 6 works with both uploads and downloads. Wi-Fi 6 uses 8x8 uplink/downlink to provide 4x larger capacity than Wi-Fi 5 to handle more devices. The enhancement of this technology in Wi-Fi 6 will largely increasing the utilization of Wi-Fi network bandwidth. The following diagram indicates that MU-MIMO has enlarged the capacity for better efficiency. In Wi-Fi 6, MU-MIMO and OFDMA mechanisms form a unity of complementation.

Both focus on improving the efficiency of Wi-Fi networks and reducing latency for time-sensitive applications. MU-MIMO and OFDMA have their advantages and applications respectively: OFDMA is ideal for low-bandwidth, small-packet applications such as IoT sensors, whereas MU-MIMO increases capacity and efficiency in high-bandwidth applications like mission-critical voice calls or video streaming.

Without MU-MIMO With MU-MIMO

**Reduce Power Consumption with TWT Technology**

Target Wake Time (TWT) allows devices to negotiate when and how often they will wake up to send or receive data, increasing the sleep time, and substantially improving battery life for devices. Introducing this new technology in Wi-Fi 6, devices will be planned out communications with a router, reducing the amount of time they need to keep their antennas powered on to transmit and search for signals. That is to say, the devices remain inactive until it's their turn to transmit data using a scheduling scheme negotiated with the APs. It's like parking a vehicle in the cell phone waiting area, rather than circling the airport for arrivals. Wi-Fi 6 Target Wake Time featuring less congestion and energy savings will create better experiences for the users.




Target Wake Time (TWT)

Use case application

1) Ensuring application assurance
2) Indoor wireless coverage
3) Enabling the intelligent edge
4) IoT convergence
5) Safer Wi-Fi

Opening spectrum for Wi-Fi in the 6Ghz band

RLAN use, including Wi-Fi, is currently authorized in the 2.4 GHz and 5GHz bands. To improve coverage and capacity, lower latency and ease congestion, and view of future innovation, it is best to make the lower 6GHz 5925-6425 MHz) available for Wi-Fi use.

That the 6 GHz band was suitable to address demand for additional Wi-Fi spectrum for three principal reasons:
a) The large amount of contiguous spectrum available would allow for wide, non-overlapping channels with the same technical conditions;
b) The adjacent 5 GHz band is already widely used fro W-Fi, therefore similarities in the ranges achievable, router and antenna design of the two bands would enable manufactures to invest fewer resources and implement 6GHz more rapidly in products. This would also mean similar deployment models for infrastructure and routers for operators
c) The 6GHz band should be used by more efficient Wi-Fi, technologies from the outset.

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