Research Alert

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MIMO Technology
is Today's Most Significant Advance in Wireless Communications— but not all MIMO Claims are Accurate

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Multiple Input/Multiple Output (MIMO) is an area of intense development in the wireless industry because it delivers profound gains in range, throughput and reliability. As a result, manufacturers of wireless local area network (WLAN), wireless metropolitan area network (WMAN), and mobile phone equipment are embracing MIMO technology.

However, not all manufacturers claiming MIMO or MIMO benefits are using the term as defined and understood by the majority of researchers in industry and academia. By wrongly invoking the term "MIMO" vendors obscure a momentous technological development.

Misuse of "MIMO" is a disservice to consumers facing an urgent problem: wireless LAN products based on existing Wi-Fi standards don't always have sufficient range to cover entire homes. Wireless LAN products incorporating genuine MIMO technology often solve this problem, while products claiming "MIMO" based on the use of multiple antennas or channels may not.

MIMO and pseudo-MIMO

"MIMO," as understood by engineers and academics, refers to the use of multiple, simultaneous signals (two or more radio waveforms) in a single frequency channel to exploit multipath propagation and thereby multiply spectral efficiency. Numerous conference presentations and refereed research papers[1] support this understanding of the term.

[1] The first description of a spectral efficiency multiplying MIMO system was published in the GLOBECOM 96 conference proceedings.

Prior to the development of MIMO, wireless communication systems treated multipath propagation as a problem to be mitigated. MIMO is the first wireless communications technology that treats multipath propagation as an opportunity—an inherent feature of wireless communication environments that may be harnessed to multiply link capacity[2].

Multiplying link capacity greatly increases throughput, range, and reliability. For example, wireless LAN products implementing MIMO have demonstrated in laboratory tests, field tests and commercial applications the ability to cover areas at least twice as large as conventional wireless LAN products at comparable or better data rates with comparable or better reliability[3,4].

Some vendors claim wireless products that use smart antennas and/or multiple channels employ "MIMO" or deliver MIMO benefits. More accurately, these products employ diversity to mitigate multipath fading, beamforming to reduce the amount of energy lost to multipath propagation, and multiple channels to increase bandwidth.

Diversity and beamforming are legitimate enhancements to conventional, one-dimensional wireless communication systems[5]. But they are not MIMO—a method of communicating in two or more dimensions simultaneously.

The upshot is that MIMO systems multiply spectral efficiency and capacity by encoding, transmitting, receiving, and decoding multiple signals. Other systems deliver incremental increases in spectral capacity or multiply capacity by multiplying the amount of spectrum consumed—spectrum not always available.

Implications

The proposed IEEE 802.11n standard strives to draft technical specifications for the next generation of high throughput WLAN technology. Supporters of the two leading 802.11n proposals—firms such as Broadcom, Intel, Qualcomm, and Texas Instruments—are promoting genuine MIMO solutions. Vendors delivering genuine

[2] A feature of MIMO systems discussed in a *Bell Labs Technical Journal* article in 1996.
[3] "Wireless Performance Evaluation," Belkin Corp. Wireless "pre-n" Router, The Tolly Group
[4] "Wireless LAN Keeps Roofing Maker's Data Safe," *eWeek*, September 13, 2004
[5] For example, "Optimum Combining in Digital Mobile Radio with Cochannel Interference" describes the use of multiple antennas to combat fading. See bibliography.

MIMO wireless LAN products today include Airgo Networks, Belkin, Linksys, and SOHOware. Samsung has announced a MIMO-based wireless LAN. Orthogon Systems has field-tested a MIMO-based wireless MAN.

The wireless industry and market must demand accurate use of the term "MIMO" to prevent vendors from making spurious claims, help customers distinguish genuine MIMO solutions from less dramatic developments, and to generally safeguard the identity of this vital technology innovation.

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