

Enhancing network efficiency with multiple antenna technology

Discover how Multiple Input Multiple Output (MIMO) on Intel® technologies improves spectral efficiency, allowing you to keep pace with the ever-increasing demand for mobile high-speed data and reliable voice services.

Q What's the challenge?

- A**
- Demand for mobile broadband high-speed data and reliable voice services continues to increase. In response, mobile operators must continuously enhance their spectrum efficiency and increase network capacity, reducing operational expenditure (OPEX) and increasing network service robustness.
 - In the crowded channel scenario, increasing traffic throughput by boosting base station transmission power or using high-order modulation degrades system capacity and signal quality due to increased interference. For example, when a base station uses omni-directional antennas (see Figure 1a), the transmission/reception of each user's signal becomes a source of interference to other users located in the same cell. Therefore, the overall system becomes interference limited.

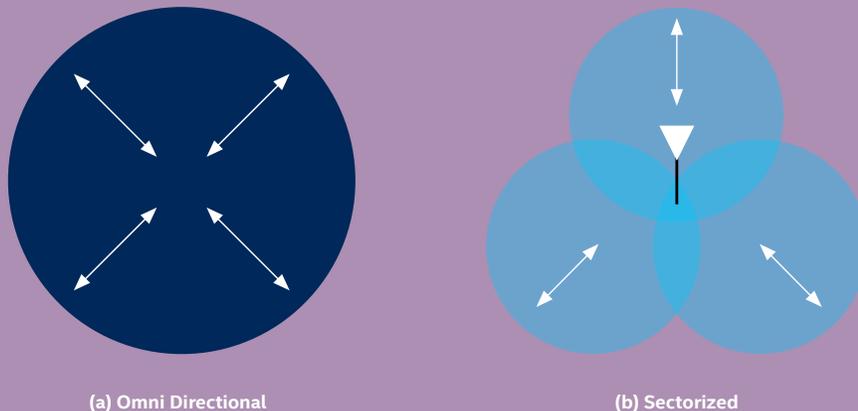


Figure 1. Omni and sectorized antenna systems.

Q What's the solution?

- A
- Sectorized antennas can effectively reduce this interference and increase capacity; the cell is split into multiple sectors with separate antennas – see Figure 1b. However, even though they incorporate frequency diversity, sectorized antennas are a static form of multiple antenna technology. Advanced multiple antenna or Multiple Input Multiple Output (MIMO) technologies—such as adaptive beamforming, Space Division Multiple Access (SDMA) and Space Time Coding (STC)—improve spectral efficiency even further.

Beamforming

- With beamforming, an advanced multiple-antenna technology, each user's signal is transmitted and received from and to the direction of that user, within the same band. Combined with advanced (smart) signal processing solutions, beamforming significantly reduces overall interference. Figure 2 illustrates an example beaming system, consisting of an antenna array.
- In beamforming, each user's signal is multiplied with complex weights that adjust the magnitude and phase of the signal to and from each antenna. As a result, the antenna array output forms a transmit/receive beam in the desired direction and minimizes the output in other directions.

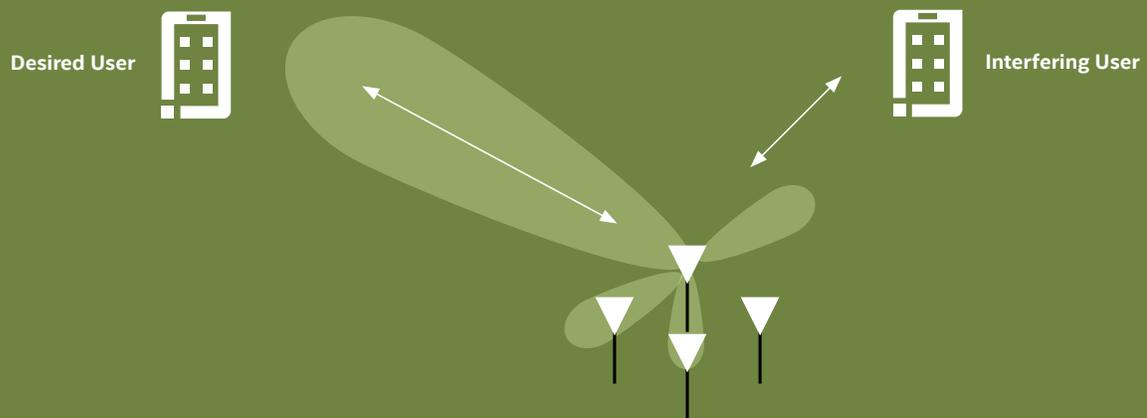


Figure 2. Smart antenna system – beamforming.

Space Division Multiple Access (SDMA)

- Like beamforming, SDMA creates parallel spatial pipes through spatial multiplexing and/or diversity in the channel scenarios of existing rich independent multiple paths. This method offers superior system performance and throughput. By using smart antenna technology and the different spatial locations of the mobile users within the cell, SDMA can convert the system from interference limited to noised limited, achieving a much higher channel spectrum efficiency.

Space Time Coding (STC)

- MIMO architectures that use STC encode a data stream onto spatial and time patterns either orthogonally or non-orthogonally. This technique is sometimes referred to as diversity coding. By transmitting multiple copies of the same data—each with a different code—signal processing techniques at the receiver can maximize the signal quality and provide higher spectral efficiency compared to non-MIMO architectures.

MIMO implementations on Intel® technologies

- Intel® eASIC™ devices and Intel® Agilix™ field programmable gate arrays (FPGAs) feature high-performance, digital signal processing (DSP) blocks and logic elements (LEs), making them ideal for smart antenna technology applications. Additionally, the dual-core ARM Cortex-A53 MPCore processor and/or the NEON acceleration unit can implement adaptive DSP algorithms.
- Many beamforming architectures and adaptive algorithms provide good performance under different scenarios, such as transmit-receive adaptive beamforming and transmit-receive switched beamforming. With embedded processors and easy-to-use development tools, such as the DSP Builder for Intel® FPGAs, Intel FPGAs offer a high degree of flexibility for implementing adaptive signal processing algorithms.
- The standards for next-generation networks are continuously evolving with complex multiple antenna technology adoption, creating an element of risk for ASIC implementation. Because Intel FPGAs are remotely upgradeable and scalable, they reduce the time to market and risk of designing efficient solutions for the evolving industry standards, while providing the option for the gradual incremental deployment of additional MIMO schemes.

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