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A Conceptual Development of MIMO Techniques and Its Advantages over Regular Networks in Mobile Communication Systems

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Abstract:

This study provides an insight into the development and deployment of MIMO systems and the numerous advantages derivable from its technology. In recent times these technologies with accelerated capacities have been developed and adopted globally for effective and efficient channel capacity utilization in telecommunication. MIMO is effectively a radio antenna technology that uses multiple antennas at the transmitters and receivers to enable a variety of signal paths to be used. Data were obtained from 4G networks, Long Term Evolution (LTE) and standard network architecture across the globe. Such data were analyzed using micro soft excel package. It is observed that MIMO enhanced network had various operational and commercial advantages over regular networks. These are considerable capacity improvement as well as enhancement of the radio link process reliability and better system performances.

Keywords: Channel, capacity, antenna, networks, reliability

1. Introduction

Multiple input /multiple output (MIMO) techniques in radio communication links have evolved over time from being channel network management to massive deployment of communication platforms and protocols to increase efficiency, improve speed and organizational support model and reduce operational cost.

MIMO is a wireless network that allows the transmitting and receiving of more than one data signal simultaneously over the same radio channel.

This is implemented by using a separate antenna for transmitting and receiving of each data signal. Typically, a standard MMO network uses 2 to 4 antennas to transmit data and uses the same number to receive it.

MIMO technology offers a lot of gains and flexibility in the radio communication sub-sector especially in fast racking data communication and enhancing more robust live streaming data opportunities for a fast moving information and communication, ICT- driven global community.

As a result of the need to reduce the area for more antennas involved, MIMO techniques require the use of high frequency and shorter wave length than the conventional mobile network standard.

Furthermore, the multiple input/output technique is a wireless communication tool for multiplying the capacity and versatility of a radio link using multiple transmit and receive antennas to implement a propagation pattern called multipath propagation.

It is worth mentioning here that while smart antenna concept is activated to drive the performance of a single data, MIMO technique encompasses the capabilities for sending and receiving more than one data signal over the same radio channel via the multipath propagation technique as well as accommodates programming of software solution and application packages such as java script and HTML.

Additionally, MIMO is effectively a radio antenna technology which compensates the conventional operation in digital communication data with the high rate spatial distribution dynamics operational in the use of multiple antennas.

2. Historical Development of MIMO Techniques

Precious studies and explorations have exploited the existing technologies at various levels to develop a progressive trend and road map involving changes in human activities and adaptations as the human race grew older and more modern various organization have different levels of findings and result as they evolved. In1984, Jack Winters at Bell laboratory wrote a potent on wireless communication system using multiple antennas. In1993, Thomas Kailath developed the concept of spatial multiplexing using MIMO techniques. In1999, Thomas Marzetta developed a model on MIMORayleigh fading. In2006, Broadcom and Intel introduced communication system using MIMO technology.

In modern telecommunication systems, MIMO is implemented in sync with 4G technology and the Long-Term Evolution (LTE).

3. Long Term Evolution (LTE)

The long term evolution standard in radio communication is a concept that utilizes high frequency technology to increase the speed of wireless communication for mobile services and data terminals based on the GSM, EDGE and UMTS technologies.

LTE increases the capacity and speed using a different radio interface together with core network improvement. The LTE is developed by the 3GPP- 3rd Generation partnership protect and it is the upgrade path for carriers with both GSM and UMTS network.

4. High Speed Packet Access (HSPA)

The high speed packet access is robust digital platform that enhances and enables the Long Term Evolution, LTE to implement its high speed and capacity in wireless radio communication. The HSPAP is the second phase of HSPA where the second P signifies a plus.

5. Multi Path Propagation

In radio communication, multipath propagation is the phenomenon that results in radio signal reaching the receiving antennas by two or more paths. There are different causes of multipath which includes reflection from water bodies such as seas and oceans, reflection and also refraction from mountains, rocks, plateaus, high rise buildings and similar terrestrial bodies. The causes of multipath propagation are constructive and destructive interferences. Another cause is a shift in phase of the signal. Destructive interference causes fading where the strength of the signals arriving by the various paths have a distance known as Rayleigh fading.

Another type of fading is the Rician fading where one component dominates and the distance provides a more accurate model.

Mimo technique uses multi-path propagation to get multiple independent channels. Multi-path interference is a phenomenon in multi-path propagation in which a wave from a source travels through two or move paths and the two elements or components of the wave interference, thereby resulting in fading of radio waves.

In the propagation condition, coherent waves that travel along two different paths will arrive with phase shift thereby interfering with each other. Interference is a phenomenon in which two waves superpose to form a resultant wave of greater, the same or even lower amplitude.

Interference depicts interaction of coherent or correlated waves of the same or close frequency and the same source. This can also be observed, with all types of waves including acoustic, surface-water waves, light or most significantly in radio waves.

Radio waves are a type of electro-magnetic radiation with wavelength in the electro-magnetic spectrum longer than infra-red light. Radio waves have frequencies as high as 300 GHz to as low as 30 Hz.

Radio waves travel at the speed of light. They are generated by electric charges, undergoing acceleration such as time varying electric current.

Radio waves are generated by transmitters and received by radio receives using antennas. Radio waves are largely used in radio communication, broadcasting, radar technology, communication satellite, wireless communication, etc.

In communication systems, antenna arrangement and configuration is networked and optimized using the MIMO techniques to enhance greater channel propagation and signal quality.

6. Line of Sight Propagation

This is a characteristic of electromagnetic radiation or wave propagation which illustrate the phenomenon of wave travelling in a direct path from the transmitter to the receiver.

Electromagnetic transmission includes light emissions, travelling in a straight line. The waves may be subject to reflection, refraction, diffraction or even absorption into the atmosphere and be obstructed by materials and hence cannot travel over the horizon.

However, in contrast to line of sight propagation, at low frequency (below 3MHz) radio waves can travel as ground waves due to diffraction. Frequency in the short ware bands between 1MHz and 30MHz can be reflected back to Earth by the ionosphere (Skywave propagation) to enable global reach of radio transmission e.g. broadcast F.M radio at low frequencies are not affected by obstructions.

7. Radio Frequency Spectrum Mechanism

This is the technology involving the application of antenna, waveguide, transmission line, and electro-magnetic field principles for the design, construction and application of devices that utilize radio signals with the radio band ranging from 20KHz to 300GHz.

They are highly applied in broadcast engineering, information and communication technology, ICT, mobile communication, Wi-Fi and general radio waves operations.

In radio frequency mechanism, emphasis is often placed on design of antenna systems to provide the sufficient coverage of a large chunk of geographical area by an electromagnetic field interface with the antennas.

However, also of electronic relevance is the design of coupling and transmission line structured to support radio frequency energy without radiation and the measurement of the performance and reliability of radio frequency devices and systems. In radio frequency mechanism and technological utilization, a great deal of MIMO techniques is usually deployed in order to optimize its numerous gains and technological value chain enhancement.

8. Massive MIMO

This is a technique with high numbers of antennas between 10 and 100. Face book and huawei ZTE have implemented massive MIMO with having the range of 96 to 128 antennas

Massive MIMO is predominantly a 5G technology. However, there are a lot of smart phones with 4G network support such as the huawei p9 and p1 and remarkably some iphone series. Where as a standard MIMO uses between 2 to 4 antennas, massive MIMO can be implemented using over 100 antennas.

The Chinese network technological corporation ZTE and Huawei both announced new Europe massive MIMO tests in October 2017.

Also, in 2017, Vodafoneand Huawei to show off massive MIMO technology. A UKcorporation also implemented massive mimo with speed up to 2.8Gbps.

Early in 2018, Nokia also implemented massive MIMO with a high level of operational efficiency. LG is set to announce a 5G ready handset in us during the first half of 2019.

Massive MIMO technology is bound to be an active component of the 5G network or the future. A number of mobile network operators across the world are at the eve of launching the 5G technologies in 2020. While standard MIMO techniques are on fall swing operation in 4G standards, the massive MIMO will be active enabler and supporter of the 5G standard in the near future. Massive MIMO with speed up to 2.8Gbps.

9. Methodology

In this study, various MIMO technique methods and modes were evaluated and implemented. The first method was a single IN multiple OUT mode. This was transmitted on one antenna and was received on multiple antennas.

Another method adopted was the transmit diversity mode in which the same information stream from multiple antennas was transmitted.

This was followed by the closed loop spatial multiplexing having feedback incorporated.

Finally the beam-forming mode was applied where linear arrays were used to enable the antennas to focus on a specific enclosed surface.

10. Findings

It is observed that in single IN multiple OUT mode there was diversity in reception. In the transmit diversity mode, there was improvement in signal quality at reception. However, there was no change in the data rate. In the closed loop mode, as a result of the feedback incorporated to close the loop, the transmitter pre-coded the data and the transmission was optimized. Hence there was separation of different data streams at the receivers. Finally, in the beam-forming mode as applied in MIMO techniques, it was observed that there was reduced interference and increased channel capacity as a result of the directivity of the antennas.

11. Advantages of MIMO Techniques over Regular Networks

MIMO techniques have a number of advantages over the regular networks. These are both small and large scales. They include but are not limited to the following;

- Stabilization of the radio communication link
- High signal strength
- Data speed enhancement
- Latency of data across the network
- Enhancement and utilization of beam forming technology
- Flexibility of operations.
- High rate antenna spatial distribution
- Optimized gains in antenna propagation
- Smarter implementation
- Enabled spectrum utilization
- Reduction of error rate
- Implementation of channel coding
- Efficient allocation of timeslot
- Improvement in performance
- Servicing of multiple user capabilities
- Capacity to serve multiple devices
- Simultaneous changing operation
- Consistency of performance
- Robust link reliability improved device sensitivity
- Capacity for expansion

- Multiplicity of without requiring more spectrum
- Higher response to devices
- Higher frequency bandwidth
- Improvement in coverage
- More antennas more signal paths
- Less cost of commercial scale
- Standardized operational efficiency
- Digital plat form for forth coming 5G operations

12. Conclusion

MIMO techniques in radio communication systems have helped to massively deploy multiple antennas technology in enhancing effective and accelerated channel capacity utilization for more data availability and affordability without a change in the spectrum. Data rate have been considerably enabled and spectral efficiency of the entire channel, enhanced while quality of service delivery and entire system reliability is greatly improved upon with MIMO technology deployed.

13. Recommendation

It is recommended that further studies should be carried out on the interface between massive MIMO networks and the 5G technology as we get closer to the monumental global launch of this new age technology in radio communication system.

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