SPATIAL MULTIPLEXING

Spatial Multiplexing

Multiplexing is transmitting message from one or more transmitter to one or more receiver over the same medium. There are many domains of multiplexing available in radio system, including space, time, frequency, phase and wavelength. In Space Division Multiplexing (SDM), it propagates signal from different sources within same medium.

Thus the basic concept of multiplexing is to divide or multiplex a data stream into branches and transmitting them through several independent channels.

Characteristics of SDMA

- It requires no bandwidth expansion.
- It needs space time equalization in receiver.
- Data streams can be separated by the equalizers.
- It is a better alternative approach to spatial diversity.
- Independent spatial channels give accurate results in transmission.

Concept

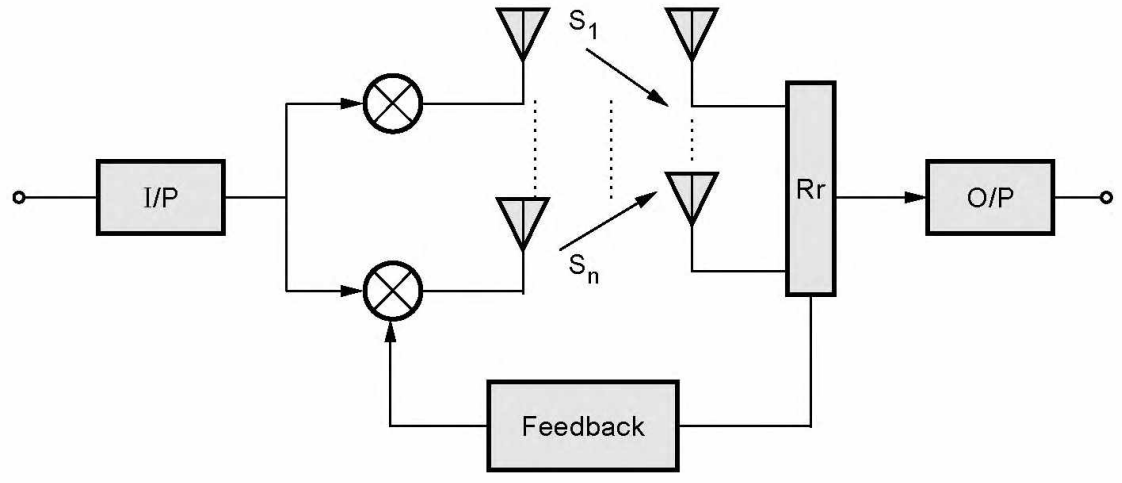

Figure - Spatial multiplexing technique

In spatial multiplexing several different type of data bits are transmitted through many independent spatial channels. The input signal to be transmitted is sent through antenna elements as branches in wireless radio. The signal received

via receiver antenna elements. There is a feedback taken and feedback to transmitter, for further analysis. The received signal is taken as output from receiver circuit.

The Linear Dispersion Coding (LDC) method combines spatial multiplexing with transmit diversity. The first layered space-time architecture was the first space multiplexing systems offered by Bell Labs. It was also meant as Layered Space-Time (LST). The serial to parallel conversion is done.

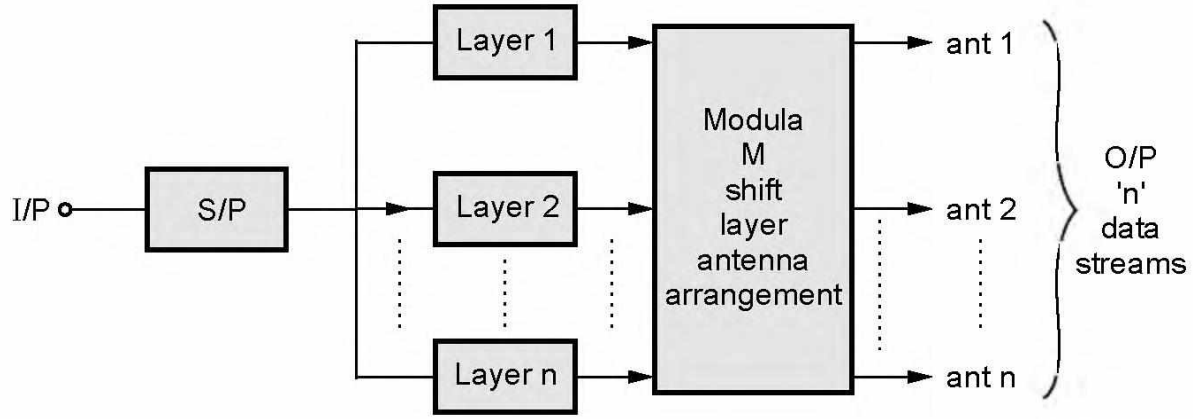

Figure - Layered spatial structure

The input signal is given to layered branches say 1, 2, ... n. The modulation and coding of signals are done and given to modulo-M unit and then transmitter through antenna elements 1, 2, ... m. Thus the data streams (1 to n) is transmitted with the layered spatial structure.

The spatial technique is also done with vertical LST where coding is not included, horizontal LST with coding included and diagonal LST where both coding and spatial interleaving are included. At the receiver end dispreading, demapping and demux procedures are done. It also follows nulling and cancellation of any noise if present. The type of spatial receivers includes linear equalizers, turbo receivers etc.

SDMA Spot Beams for Location Finding

The Space Division Multiple Access (SDMA) technique is a better multiple access scheme that can be applied for wireless networks.

The SDMA technique is capable of controlling radiated energy for each and every user in space. That is by spot beams a spatially filtered base station antenna serves different cellular users. The different cellular area can be effectively covered by the antenna beam that may be served either by same frequency or a set of different frequencies.

For example a primitive application of SDMA.

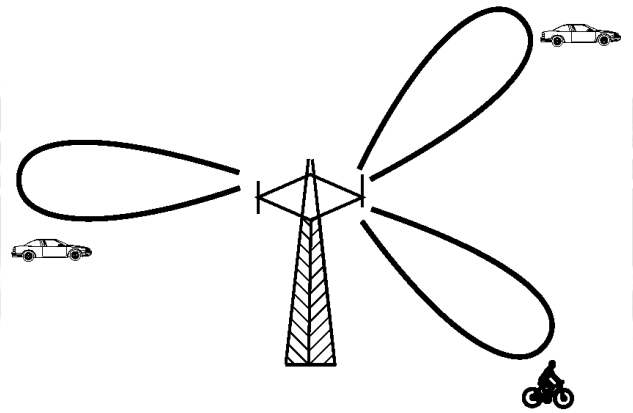

Figure - SDMA - Serving various users by using spatially filtered base station antenna with spot beams

The base station has full control of transmitted signal power in case of forward link.

It is worth noting that the power of each user has to be dynamically controlled to avoid interferences between users. The radio propagation path between every user and base station is different and hence their powers has to be individually controlled by the base station is very important. The transmit power is suppressed by battery consumption at user end. Like this there are limits available depending on which power would be controlled on the reverse links.The reverse link for every user is improved and a less power is maintained if spatially filtered base station antenna is used to serve different users by the antenna spot beams.

Adaptive antennas also tries mitigate these problems discussed so far to an extent on the reverse link.

Adaptive antennas in the limiting cases of

i) Infinitely fast tracking ability and

ii) Infinitesimal beamwidth, would provide an optimal SDMA scheme such that interference free unique channel can be provided to each user in a cell.

Advantages of SDMA Technique

1) With SDMA technique all the subscribers can communicate using the same channel in their system at a time.
2) Individual multipath component can be tracked effectively if an ideal adaptive antenna system is used.

*** The perfect 'Adaptive antennas' is practically not possible to implement. Because they require infinitely large antennas in the design.**

Capacity of Cellular

The application of directive antennas considerably improves the performance of reverse link in single cell CDMA systems. For simplicity three different base station antenna configurations. An adaptive antenna set up with spot beams for users provides best coverage and helps to increase cellular capacity in Space Division Multiple Access (SDMA) systems.

Sectored antenna is used that naturally divides the noise present and increases the number of subscribers. The omni-directional receiving antenna is used where it tries to improve coverage but the level of noise is too high.

In SDMA the better approach to increase capacity is to use adaptive antennas with spot beams for each subscriber. If an ideal adaptive antenna is used it is easier for the base station to track the individual cellular users efficiently.

While comparing cellular CDMA and SDMA techniques it is observed that their is a better capacity gain present in SDMA technique than CDMA. The average Bit Error Ratio (BER) versus number of subscribers in single cell (S).

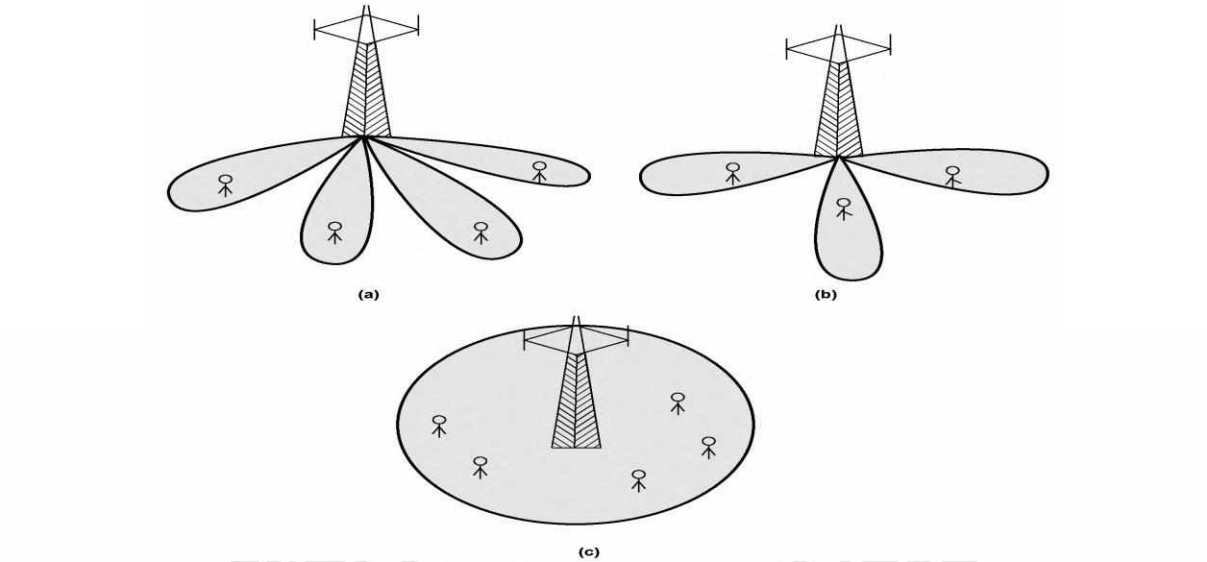

Figure - Base station antenna configurations (Different antenna patterns)
a) Adaptive antenna with spot beams for individual users
b) Base station antenna with sectorization
c) Omni-directional antenna pattern

From the relation between BER and S it is evident that the amount of error is reduced significantly. In SDMA technique using antenna spot beams for users. In addition to this the capacity of cellular system is high in SDMA technique than the CDMA due to less interference among subscribers.

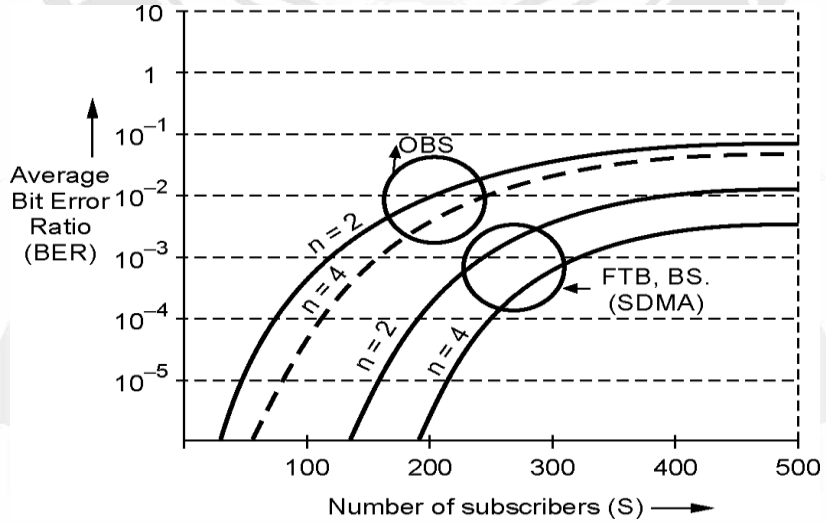

Figure - Bit error ratio Vs number of users; probability of error for an user in the CDMA system considering one interfering layer of its cochannel cells

- **OBS → Omni-base station (Base station using omni-directional antenna)**
- **FTB, BS → Base station using flat-topped beam in SDMA**
- **n → Propagation path loss (here n = 2 and n = 4 is considered)**