Massive MIMO

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Background

Two timeless truths are evident: [3]

first, demand for wireless throughput will always grow;

second, the quantity of available electromagnetic spectrum will never increase.

The fundamental and perennial wireless problem is a physical layer problem:

how to provide ever-increasing total wireless throughput reliably and uniformly

throughout a designated area.

All proposed solutions seem to fall into one of three categories:

1) exploitation of spectrum that is currently unused or underutilized;

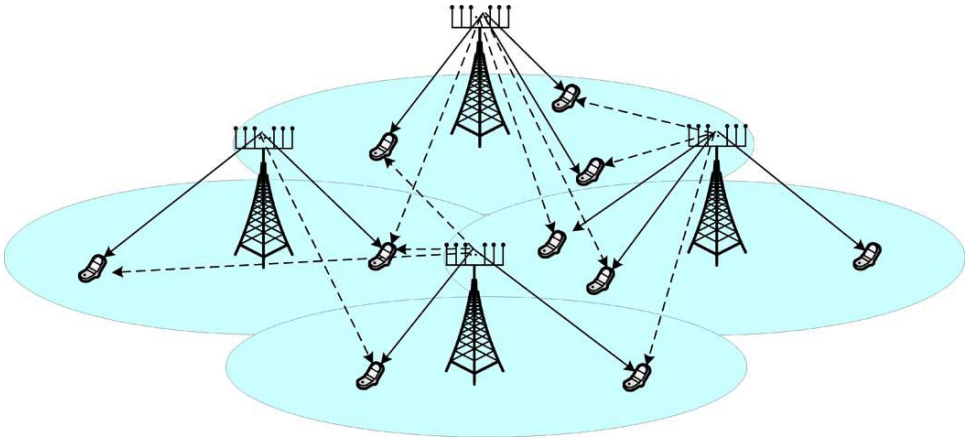
2) deployment of ever more access points, each covering a commensurately smaller area;

3) **use of access points and/or terminals with multiple antennas**.

Introduction

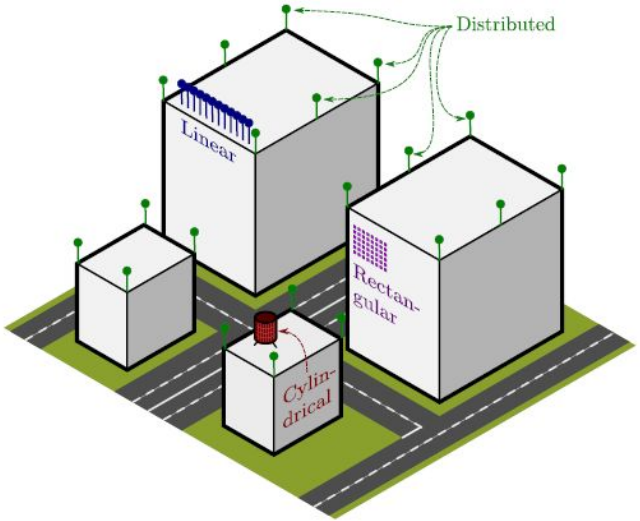
Stemming from research that blossomed in the late 1990s, MIMO communication was introduced into WiFi systems around 2006 and into 3G cellular shortly thereafter. In essence, MIMO embodies the spatial dimension of the communication that arises once a multiplicity of antennas are available at base stations and mobile units.

Picture[1]



Explanation

Massive MIMO (also known as “Large-Scale Antenna Systems”, “Very Large MIMO”, “Hyper MIMO”, “Full-Dimension MIMO” and “ARGOS”).[2]



Explanation

With massive MIMO, we think of systems that use antenna arrays with a few hundred antennas simultaneously serving many tens of terminals in the same time-frequency resource. The basic premise behind massive MIMO is to reap all the benefits of conventional MIMO, but on a much greater scale.

Overall, massive MIMO is an enabler for the development of future broadband (fixed and mobile) networks, which will be energy-efficient, secure, and robust, and will use the spectrum efficiently.

Benefits

Extra antennas help by focusing energy into ever smaller regions of space to bring huge improvements in throughput and radiated energy efficiency.

Extensive use of inexpensive low-power components.

Reduced latency.

Simplification of the MAC layer.

Robustness against intentional jamming.

And so on.

Potential

Massive MIMO can increase the capacity 10 times or more

Potential

Massive MIMO increases data rate:

Because the more antennas, the more independent data streams can be sent out and the more terminals can be served simultaneously.

Potential

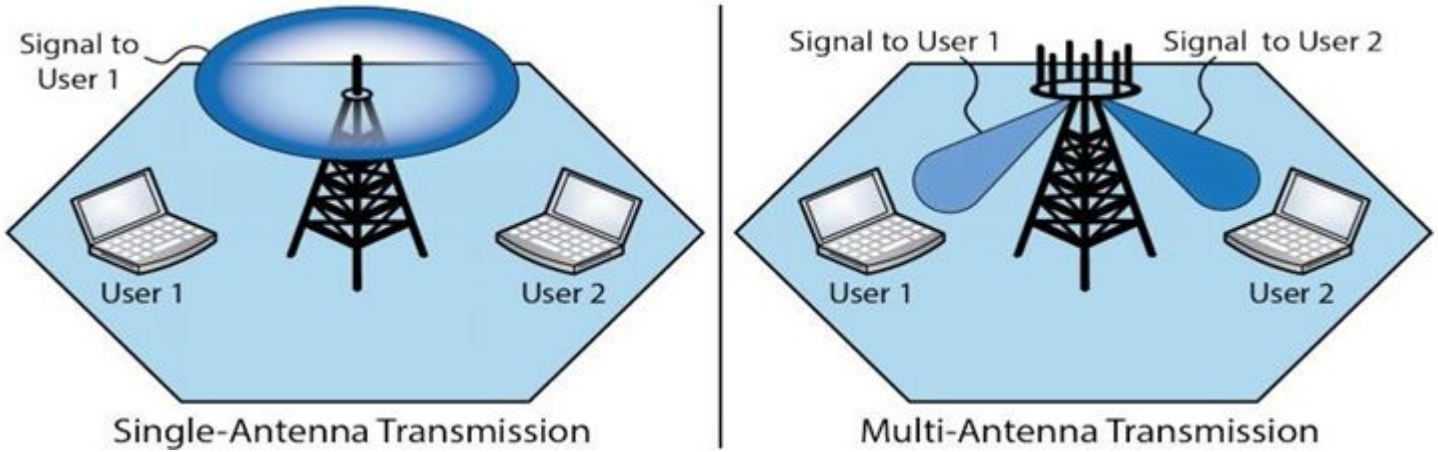
Reduce interference

because the base station can purposely avoid transmitting into directions where spreading interference is unwanted.

Quasi-orthogonal feature, in terms of mathematic, due to the large scale antennas array.

Potential

Improved energy efficiency.



Potential

Massive MIMO enables a significant reduction of latency on the air interface.

The performance of wireless communication systems is normally limited by fading.It is this fading that makes it hard to build low-latency wireless links. Massive MIMO relies on the law of large numbers and beamforming in order to avoid fading dips, so that fading no longer limits latency.

Potential

Massive MIMO increases the robustness against both unintended man-made interference and intentional jamming.

Massive MIMO offers many excess degrees of freedom that can be used to cancel signals from intentional jammers.[2]

When the power is ideally unlimited, spectrum efficiency/power = degrees of freedom. To simply put, degrees of freedom depends on how many antennas.

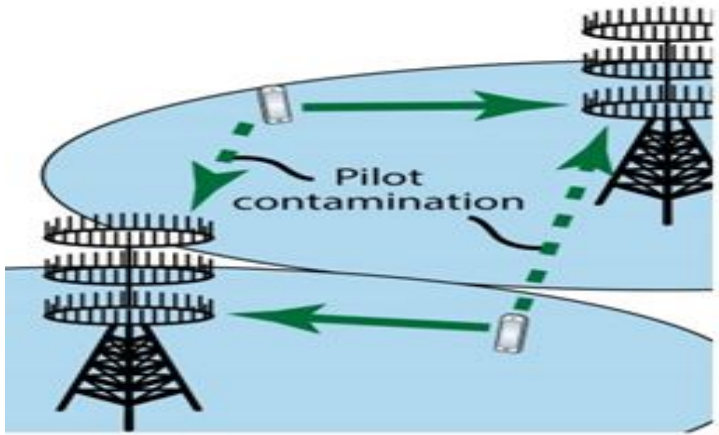
Potential

Massive MIMO can be built with inexpensive, low-power components.

With massive MIMO, expensive ultra-linear 50 W amplifiers used in conventional systems are replaced by hundreds of low-cost amplifiers with output power in the milli-Watt range. The contrast to classical array designs, which use few antennas fed from high-power amplifiers, is significant. Several expensive and bulky items, such as large coaxial cables, can be eliminated altogether.

Limitation

- Channel Reciprocity
- Pilot Contamination
- Radio Propagation and Orthogonality of channel Response



Future(research problem)

- Fast and distributed, coherent signal processing
- The challenge of low-cost hardware
- Internal power consumption-the total power consumed must be considered:
- Pilot contamination

Reference

1. An Overview of Massive MIMO: Benefits and Challenges
2. Massive MIMO for Next Generation Wireless Systems
3. MASSIVE MIMO: AN INTRODUCTION

Thank you! Any question?