MULTIPLE INPUT MULTIPLE OUTPUT SYSTEMS (MIMO)

MIMO systems are systems with Multiple Element Antennas(MEAs) at both link ends.

MIMO uses:

The MEAs of a MIMO system

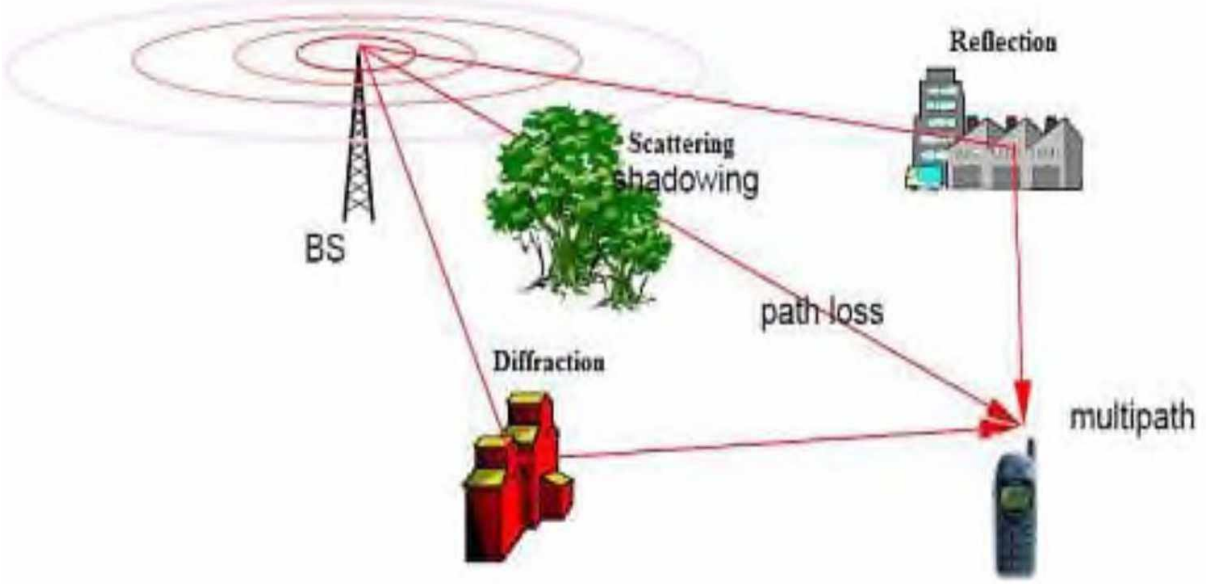
beamforming,

diversity,

interference suppression

spatial multiplexing (transmission of several data streams in parallel).

Technology that uses multiple antenna in transmitter side as well as in receiver side.



How MIMO Works:

- MIMO takes advantages of Multipath.
- MIMO uses multiple antennas to send multiple parallel signals (from transmitter).
- In an urban environment, these signals will bounce off trees, buildings, etc. and continue on their way to their destination (the receiver) .

- With MIMO, the receiving end uses an algorithm or special signal processing to sort out the multiple signals to produce one signal that has the originally transmitted data.
- Multiple data streams transmitted in a single channel at the same time.
- Multiple radio collects multipath signals.
- Adaptive signal processing at both transmitter and receiver
- Multiple antennas at both link ends leads to some interesting new technical possibilities
- Spatial multiplexing, is a new concept.
- It allows direct improvement of capacity by simultaneous transmission of multiple data streams.

System model

- At the TX, the data stream enters an encoder, whose outputs are forwarded to Nt transmit antennas.

From the antennas

- the signal is sent through the wireless propagation channel
- which is assumed to be quasi-static and frequency-flat

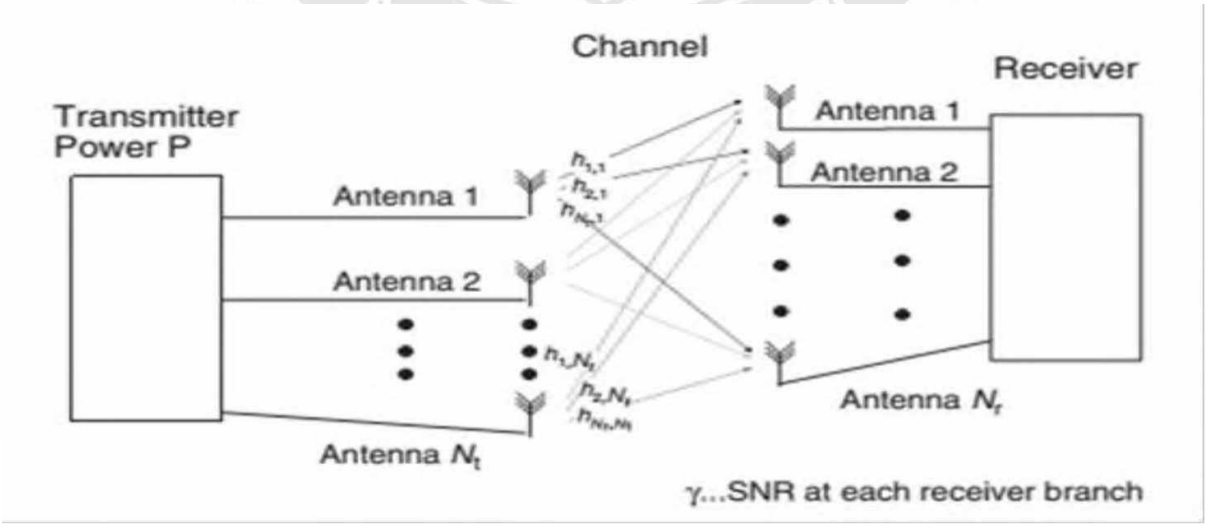


Fig: MIMO system .[Source : Wireless communications by Andreas F.Molisch]

By quasi-static we mean that the coherence time of the channel is so long that "a large number" of bits can be transmitted within this time.

We denote the Nr xNt matrix of the channel as

$$\mathbf{H} = \begin{pmatrix} h_{11} & h_{12} & \cdots & h_{1N_t} \\ h_{21} & h_{22} & \cdots & h_{2N_t} \\ \vdots & \vdots & \cdots & \vdots \\ h_{N_r1} & h_{N_r2} & \cdots & h_{N_rN_t} \end{pmatrix}$$

- hij are complex channel gains (transfer functions) from the jth transmit to the ith receive antenna.
- The received signal vector

$$\mathbf{r} = \mathbf{Hs} + \mathbf{n} = \mathbf{x} + \mathbf{n}$$

contains the signals received by Nr antenna elements

where s is the transmit signal vector and

n is the noise vector.

The two main formats for MIMO are given below:

Spatial diversity: Spatial diversity is refers to transmit and receive diversity. These two methodologies are used to provide improvements in the signal to noise ratio and they are characterized by improving the reliability of the system with respect to the various forms of fading.

Spatial multiplexing : This form of MIMO is used to provide additional data capacity by utilising the different paths to carry additional traffic, i.e. increasing the data throughput capability.

As a result of the use multiple antennas, MIMO wireless technology is able to considerably increase the capacity of a given channel while still obeying Shannon's law.

By increasing the number of receive and transmit antennas it is possible to linearly increase the throughput of the channel with every pair of antennas added to the system.

Spatial Multiplexing

Spatial multiplexing uses MEAs at the TX for transmission of parallel data streams .

An original high-rate data stream is multiplexed into several parallel streams, each of which is sent from one transmit antenna element.

The channel “mixes up” these data streams, so that each of the receive antenna elements sees a combination of them. If the channel is well behaved, the received signals represent linearly independent combinations.

In this case, appropriate signal processing at the RX can separate the data streams.

A basic condition is that the number of receive antenna elements is at least as large as the number of transmit data streams.

This approach allows the data rate to be drastically increased - namely, by a factor of min(Nt,Nr).

For the case when the TX knows the channel

With Nt transmit antennas, can form Nt different beams.

We point all these beams at different Interacting Objects (IOs), and transmit different data streams over them.

At the RX, we can use Nr antenna elements to form Nr beams, and also point them at different IOs.

If all the beams can be kept orthogonal to each other, there is no interference between the data streams.