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Whitepaper

3DHD Wireless: WiFi Technology for HD and 3DHD Delivery

Satisfying the demands of interference free reliable streaming of video over wireless

Introduction

The ability to wirelessly deliver multiple streams of high-definition video throughout today's connected homes is a hot topic. In addition to eliminating the cost and hassle of physical cabling, moving video reliably over Wi-Fi to HDTVs also makes it easy to position additional HDTVs at any location within the home. However, as with any wireless communication, bandwidth and interference challenges must be overcome before high-quality video can be effectively transmitted via wireless methods.

Today's high definition video requires a significant amount of bandwidth. This bandwidth requirement is even greater for 3DHD, since 3D involves 2 separate HD streams, one for each eye. As the number of consumer electronics wireless devices continues to increase, the lack of the bandwidth will become more of an issue. Additionally, the large number and wide range of wireless devices – both inside the home and in neighboring homes – crowd the wireless spectrum, which creates interference. Most Wi-Fi devices, from cordless telephones, to baby monitors, to microwave ovens, utilize the 2.4 GHz band. As a result, the band is extremely crowded and device interference is quite common. For this reason, the preferred band for video delivery is 5GHz, since it is less crowded and interference is greatly reduced.

Two additional advantages of using the 5 GHz band are the number of channels available in the band, and the higher path loss for the 5GHz frequency. The 5GHz band has more than double the number channels as 2.4 GHz. It also includes several non-overlapping channels, compared with only 3 non-overlapping channels that are available in the 2.4 GHz band. As a result, more devices can share the 5GHz band without interfering with one another. Additionally, the higher path loss for the 5GHz frequency means that the signals are absorbed by the walls and other obstacles in a greater scale. This can be both good and bad. The disadvantage is that it decreases the range of signals inside the home. However, the major advantage is that there is less interference from neighboring homes.

Regardless of the band employed, wireless signals, by their very nature, continuously face interference from obstacles and other wireless devices close to their transmission path. Therefore, technologies such as MIMO, beamforming, Channel aware wireless, and STBC are recommended to minimize this interference and secure reliable and high performance video delivery in every corner of the house.

4x4 MIMO Antenna Technology

MIMO systems employ multiple antennas at the transmitter and receiver, which significantly increases data rates, range, and reliability – without the need for additional band or transmit power. These benefits are obtained by exploiting the spatial dimension associated with the multiple antennas. Specifically, utilizing several antennas at both the transmitter and the receiver can create multiple independent channels for sending multiple data streams.

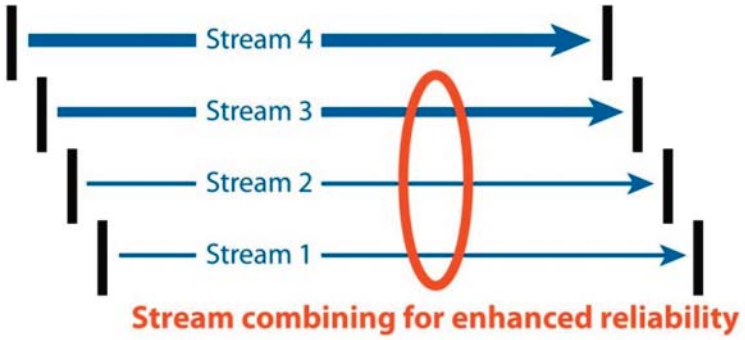

Figure 1. 4x4 MIMO with four data streams

The number of independent data streams that can be supported over a MIMO channel is determined by the number of antennas at the transmitter or receiver. As illustrated in Figure 1, a 2x2 system can support two streams, a 3x3 system can support three streams, and a 4x4 system can support four streams. To increase reliability and range, some of the independent streams can be combined through dynamic digital beamforming and MIMO receiver processing. Table 1 illustrates the probability of supporting one or two data streams at the maximum data rate (64 QAM) in 2x2, 3x3, and 4x4 systems. Notice that a 4x4 MIMO system with dynamic digital beamforming and MIMO receiver processing is capable of supporting two maximum-rate data streams 99 percent of the time. Other configurations are less reliable, since they have fewer antennas and thus fewer extra spatial dimensions that can be combined.

MIMO Configuration	2x2	3x3	4x4
Percentage of channels supporting 1 max-rate data stream	99.5%	100%	100%
Percentage of channels supporting 2 max-rate data streams	4.4%	68.1%	99%

Table 1. Reliability of 64 QAM for 2x2, 3x3, and 4x4 MIMO

Dynamic Digital Beamforming

Dynamic digital beamforming dramatically reduces the interference between various data streams. Without this technology, placing extra antennas at the transmitter would not be very useful. As illustrated in Figure 2, dynamic digital beamforming avoids interference by applying optimal complex weights to each transmit antenna, thereby steering the energy of the antenna array in independent spatial directions associated with the various data streams.

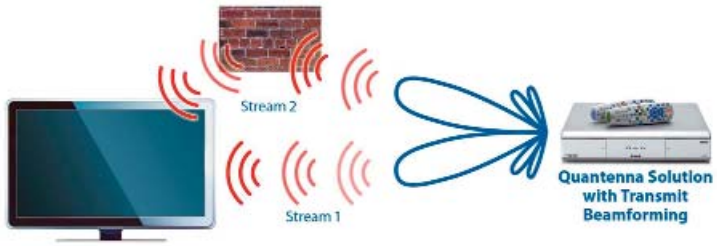

Figure 2. Dynamic Digital Beamforming in a 4x4 MIMO System with Two Data Streams

This optimal weighting requires channel estimation at the receiver, as well as explicit feedback of the weights or channel estimates from the receiver to the transmitter. Implicit transmit beamforming, where the weights are based on metrics such as minimizing packet error rate, can also be used. However, this method is far less effective than basing the weights on explicit channel measurements.

A 4x4 MIMO configuration supporting two data streams provides two extra transmit antennas for beamforming, which allows energy to be significantly focused in two different directions. This feature not only improves reliability, but also reduces interference with coexisting systems, since steering energy in the direction of the desired receiver moves it away from other locations. In contrast, a 3x3 system is significantly less reliable, since only one extra antenna is available to focus energy in the two required directions. Similarly, a 2x2 system exhibits negligible transmit beamforming performance gain, since there are no extra antennas beyond the minimum requirement. Therefore, while dynamic digital beamforming will work with any number of receive antennas, it is most powerful in a 4x4 configuration with MIMO receiver processing optimized for the transmit beamforming weights. Figure 3 illustrates the Packet Error Rate (PER) for a 4x4 MIMO configuration with dynamic digital beamforming, compared with 3x3 and 2x2 MIMO configurations that do not employ this technology.

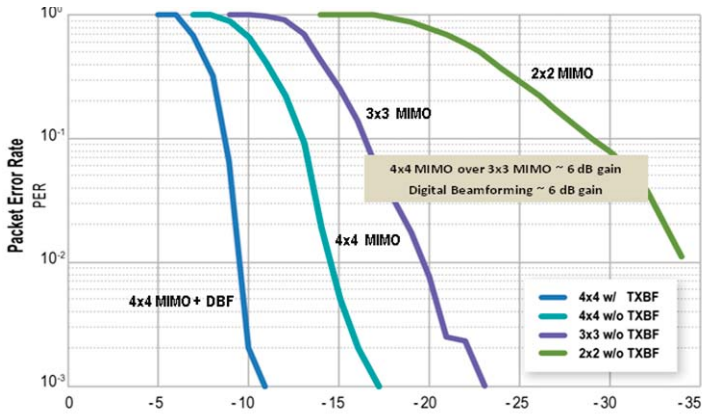

Figure 3. Packet Error Rate versus received SNR for various IEEE 802.11n systems (MCS12, 40 MHz, Channel D, 1000 Channels, 1000 byte packets)

Space-Time Block Code (STBC)

Space-Time Block Code (STBC) sends multiple copies of the data stream over multiple antennas. Because antennas are affected by reflection, thermal noise, and other environmental difficulties, their ability to successfully transmit data can vary dramatically at any given point in time. STBC combines the redundant copies to properly decode the received signal, thereby maximizing deliverability of the entire data stream.

Summary

HD and 3DHD TV content require significant amounts of sustained reliable bandwidth to deliver a high-quality, high-resolution experience. As more video content moves to these display formats to be shared amongst a growing number of televisions, there is a corresponding need for significantly more wireless bandwidth with 99.9% reliability.

Achieving this wireless bandwidth demands robust Wi-Fi transmission that is capable of eliminating the impact of interference from physical in-home obstacles, as well as from other wireless devices. By using 4x4 MIMO and transmit beamforming, transmitted signals are less sensitive to interference and better capable of decoding received signals with greater accuracy. The higher MIMO antenna order is necessary to send multiple data streams over multiple independent channels to increase data rate and range without requiring additional transmit power or bandwidth. Meanwhile, dynamic digital beamforming delivers the necessary range and data rate improvements for HD video transmission by better focusing signal energy in the direction of optimal connection performance, while reducing interference with other coexisting systems. The combination of 4x4 MIMO and transmit beamforming enables video to be wirelessly delivered to any corner of the house to ensure the best possible user experience.