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# A Quantitative Analysis of 802.11 ah Wireless Standard

Shanmuga Sundaram B[1]
[1]*M.Tech Software Systems, Birla Institute of Technology and Science, Pilani, Rajasthan, India*

**Abstract :** Wireless Networks have become an essential part of our life. Like all other computing devices they are under a constant evolution. While there are many Wi-Fi standards defined for every aspect of wireless communication, we tend to stick to the generic 802.11 standard for general analysis purposes. Getting a deep dive into other standards is important for us to get an understanding on how this technology is implemented and how it helps in improving our communication standards day by day .With a clear understanding of the existing wireless technologies we will be able to understand the future improvements which are in pipeline and which can make a lot of difference to the way we communicate. The objective of this paper is to address one such standard 802.11 ah also called as Wi-Fi HaLow and how it differs from the traditional wireless standards we have been using.

**Keywords –** Wi-Fi HaLow, 802.11, IoT, M2M, FSPL

## I. INTRODUCTION

Wi-Fi 802.11ah or the Wi-Fi HaLow is standard that will benefit from its lower power consumption and a longer range of operation. To understand the true advantage of this standard, it is important to understand the capabilities of previous standards and what they lack in comparison to this. We will start with an introduction to 802.11 ah and go with a comparative study along with other existing standards.

## II. 802.11 AH AND COMPARISON AGAINST OTHER STANDARDS

### 2.1 802.11 ah

IEEE 802.11 ah is a new design that operates in the sub-gigahertz band (900 MHz). This design is intended to support low power consumption and wider range and scalable operation. This enhances the link budget compared to the 2.4GHz technologies. It can provide a minimum data rate of 150 Kbits/sec. Though the coverage range is said to be more than one kilometer, ideally one can expect it to be at least twice that of the existing standards. These characteristics open up new use cases for Wi-Fi on IoT, smart homes, low power sensors etc. By operating at 900 MHz 802.11 ah extends the range of Wi-Fi beyond the limited range of 2.4 GHz and 5.4GHz by improved propagation and penetration. With this, Wi-Fi connections will improve in previously hard to reach places like malls, back yards and attics. [1]

### 2.2 How does 802.11 ah achieve it?

The main advantages of 802.11 ah being longer range and low power, we need to know how it is possible for this standard to surpass the capabilities of its counterparts. While the range for a normal Wi-Fi is somewhere between 30-40 meters, HaLow can easily reach double of the distance. With repeaters it can further be extended. It makes this possible by operating at a lower frequency.

Lower frequency waves always travel further than the higher frequency waves because the latter get absorbed by air and other interferences in the way. Also high frequency means high attenuation. Operating at a lower frequency of 900 MHz 802.11 ah has better object penetration and longer range. This can be explained using Friis transmission equation, which is used to calculate Free Space Path Loss (FSPL). FSPL is the loss in signal strength of an electromagnetic wave that would result in the line of sight path, in free space.

$$FSPL = ((4 * pi * d) / \lambda)) \wedge 2$$

d - Distance

λ – Wavelength

λ = c/f, where 'f' is the frequency and 'c' is the speed of light. So,

$$FSPL = = ((4 * pi * d * f) / c)) \wedge 2$$

This clearly explains that signal loss goes up with the frequency. Higher the frequency, higher the loss. At lower frequencies 802.11 ah has relatively less attenuation and hence has longer range. One disadvantage at this frequency is the speeds it is able to provide. Though the range can extend up to a kilometer the data rate could get as low as 150 Kbits/sec.

802.11ah is less resource intensive than the other wireless standards since it transmits at low frequency. So it turns out to be beneficial in terms of batter y use and processing power.

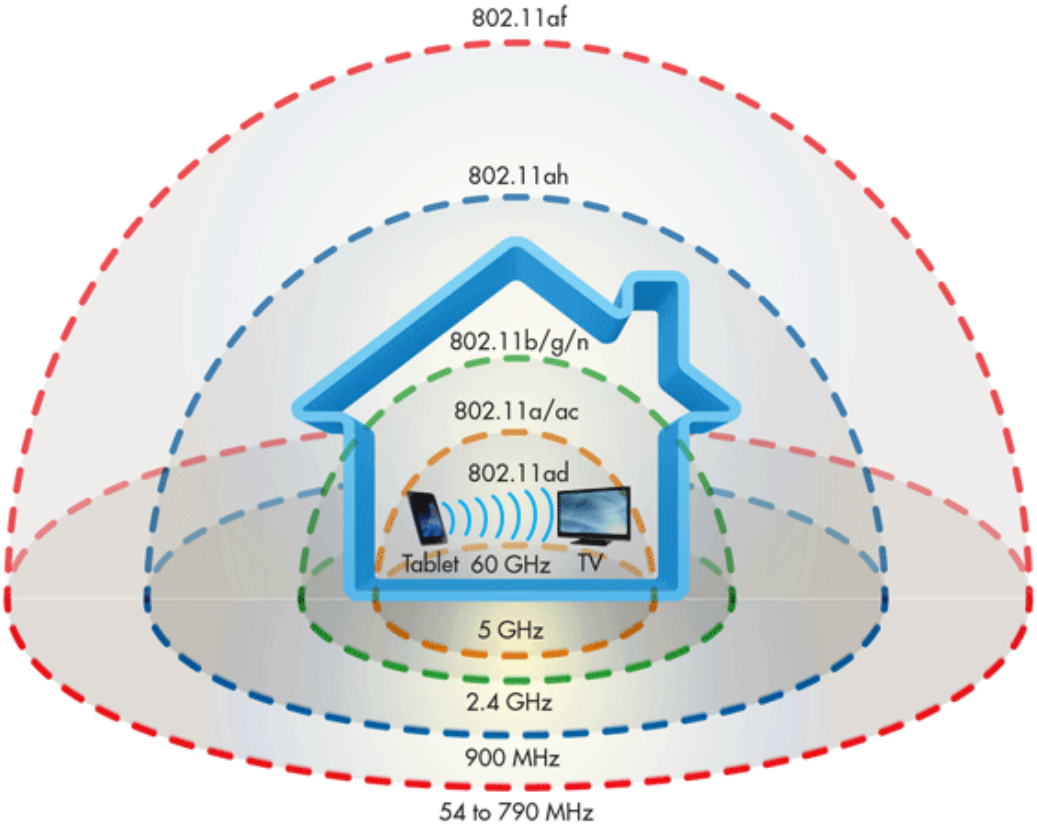
### 2.3 Comparison with other standards

Below table shows the comparison between Wi-Fi HaLow and other 802.11 standards [2]

TABLE 1: IEEE 802.11 COMMON WIFI STANDARDS BREAKDOWN

| Standard | Frequency Band | Bandwidth | Modulation Scheme | Channel Arch. | Maximum Data Rate | Range | Max Transmit Power |
|---|---|---|---|---|---|---|---|
| 802.11 | 2.4 GHz | 20 MHz | BPSK to 256-QAM | DSSS, FHSS | 2 Mbps | 20 m | 100 mW |
| b | 2.4 GHz | 21 MHz | BPSK to 256-QAM | CCK, DSSS | 11 Mbps | 35 m | 100 mW |
| a | 5 GHz | 22 MHz | BPSK to 256-QAM | OFDM | 54 Mbps | 35 m | 100 mW |
| g | 2.4 GHz | 23 MHz | BPSK to 256-QAM | DSSS, OFDM | 54 Mbps | 70 m | 100 mW |
| n | 2.4 GHz, 5 GHz | 24 MHz and 40 MHz | BPSK to 256-QAM | OFDM | 600 Mbps | 70 m | 100 mW |
| ac | 5 GHz | 20, 40, 80, 80+80= 160 MHz | BPSK to 256-QAM | OFDM | 6.93 Gbps | 35 m | 160 mW |
| ad | 60 GHz | 2.16 GHz | BPSK to 64-QAM | SC, OFDM | 6.76 Gbps | 10 m | 10 mW |
| af | 54-790 MHz | 6, 7, and 8 MHz | BPSK to 256-QAM | SC, OFDM | 26.7 Mbps | >1km ? | 100 mW |
| ah | 900 MHz | 1, 2, 4, 8, and 16 MHz | BPSK to 256-QAM | SC, OFDM | 40 Mbps | 1 km | 100 mW |

A pictorial representation of the 802.11 standards, their operating frequencies and the range. [3]




**2.4 Why not 802.11 af?**

From the table and the figure above, we can see that both the .af and .ah standards are closely related to each other in terms of range and frequency band. There is an obvious question of why can't we use .af in place of .ah.

With different MAC and PHY designs, 802.11ah hardware will be more power efficient than its predecessor. 802.11 ah can operate in bursty packet nodes and within field of wireless nodes. Here data sent by a node has to traverse only to a nearest node, thereby reducing power consumption. 802.11af is optimized to make data transfer in a more Wi-Fi like manner. Its access points send and receive data from remote portable devices instead of using other access points and nodes. Also 802.11 ah has bidirectional transmit opportunity, restricted access window and target wake times which help to enable lower power machine to machine and IoT applications. [4]

## III. 802.11 AH USE CASES

As seen in earlier sections, one important characteristic of 802.11ah is the ability to transmit a minimum of 150 Kbits/sec over 1 or 2 MHz channels. With such short, bursty transmissions, the sensors of IoT devices need to be on only for a short time, thereby conserving battery and energy. 802.11ah as a standard with data rates in tens of megabits per second will be perfectly fine for IoT related purpose. This standard should find an extensive usage in IoT and M2M communication. Below use cases adopted by IEEE are included in this section for completion sake. [5]

1) Sensor Networks
2) Backhaul Networks for Sensors
3) Extended Wi-Fi range for cellular traffic offloading
4) Machine to Machine Communication
5) Rural Communication

## IV. CONCLUSION

Increased range and lower power consumption make 802.11 ah a perfect protocol. With lesser speeds it can improve the connectivity situation of Internet of Things. The objective of this paper is to provide a quantitative analysis of 802.11ah as a technology and compare it with other standards. Even though details like PHY and MAC designs are quoted, there are not explained because it is out of scope of this document.

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