# Multiple antenna technology enables high capacity and high data rates.

**Q: Right now there is a limitation on data rate for each user. Can MUMIMO overcome these limitations and if so, how?**

William J. McFarland, Chief Technology Officer for Atheros Communications

The advent of Web-enabled phones has clearly pointed out that wireless carriers need more system capacity to meet the expectations of their users. AT&T has even taken the approach of offloading as much traffic as possible to Wi-Fi networks. While offloading traffic to higher data rate, lower cost Wi-Fi networks will be critical, it would still be beneficial to increase the capacity of the cellular system itself. Of particular interest is Multi-User MIMO (MU-MIMO), in which the base station communicates with multiple client devices simultaneously, using spatial division multiplexing.

MU-MIMO directly multiplies the overall system capacity. For example, if a base station can communicate simultaneously with 10 clients, the total system capacity of the base station will be 10 times greater. In this example, a traditional base station would have to time division multiplex between the 10 clients, while in the MU-MIMO case, each client would be able to receive a continuous stream of data, resulting in 10 times the throughput for each user.

MU-MIMO requires multiple antennas, multiple transmit and receive chains, and sophisticated signal processing. However, most of the complexity can be confined to the base station or AP. An AP with 10 antennas can (theoretically) communicate simultaneously with 10 clients, each of which has only a single antenna.

MU-MIMO is under active development as part of 802.11ac, an enhancement to Wi-Fi that will provide data rates in excess of 1Gbps. Industry work on this topic has pointed out a number of technical difficulties. In practice, the system works better when the devices have extra antennas. In the example above, the chances of simultaneously communicating with 10 clients would be much greater if the base station had 20 antennas, and each of the clients had 2 antennas. Other challenges include the need to sound the communications channel very accurately and frequently, and in the case that multiple clients are transmitting to the base station at the same time, accurately align their transmit power, transmit frequency, and transmission time.

The challenges will reduce the potential benefit from MU-MIMO, but the potential benefit is large enough that MU-MIMO will still be a useful technology for increasing the data rate for users in cellular and Wi-Fi networks.

George Reed, VP of marketing and Product Management, Azimuth Systems

The promise of high capacity data throughput and improved range, reliability and performance in third generation wireless networks is being achieved through the implementation of advanced transmission schemes such as Orthogonal Frequency Division Multiplexing (OFDM) and advanced multi-antenna technologies such Multiple Input, Multiple Output (MIMO). MIMO systems use multiple transmit and receive (antennas) paths to provide significant increases in data throughput and performance by exploiting the dynamically-changing characteristics of the radio channel.

There are many implementations of MIMO differentiated by features including number of antennas, single versus multi user, open-loop versus closed loop, transmit versus receiver based, with or without precoding - where each technique or combination of techniques can maximize gain and/or performance over differing channel conditions. Substantial amounts of research have been conducted in these areas and research findings point to multi-user MIMO (MU-MIMO) as a promising technique to achieve the next level of desired throughput and performance.

Single-user MIMO utilizes antennas that are physically connected to the device and communication between base station and user can be considered as point-to-point. In MU-MIMO systems, a base station will transmit to multiple users simultaneously over the same frequency, which provides several advantages. Increased immunity to propagation effects, specifically versus single user channel rank loss, antenna correlation effects and line of sight effects when using single user spatial multiplexing can be achieved.

Direct gains in access capacity can also be achieved through multi-user multiplexing schemes where gain is proportional to the number of base station antennas. Additionally, spatial multiplexing gains at the base station can be realized without the need for multi-antenna terminals, enabling a reduction in the cost of terminals.

It is fair to say that the improvement expectations and costs associated with the implementation of MU-MIMO solutions have yet to be realized. Of course, the advantages of MU-MIMO are not free and additional cost is measured in increased product complexity and reduction in uplink capacity. Further analysis and substantial testing will be required to prove in MU-MIMO potential gains and cost tradeoffs, however, if the past performance is any indicator of future performance, expected MU-MIMO gains will be achieved.