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Right Wi−Fi® Technology for Multi−Media Distribution

Best and not “Almost Good Enough”

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Right Wi‐Fi® Technology for Multi‐Media Distribution

Overview

Mainstream wireless video service is happening faster than anticipated. Service providers are realizing the three fold benefits of deploying such services:

- Deployment costs are reduced by millions of dollars
- Revenue per household increases due to the ease of adding new screens
- Revenue per user increases with the addition of compelling new services enabled by the wireless ecosystem

Deploying such services is presenting challenges as Wi‐Fi evolves from a convenient and pervasive data pipeline into a solution that can deliver carrier grade HD quality video, with wire‐like performance and reliability. The Wi‐Fi standard has been updated to deliver higher throughput, extended range, and support for mobile devices. Higher throughput and extended range are required to support extensive video traffic for whole home coverage as Wireless Set Top Boxes have gained significant traction in the market. Mobile devices require fast transfer rates to preserve battery life, and consumers are quickly adopting mobile devices as a preferred choice for viewing video. The key advances of the Wi‐Fi standard for video delivery and whole home coverage are higher order Multi‐Input Multi‐Output (e.g. 4x4 MIMO), Multi‐User MIMO (MU‐MIMO), Digital Beamforming and higher density Modulation and Coding Schemes (MCS). The 5 GHz spectrum offers ample bandwidth with the potential of satisfying the needs for mass deployment of whole home video and data service, but only if managed properly.

Service providers' qualification cycles are long and the deployed hardware is the foundational infrastructure upon which services will be built for the coming years. How can Service Providers be sure that their wireless network not only support existing needs but will also have ample margin to support future use models and environmental changes?

This white paper lists major criteria to consider when selecting Wi‐Fi technology for the deployment of paid video and data services. As service providers seek to differentiate themselves, the winners in this space will make sure that their network operates in DFS channels, support multiple wireless clients by using the available spectrum efficiently and have sufficient margin to support future devices that would join the network.

Introduction:

Motivations for High Performance Wireless Distribution and Use of Wi−Fi:

An impressive technological shift has positioned Wireless as a viable solution for paid video service distribution inside the home. Video services from Telcos, MSOs (multi service operators), and Satellite Service Providers demand a higher class of performance, range and reliability than what traditional wireless systems have provided. Historically, wireless has been known for convenience but not quality. As new generations of wireless devices using advanced technologies such as 4x4 MIMO are deployed, the paradigm is changing as convenience does not have to be separate from quality and performance.

The low cost of installation of wireless and its intuitive ease of use will enable hundreds of millions of dollars in OpEx saving. Furthermore, the timing for the shift to wireless is right as lowering the CapEx and enabling new services are parallel factors driving a new generation of devices. To lower the CapEx, IP distribution inside of the home is becoming more dominant by concentrating the main functionalities such as DVR and tuner in one master set top box (or cloud DVR) per home. Additional set top boxes can then be just low cost thin clients connected via an IP network. Deploying new services will be required to maintain competitiveness and enable new sources of revenue. Going forward, enabling multiple mobile devices as portable TVs will be very important for Service Providers to compete with Over−The−Top (OTT) services such as Netflix, HBO Go, Catch−up TV, and Hulu. New services such as home automation, security, and video conferencing are breaking through the economic and technical barriers to finally deliver on the long awaited promise of the digital networked home.

Utilization of Wi−Fi in the 5 GHz band is the best technology to provide connectivity for these applications. Wi−Fi is the dominant interface standard (wired or wireless) going forward; there were about 1.5 Billion Wi−Fi enabled devices sold in 2012 and it is anticipated that more than 2 Billion new Wi−Fi enable devices will be sold in 2015.

What to consider in selecting the next 802.11ac solution?

- *Build for the future and not just for today*
- *Be able to operate in any portion of the available 5 GHz band to avoid interference*
- *Use available spectrum as efficiently as possible to achieve the required throughput*
- *Output Power: Less is better*
- *Wi−Fi advanced features are important: Video requires special care*

Criteria for Selecting Next 11ac Solution

Build for the Future and not just for Today

Deploying Wi−Fi technology for Multi−Media Distribution covering the whole home is a long term infrastructure investment; long deployment duration will allow the best amortization of the total system cost.

The wealth of applications to utilize the increased bandwidth of today's Wi−Fi standards is yet to be realized. The infrastructure should support future applications as the means of additional revenue for service providers. Using the similar analogy as storage and computing, the state of the art is exhausted quickly. While the FCC is looking to increase the 5 GHz band for Wi−Fi use in the long term, the number of users to compete for the same band is growing faster than ever. There were about 1.5 Billion new Wi−Fi devices in 2012 and the number will continue to grow. As consumption of both available channels and airtime within each channel of the 5 GHz unlicensed band increases, so increases the probability of RF interferers. Carriers need to deploy systems with as much margin as possible to assure the robust reliability consumers expect.

Figure 1 an 2 show a typical deployment house with only two clients but one of them considered to be in challenging location, i.e. a location with limited Wi−Fi reception. As Figure 2 shows, everything assumed equal (power, interference, coding gain, etc.), the 4x4 MIMO system, independent of being 802.11n or 802.11ac, provides up to 70% margin for future expansion. A 3x3 MIMO system is not able to close the link independent of being 802.11n or 802.11ac. This is primarily due to the fact that benefits from 802.11ac diminish at extended range while the benefits of 4x4 MIMO are consistent across distance or network topology.

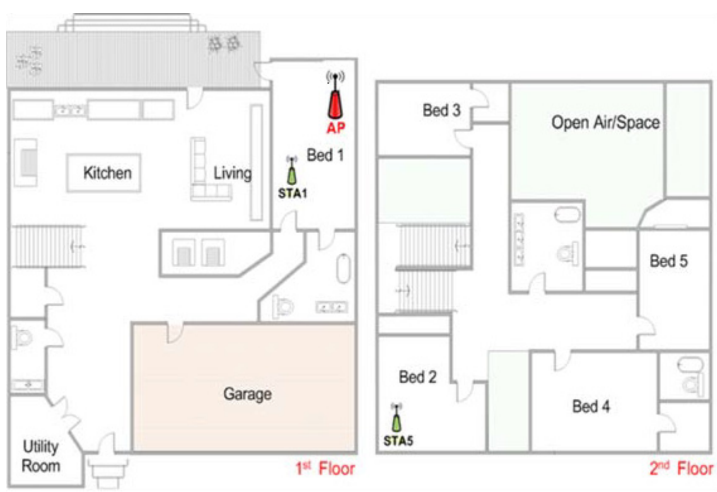

Figure 1. Example of Home Deployment with Two Set Top Boxes in a Typical Home

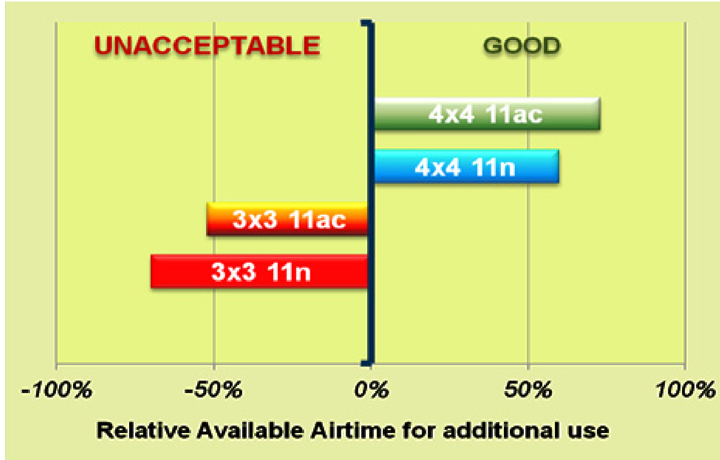

Figure 2. The Available Airtime in Percentage of Available Airtime When Delivering 15 Mbps to Each Set Top Box in Figure 1. The 3x3 11ac and 3x3 11n Networks in this Case are Oversubscribed and Cannot Guarantee the Service

Be Able to Operate in any Portion of the Available 5 GHz Band to Avoid Interference

Some of the channels in the 5 GHz band used by 802.11ac/n/a are reserved for radar operation. It is now allowed for an AP to use these channels as long as they behave according to a protocol named Dynamic Frequency Selection (DFS). Figure 3 shows these DFS channels relative to the 5 GHz spectrum.

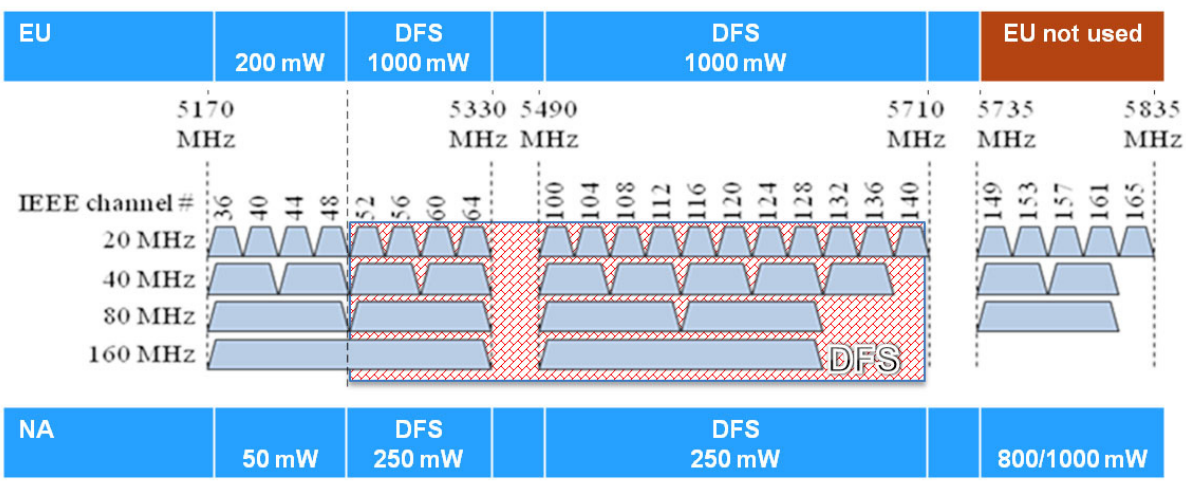

Figure 3. DFS Channels in 802.11ac for Europe and North America and the Maximum Power Allowed Per Channel, Channels 120−128 currently restricted in Some Regulatory Regions, including the U.S

DFS dictates that to be compliant, the AP must be capable of detecting the presence of radar signals. If a radar signal is detected, the AP must stop transmitting on that channel to protect the radar service. Wireless transmission continues by either jumping to a non DFS channel and immediately continuing transmission, or selecting a different DFS channel, but transmission resumes only after monitoring the new DFS channel. Advanced Wi−Fi systems designed for video delivery must be designed with smart channel switching services. Smart channel switching must allow the AP to tell all clients an organized channel change is occurring so that all clients jump simultaneously. In this manner, the wireless channel change is not perceived by the consumer as degradation in video quality.

Achieving DFS certification is much easier than providing true DFS stability. DFS stability is required for reliable carrier grade video delivery. DFS certification can be achieved simply by jumping away from the DFS channel when any interference is detected, regardless of whether a radar pulse was the cause. The detection and identification of a true radar signal by the AP is a complicated task and could be erroneous. It is important that the AP reliably detect the actual on−channel radar and only jump channels in the presence of a true radar signature. Accurate detection presents a set of difficult problems for the systems and software designers of Wi−Fi equipment. The majority of retail Access Points are either not DFS certified or if certified, cannot use the DFS bands effectively. This means that the overcrowding of the non−DFS bands will only worsen in the future. Devices must not only be DFS certified, but also they must be able to maintain continuous transmission in the radar bands.

Use Available Spectrum as Efficiently as Possible to Achieve the Required Throughput

While support of 80 MHz is mandatory in 802.11ac, the standard also allows transmitting using 20, 40, and 160 MHz channel bandwidths. The multiple channel widths correspond with a varying number of total channels per region. For whole home video distribution, 40 MHz and 80 MHz mode provide the most viable combination of range versus rate and quality of service. 40 MHz and 80 MHz modes offer the following number channels[1]:

- 40 MHz channel width provides 9 channels in US and up to 7 channels in the E.U.
- 80 MHz channel width provides 4 channels in the US and 3 in the E.U.

For Service Providers implementing a mass deployment for wireless video distribution, a key goal must be to minimize the impact of interference. In contrast, if the system goal was to design a system mainly for high burst traffic to mobile devices, utilizing 80 MHz or 160 MHz channel width would be optimal as it enables fast transmission and with that better battery life. But what’s optimal for mobile devices does not translate into the best mode of operation for video delivery where robust and uninterrupted quality of service is paramount. Paid video distribution in the home utilizes thin clients such as a Set Top Box receiver which is neither battery operated nor requires high bandwidth streams.

The key tradeoff between paid whole home HD quality video distribution and consumer mobile devices and can be reduced to the optimal channel width for each application. When channel bandwidth increases (better for mobile devices), the number of available channels more than

[1] FCC is considering augmenting the existing 5 GHz band with addition spectrum for Wi−Fi use in USA.

proportionally decreases. With fewer channels available, chances increase that different networks (BSSs) will have to share a channel. This is easily demonstrated in the Figure 4.

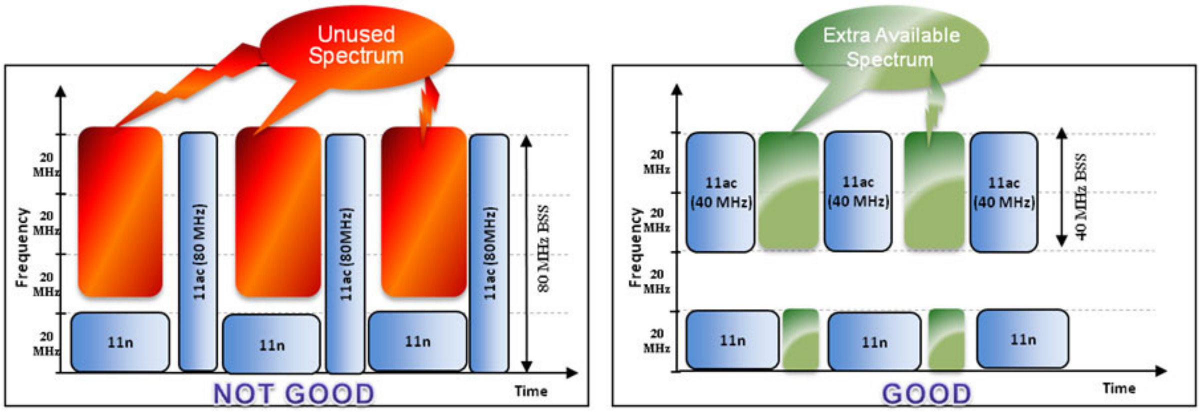

Figure 4. Utilizing 80 MHz in The Presence of Interference Does Lead To System Inefficiencies

In the left part of the Figure 4, we illustrate a case where an 80 MHz network overlaps with a legacy 20 MHz system. Whenever the 20 MHz system accesses the medium, it pre−empts usage of the entire 80 MHz band. This contention between the 20 MHz and 80 MHz networks leads to very inefficient usage of the 80 MHz channel, leaving little margin for interference, additional clients, new services, or environmental changes for the 80 MHz network. On the other hand, when configured to operate in 40 MHz mode (as illustrated in the right part of the Figure 4, a 40 MHz network can perform its channel selection to avoid the 20 MHz legacy system. This gives it exclusive access to a 40 MHz channel, resulting in much better usage of the total spectrum as contention is now avoided. When contention free, the performance an 80 MHz channel can achieve is desirable, but basing mass deployment depending exclusively on 80 MHz bandwidth is risky. Ensuring deployment criteria is met for both 40 MHz and 80 MHz channel widths facilitates the avoidance of channel sharing and contention between networks by virtue of providing a higher number of channels and better granularity to fill the spectrum.

Output Power:Less is Better

It does not matter what option of the 802.11 standard the device is using, the more power out of the antennas, the further that signal travels in the air. This is just the simple laws of physics. Achieving the same performance with less power will yield less environmental noise or interference.

Having low interference is especially important for Service Providers as they deploy across entire neighborhoods and MDUs. Service Providers can significantly reduce environmental interference by deploying devices that meet the performance objectives with less power.

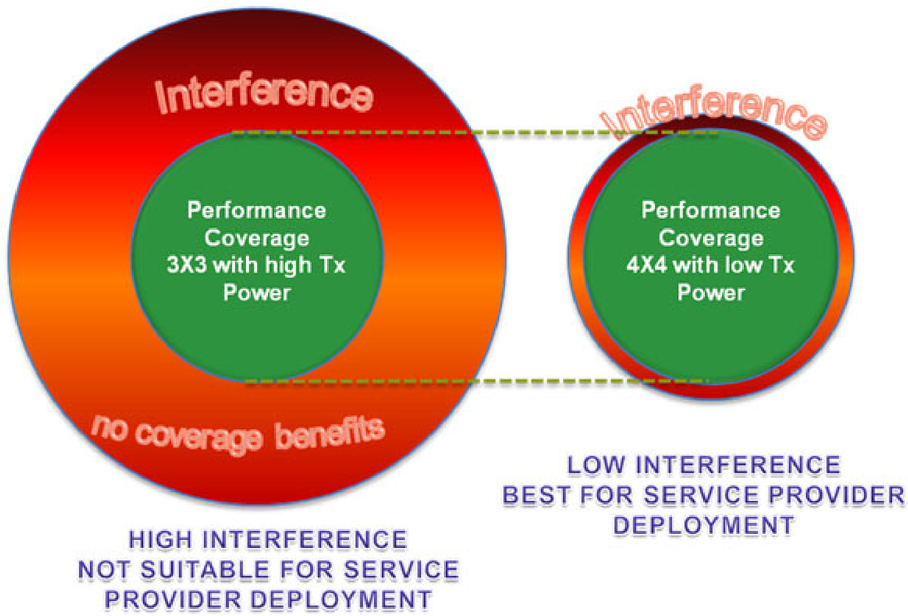

Figure 5. 4X4 Can Deploy With Lower Tx Power and Will Provide The Same Coverage with Less Interference and Implementation Issues

In Figure 5, the 3x3 MIMO network *"theoretically"* may achieve the same desired performance as 4x4 MIMO Networks but with significantly more environmental noise to neighboring systems. However an implementation of such system is not practical. It is worth noting that enhancing performance by simply increasing the transmit power is not always feasible.

This is due mainly for the following reasons:

- Each wireless channel has a maximum specified transmit power. A lower order MIMO system cannot simply increase its Tx power past the regulatory limit to make up for its design limitations.
- The increase of Tx power also equates to increase of interference to neighboring networks. For a Service Provider, interference from overly powerful neighboring networks will cause contention and higher packet errors on both networks, which has the reverse effect on performance.
- All Wi−Fi networks require "positive acknowledgement" for each transmitted frame. Thus simply increasing transmit power (yelling) does not help unless the receiver is proportionally improved to hear the acknowledgements back from the clients. Higher order MIMO provides much better sensitivity to listen for acknowledgements from all types of clients.

Figure 6 demonstrates the actual gain from using high Tx power in real life deployment. While high Tx power may be good for showing controlled video demos or for non−critical data services, service providers should consider real deployment scenarios when evaluating a Wi−Fi solution.

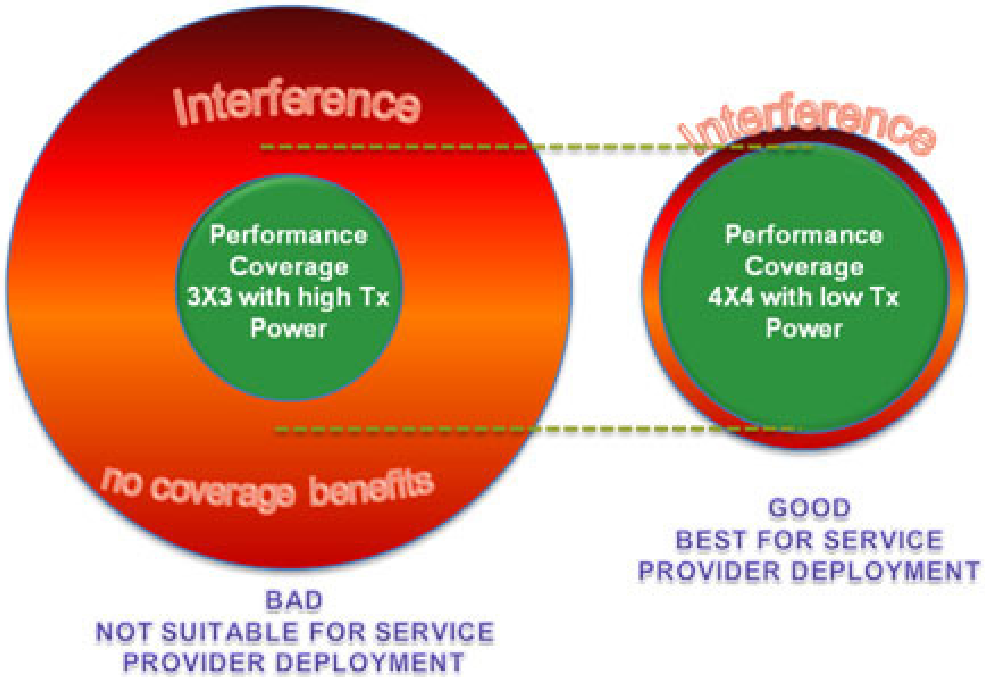

Figure 6. Actual Gain in Real Deployment Environment. 3x3 Coverage Will Suffer Even with High Tx Power while 4x4 Coverage Stays the Same

Higher power solutions have additional implementation risks such as a larger BOM cost, complex thermal design, EMI considerations, and energy compliancy (EU CoC) while the benefits are nominal or none. For example, in the US, a 1000 mW system will yield a benefit on only a single non−DFS 80 MHz channel. In the EU, a 1000 mW implementation may push system power consumption over regional agreements. The deployment of maximum power systems may not yield desirable results or be the best implementation for supporting the performance needs of multiple households. Therefore, most of the systems converge to implementations with equal power. Figure 7 demonstrates the advantages of using higher order MIMO when Tx power is equal.

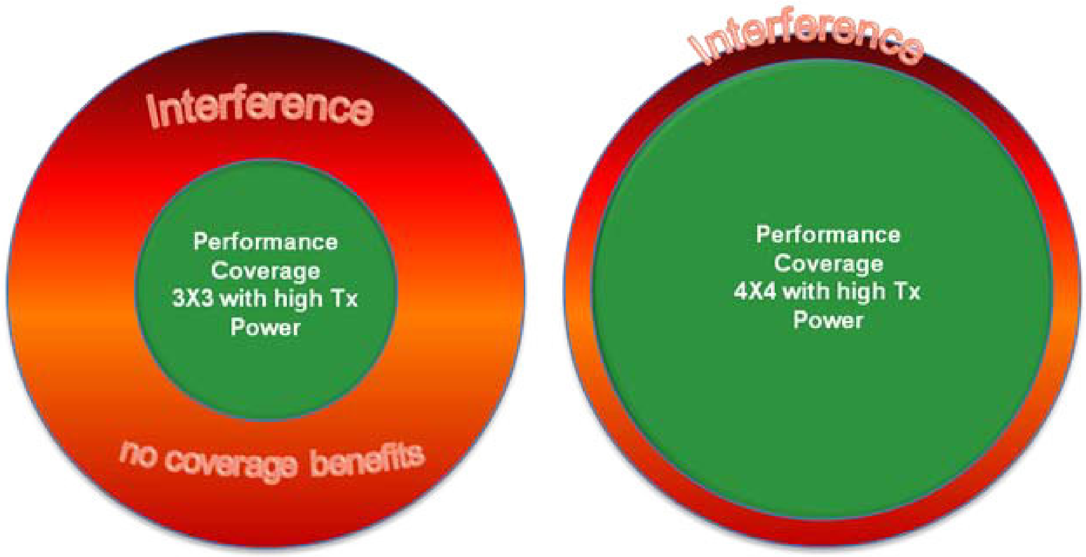

Figure 7. With High Tx Power, Higher order MIMO Provides Unparalleled Coverage

Using a 4x4 MIMO solution can deliver either twice the performance at equal power or the same performance at less than one forth the power when compared to 3x3 MIMO solutions. Utilizing better technology will enable the requisite performance levels with lower transmit power and therefore limit the interference to adjacent units. This is especially true when deployment happens in neighborhoods with closely spaces homes or apartment complexes.

In conclusion, Service Providers must weigh the questionable benefits of trying to overcome design limitations of lower order MIMO solutions simply by using maximum transmit power. Using a highly efficient 4x4 MIMO system provides a simple and reliable deployment model to cover installations ranging from large houses through MDUs.

Wi−Fi Advanced Features are Important: Video Requires Special Care

There are many options specified in both the 802.11ac and 802.11n standards that provide chipset and system developers with the flexibility to optimize their design for one or more of the following parameters: performance, range, reliability, cost, and power consumption. For example, Wi−Fi solutions available today have range from 1x1 to 4x4 and there are a wealth of other optional features such as unequal MCS, LDPC, Digital Beamforming, and STBC available for implementation. Implementation tradeoffs are highly dependent on the application used. For mobile devices, power is the most important, next is cost and lastly performance. In contrast, for whole home video distribution and general access points, higher performance connectivity with continuous error free distribution is a must. Error free video in the presence of interference cannot be compromised.

While best effort data communication can easily withstand the rate fluctuations and burst packet errors of standard quality Wi−Fi, carrier grade video requires maintaining a minimum throughput and any packet errors are detrimental to the consumer’s Quality of Experience.

In recent years, there has been a wealth of features developed purely for Video Centric Wi−Fi to optimize network performance and protect video quality in presence of interference. Examples of such features are smart channel switching schemes, Video centric QoS, Transmit Digital Beamforming, MU−MIMO and more.

Conclusion

Not all Wi−Fi solutions are created equal. There is no such thing as "almost good enough" wireless performance for paid video service inside home. *Maximum performance delivers maximum revenue and maximum cost savings.* The figure of merit for performance is multi−dimensional and should include the airtime margin, whole home coverage, tolerance to error, and agility and adaptability to the environment. Service providers deploying wireless video distribution systems must manage their systems wisely to preserve as much bandwidth as possible and maximize their ROI.

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