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Emergence of New Wireless Technologies : 802.11ac and 802.11ad

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Abstract

Over the past two decade, wireless technologies have been burgeoning and disseminating in every aspect of technology. Ever since the adoption of the first wireless standard 802.11 in 1997, there has been an exponential growth in popularity of wireless technologies. It's impact has been so profound that its become a desideratum. Currently, the most widely used wireless technology is 802.11n which has evolved leaps and bounds, however it still has certain limitations which have been overcome by newer technologies 802.11ac and 802.11ad (which is currently being drafted).

Keywords: Ethernet, Wireless Technology Standards, 802.11n, 802.11ac, 802.11ad

Introduction

Initially, Ethernet technologies were developed under the IEEE 802.3 standard which was based on Carrier Sense Multiple Access/Collision Detection (from now on referenced as CSMA/CD) protocol. The issue with CSMA/CD is that, it detects collision but it does not completely eliminate the possibility of collisions. Ethernet is a wired technology which is now considered primitive when compared to the newer wireless technologies, since they are capable of delivering quad-play services.

802.11 is the official IEEE standard for wireless communication. It works on Carrier Sense Multiple Access/Collision Avoidance (from now on referenced as CSMA/CA) protocol. The major advantage of this protocol is that it eliminates the possibility of collision.

Having published its first 802.11 standard in 1997, the Working Group (WG) received feed- back that many products did not provide the degree of compatibility customers expected. [1]

The shortcoming of incompatibility between devices of different vendors led to the development of Wi-fi Certification which alleviated the flaws in the initial 802.11 standard. This was one of the remarkable patches made to the original 802.11 standard which led to the development of advance standards.

Current wireless technologies

802.11b

IEEE 802.11b was the first wireless LAN standard to be widely adopted and built in to many laptop computers and other forms of equipment. The standard for 802.11b was ratified by the IEEE in July 1999 and the idea for wireless networking quickly caught on with many W-Fi hotspots being set up so that business people could access their emails and surf the Internet as required when they were travelling. [2]

802.11b standard was approved in July 1999. It is capable of delivering data at 11Mbps over a distance of ~30m.

802.11g

Though 802.11a was capable of delivering higher transfer rates, it was not ubiquitously used because the cost of manufacturing chips operating at 5GHz was exorbitant. This was the cardinal reason for the establishment of 802.11g.

802.11g operates in the 2.4 GHz ISM band. It provides a maximum raw data throughput of 54 Mbps, although this translates to a real maximum throughput of just over 24 Mbps. In order to provide resilience against multi-path effects while also being able to carry the high data rates, the main modulation method chosen for 802.11g was that of OFDM - orthogonal frequency division multiplex, although other schemes are used to maintain compatibility, etc. [3]

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802.11n

The principal idea behind the development of 802.11n was to provide higher data transfer rates at 2.4GHz and 5GHz spectrum.

To achieve this, a number of new features have been incorporated into the IEEE 802.11n standard to ameliorate the performance. The novelties in 802.11n are summarized below:

- Changes to implementation of Orthogonal Frequency Division Multiplex (from now on referenced as OFDM)
- Introduction of Multiple Input Multiple Output (from now on referenced as MIMO)
- MIMO power saving
- Wider channel bandwidth
- Antenna technology
- Reduced support for backward compatibility under special circumstances to improve data throughput. [4]

802.11n provides backward compatibility for devices which support archaic standards. This adds significant amount of overhead to any data exchange, thereby reducing the data throughput. For maximum data transfer rates, the backward compatibility can be disabled. 802.11n can be operated in 3 modes:

- Legacy (802.11a/b/g)
- Mixed (802.11a/b/g/n)
- Greenfield (only 802.11 n) - maximum performance

To achieve high data rates, 802.11n makes use of MIMO. MIMO provides a way of utilising the multiple signal paths that exist between a transmitter and receiver to significantly improve the data throughput available on a given channel with its defined bandwidth. By using multiple antennas at the transmitter and receiver along with some complex digital signal processing, MIMO technology enables the system to set up multiple data streams on the same channel, thereby increasing the data capacity ofa channel. [4]

802.11n has efficient power usage. Data exchanges are made in a bursty fashion. Hence the system remains in idle state for prolong periods of time. In the idle states, the power consumption is minimal.

802.11n run using double sized channel bandwidth which includes 20MHz and 40MHz. There are 3 channels of 20MHz in the 2.4GHz spectrum and only one channel in the 40MHz channel.

For 802.11n, the antenna associated technologies have been significantly enhanced by the introduction of beam forming and diversity. A higher signal level and better signal to noise ratio will ensure complete utilization of channel. [4]

Limitations of Current Technoloiges

- Range of 802.11n is inadequate.
- Data rates in 802.11n are not high.
- With the advent of new multimedia technologies such as UHD, the bandwidth requirements have increased tremendously.

The average number of wireless devices used by each user has increased.

Current wireless technologies

Preface to 802.11ac

Due to the limitations of 802.11n, a need for better technology arose. Hence 802.11ac came into existence. 802.11ac builds upon 802.11n and improves on several factors data transfer rates and efficiency.

Salient Features of 802.11ac

The 3X speed improvement achieved by the new standard means that the 450 Mbps performance from today's fastest 3 antenna 802.11n device can be achieved by single antenna 802.11ac device – with similar power consumption. This means that a typical tablet with single antenna 802.11n 150Mbps WiFi can now support 450 Mbps with 802.11ac − without any increase in power consumption or decrease in battery life. [5]

Novel multimedia technology like UHD, have higher bit rate requirements than its predecessors which degrades the Quality of Service (from now on referenced as QOS) if used with archaic wireless standards. This shortcoming was overcome by the advance antenna technology of 802.11ac.

Advance Antenna Technologies in 802.11ac include Beamforming, which provides directional signal transmission and reception. Previous standards only received and transmitted omnidirectional signals, which were subjected to significant levels of interference, due to the fact that the signals were transmitted indiscriminately in every possible direction. With Beamforming, there's an understanding of the relative location of the device, and the signal is correspondingly strengthened in that direction. [5] The three stream (3x3) antenna configuration in 802.11ac helps in reducing the number of dead zones - areas in the coverage radius but denied network connection.

802.11ac supports Multi-user multiple-input

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multiple-output (from now on referenced as MU-MIMO). It enables multiple users to perform data exchange and acknowledgements simultaneously.
802.11ac works in the 5GHz spectrum which is less prone to interference. 2.4GHz spectrum comprises of 3 non-overlapping channels for transmission which are overcrowded because a number of wireless access points such as bluetooth devices, microwave ovens, etc operate in the same spectrum. Due to this, the 2.4GHz spectrum is filled with lot of noise thus increasing interference. 5GHz is cleaner spectrum and has 23 non-overlapping channels (8 times that of 2.4GHz).

Advantages of 802.11ac

The advantages of 802.11ac have been listed below:

- Provides better QOS, less jitter and lower latency; allows swift streaming of UHD content and games
- Reduces number of dead zones considerably.
- Data transfer rates increases by 3 times in comparison to 802.11n.
- It works in 5GHz spectrum which is cleaner and less prone to interference.

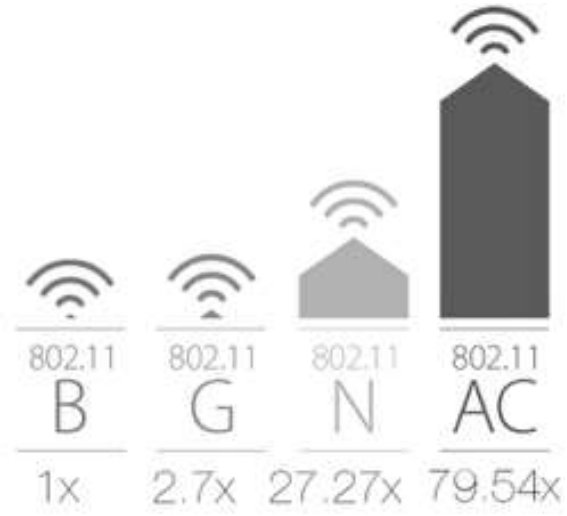

Figure 1. Comparison of Different Wireless Technology Standards

Future scope

802.11ac has tremendous potential to grow, however due to still being in its inchoate state, it has a few shortcomings which are promised to be alleviated by 802.11ad a wireless standard still in alpha stages of testing and implementations.

Current iteration of 802.11ad improves the data transfer rate to 7Gbps from the then previous highest 1.75Gbps. It operates on 2.4GHz, 5GHz and 60GHz spectrum thus providing larger bandwidth. It also improves the power efficiency and thus the battery life of any device using the technology.

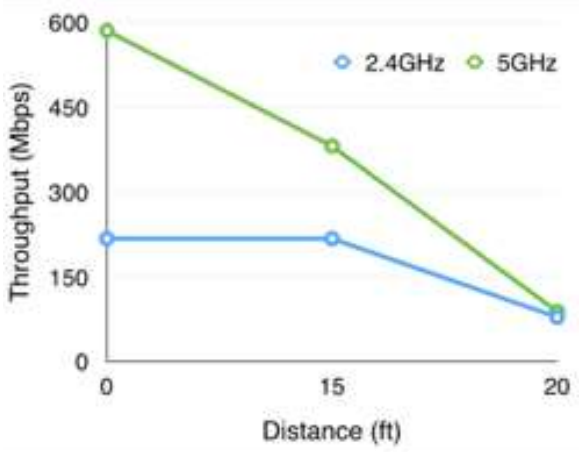

Figure 2. Dual Band Throughput Analysis (802.11n/ac)

The above images show results of throughput analysis performed using a 802.11n/ac Asus Router RT-AC66U in a closed environment.

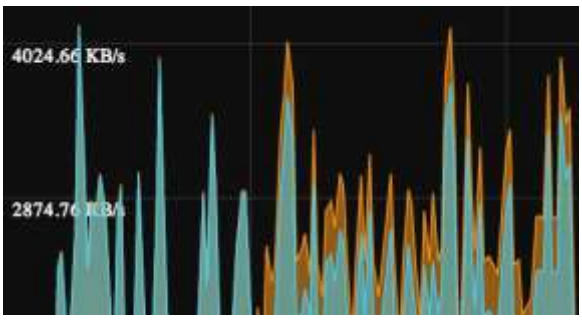

Figure 3. Wireless Streaming On 802.11n/ac in 5GHz Spectrum

802.11ac and 802.11n standards have been specifically designed considering multimedia streaming as a major application. In spite of performing numerous tests in a non ideal closed environment with several interfering devices operating in the frequency band of 2.4GHz, leading to the attenuation of our signal, we obtained staggering result viz. a throughput of 585Mbps in 5GHz spectrum and a throughput 217Mbps in 2.4GHz spectrum which sums up to 802Mbps.
These humongous throughput rates allowed us to stream Full High Definition Multimedia content simultaneously on three devices without any jitter.

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Conclusion

As time passed, the world gradually advanced from the primitive and obsolete 802.11 standards to more efficient addendum's of the same. The 802.11 and its modifications gave rise to an eclectic set of features for wireless communication. Furthermore, the 802.11ac standard stands out as one of the groundbreaking advancements to have ever been implemented in the domain of computer networks. The ancestral 802.11n wireless technology standard has captured the majority of the current market share. 139.1 million 802.11n Wi-fi routers were shipped worldwide in 2013. But with so much variation in a single technology, it becomes very difficult to maintain a cohesive universal standard. However device manufacturers have accelerated the production of 802.11ac devices since 2013, which cater dual-band access in order to provide backward compatibility service to the existing 802.11n devices. While we are talking about 802.11ac, the next generation technology 802.11ad is being tested and perfected, and the scope for which knows no bounds; the sky is the limit. If planned and executed perfectly, the transition from its predecessors to the modern 802.11ac/ad would be a revolutionary innovation in the filed of wireless technology.

Acknowledgements

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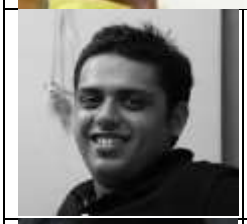

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