Cellular Networks Keep up with Video, Data Demand by Offloading to WiFi with MIMO Antennas

PCTEL®
Connected Solutions

Anyone who has recently been to a major sporting event knows that there is more going on inside the venue than the sport itself. Mobile wireless devices are in full use. People are checking other games to see how their "fantasy" football and baseball players are doing. Cameras are flashing, fingers and thumbs are busy sending texts, while comments and videos are uploaded to social networking sites. Entertainment venues, transportation hubs and office buildings experience the same high demand for transferring data between the network and device. And the data traffic is only going to increase in the future.

The exploding use of multi-media through smartphone technology is expected to fuel cellular growth. A recent release by research firm iSuppli Corp. reports that global smart phone shipments are expected to increase 105% from 246.9 million in 2010 to over 506 million units by 2014.[1] This growth has put tremendous pressure on the capacity of existing cellular networks.

Wireless voice and data offloading

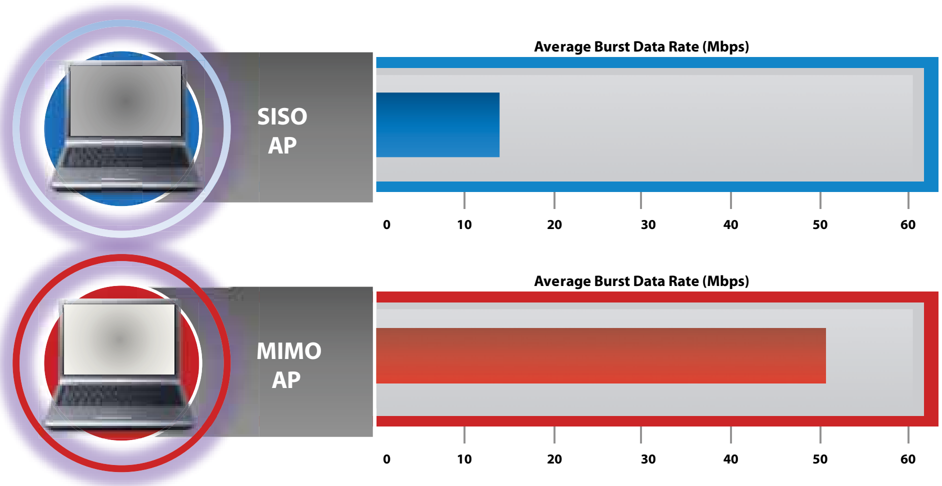
As a result of this increasing demand for voice and data video streaming capabilities worldwide, IT network architects and cellular operators are leveraging 802.11n-based wireless LAN networks that utilize Multiple Input Multiple Output (MIMO) antenna technology to off-load and support the high data rate demand.

Single Input Single Output (SISO) vs. Multiple Input Multiple Output (MIMO)

Conventional 802.11 (a,b, or g) networks typically utilize Single Input Single Output (SISO) technology. This technology utilizes a single transmitter and a single receiver with either one or two antennas on each side. Networks that use this technology are designed to avoid multipath and line-of-sight obstacles that can create signal nulls and degrade wireless coverage.

APPLICATION NOTE

Multiple Input Multiple Output (MIMO) technology uses multiple transmitters and receivers. It leverages multipath signals to deliver enhanced data throughput, range, reliability and spectral efficiency, even in environments that would typically be susceptible to line of sight interference and signal fading. In optimal signal to noise ratio (SNR) conditions, a data stream can also be split between multiple transceivers with independent antennas for transmission allowing for higher data rates. This is an ideal technology for offloading data traffic from cellular to WiFi networks.



In MIMO 2x3 Receive Diversity Systems, smart antennas use spatial diversity technology to improve signal-to-noise ratio. For example, if the receiver has more antennas than spatial streams (in a 2x3 system two antennas transmit while three antennas receive) the third antenna can add diversity to the receiver end, improving system robustness through longer distances at given speeds.

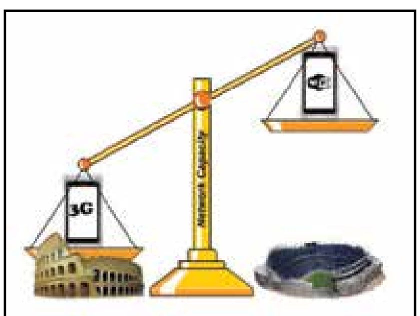
When multiple spatial streams are used with MIMO (3x3, three transmit antennas and three receive antennas) it is called SDM (Spatial Division Multiplexing). This method requires advanced signal processing for transmit (Tx) and receive (Rx) streams in order to avoid cross signal interference that can lead to degraded system performance. Spatial streams require complete matching Tx/Rx radio links while diversity only systems require a single Rx (receive) radio.

Several of the 802.11n wireless LAN systems that are currently being deployed are dual band covering 2.4GHz and 5GHz bands. These systems get deployed in a variety of different locations including transportation hubs (airports, train stations etc.), entertainment venues (stadiums, concert halls etc.) and office buildings, to name a few. Each of these locations present their own set of propagation environment, coverage, and antenna installation challenges. Most of these locations are space constrained resulting in requirements for compact antennas. Aesthetics are important, so antennas need to either blend in with the environment or have to be hidden in locations that may not be ideal for radio signal propagation and coverage.

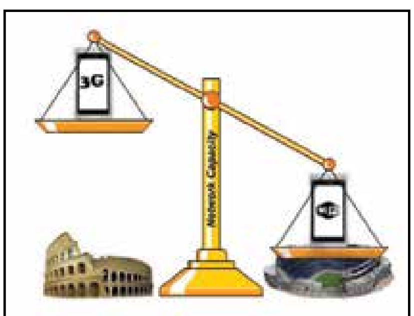
Multiple stand-alone antennas are commonly used in MIMO systems, but because the spacing and interaction between the antenna elements are crucial to achieve optimal throughput rates, system designers often opt to house multiple antennas into a single radome. This allows them to control the exact spacing between the antenna elements.

Since antennas are also utilized to mitigate multipath, the propagation environment needs to be taken into consideration. That is why antenna installation and placement requirements should be thoroughly understood at the beginning of the design cycle (for example, will the antenna be wall, mast or ceiling mounted?). Other considerations, including customer size restrictions for the antenna as it relates to cosmetic or practical installation issues are also important, but often overlooked, until far too late into the design development cycle.

WLAN MIMO antennas typically involve multiple elements covering 2.4GHz and 5GHz frequencies in a single housing with each element linked to a separate transceiver. A well designed MIMO antenna must provide consistent radiation patterns among spatial streams, stable gain performance across all the operating frequencies, and proper isolation between radiating elements. Because electrical performance is dependent on the size of the antenna, larger antennas can provide higher gain and narrower beam widths which are ideal for deployments where there is a high concentration of data intensive users.



Yesterday



Today

So let's revisit the sport venue where it is crucial to have dual band 802.11n coverage for offloading voice and video traffic from smart phones. A professional football stadium could require as many as 200 access points, with each access point providing coverage over a fairly narrow area to limit the number of users and minimize interference. Antennas for these access points need to have narrow beam widths, about 35 degree elevation and 55 degree azimuth. One needs a larger antenna housing (about 14" x 14") to achieve this beam width and to collocate 6 antenna elements (3 for 2.4GHz and 3 for 6GHz) with ideal port to port isolation. This design would yield a gain of 12dBi or higher for both frequency bands, although gain may have to be attenuated to meet FCC requirements.

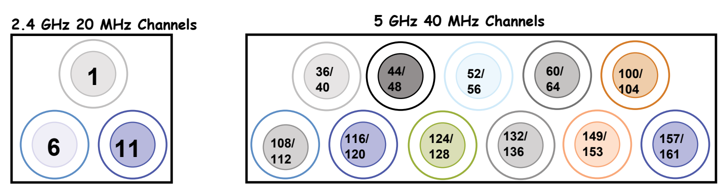
A well designed antenna would yield fairly consistent patterns across frequency range and among different radiating elements. There may be several scenarios where space is limited and a 14" x 14" housing may be too large. For these cases, one can consider smaller 8"x12" housing as an example. This design will face several challenges in meeting the desired specifications as the beam width would be larger, approximately 35 degree elevation and 90 degree azimuth at 2.4GHz. Port to port isolation between elements would suffer and would be about 10dB lower than the larger antenna. Gain would be lower and patterns would not be as consistent due to reflections caused by the close proximity of other radiating elements.

Customer expectations for higher gain in small packages, set by their experience with traditional SISO systems, have forced designers to find attractive, less obtrusive ways to implement their MIMO systems. As long as the antenna designer has a full understanding of the system requirements, various techniques can be utilized to achieve the optimal MIMO antenna design.

For example, to address size constraint issues while delivering required spatial stream RF properties, designers can optimize their antenna designs by making fine adjustments to the antenna radome shape or thickness; also, variations in the placement and/or the spacing of the antenna elements within the required footprint can help a designer achieve targeted azimuth ripple or isolation specs, despite the size constraints.

Demand for high data rate applications will continue to grow and MIMO based 802.11n WiFi systems will play a key role in enabling high throughput wireless access. In addition, by freeing up scarce network bandwidth through offloading, these efficient networks will help carriers retain customers, decrease operating costs, and increase customer satisfaction.

- 5 GHz Recommended for 802.11n
  - – More available spectrum; greater number of channels
  - – Benefits from 40 MHz channels, although 20 MHz still works well
- 2.4 GHz still benefits from MIMO and frame aggregation
  - – Ideal for legacy applications (handhelds, scanners, & medical applications)



CONTACT PCTEL FOR ASSISTANCE WITH CELLULAR OFFLOADING SOLUTIONS

PCTEL, Inc. is a customer-focused company dedicating its research and development to create high performance antenna products to meet market needs.