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Security and Performance in Multiple-Input Multiple-Output (MIMO) Networks

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***Abstract* - MIMO networks are providing a perfect solution to increase throughput of the data. Basically, MIMO networks are based on multiple receivers and transmitters. These multiple transmitters and receivers are providing best performance with secure data transmission. This paper is focusing on MIMO networks, like how these networks are being used to reduce transmission cost, because MIMO is using digital signal processing technique known as beamforming. This technique is quite helpful to improve the signal quality, signal interference problem can be reduced and overall data quality is also improve by using this beamforming technique. This paper is going to discuss all functions and working process of beamforming. Security is another main requirement of any network, MIMO networks are providing advance security for wireless networks. Fading of signals can be reduced by using MIMO. But still MIMO networks are not secure enough, because network is sending data to the receivers without any authentication and MIMO networks are also broadcasting data. The adaptive transmit processes can easily increase the capacity of the channel and this will also improve the security of MIMO networks. Last part of the paper is based on the performance and cost gain of the MIMO wireless networks. MIMO is using multiple antennas on both sides to improve the spectral efficiency of the network, because when multiple antennas are used on both sides, then spatial multiplexing is also increase. MIMO technique is a best choice to improve the security of wireless networks. And also it is quite helpful to increase network capacity.**

Key words:- Latency, beam forming, modulation, Amplitude, adaptive beam arrays, eavesdropper, wiretap, relay nodes, malicious, multiuser scheduling, spatial diversity, Spatial multiplexing, scattering, co-channels, equalization, central fusion.

I. INTRODUCTION

Designing of new digital fonts is very tough and time Human depends greatly on wireless and wired networks for worldwide communication. Unlike wired networks, wireless technologies offer people mobility and comfort. New technologies have been constantly researched to improve the coverage of wireless technologies by using signal processing techniques and modulation. To improve the quality of service, diversity systems were introduced. In diversity systems, multiple transmitters are used to decide which transmitter is suitable for use in a given time or location. Previously only one transmitter and receiver were used in a network. Another improved approach was introduced where the concept of multiple antennas were used in a network at the same time at a given time. The multiple antennas are also known as Multiple Input/Multiple Output Antenna (MIMO).

The MIMO antennas helped to improve the throughput greatly as compared to the single antenna systems (Hampton, 2013). It also helps to improve the digital signal processing techniques due to simultaneous transmission of signals. MIMO uses beamforming digital signal processing technique which points the RF signals to a specific location. Hence it helps to improve the quality of the data transmitted and also resolve signal interference problems. MIMO antennas use same codes for using the beamforming technology (Almradi, Information and Energy Beamforming in MIMO Wireless Powered Systems, 2015). The antenna basically tunes phases in multiple ways and forms a beam in specific direction by changing amplitude.

MIMO is also termed as a smart antenna due to its signal adaptation feature based on different situations and requirements (Hampton, 2013). The adaptive arrays can now be switched into adaptive beam arrays. The switched beam array has multiple fixed beams that the user can select to improve the performance and reduce interfering signals.

II. SECURITY IMPROVEMENT IN MIMO WIRELESS NETWORKS

A. Traditionally the diversity systems were used to improve the transmission reliability. However, the system also has great potential to be exploited for wireless security. Physical layer security is also improved through the use of MIMO and multiuser diversity (Chen, Chen, & Liu, 2015). The wireless networks are built by multiple users and Wi-Fi routers therefore the multiuser and MIMO diversity is applicable is the system. MIMO has shown great mean to improve the capacity of the wireless channel and reduce the wireless fading. Unfortunately, the eavesdropper can misuse the MIMO structure to increase the capacity of the wiretap from the sender to itself (Zou Y. e., 2015). Hence it is very important to develop and built a strong network as it may decrease the secrecy of the wireless network. In a traditional open-loop space-time block coding, the receiver estimates the channel matrix to perform the space-time decoding leading to diversity gain for the main channel. The same process can also be applied by the eavesdropper for diversity gain for the wiretap channel. Therefore, the traditional space-time coding is not effective for improving the physical layer security. It can also be said that the when a sender sends signals to the receiver through multiple antennas, the same copies are also intercepted by the eavesdropper (Zou & al, A Survey on Wireless Security: Technical Challenges, Recent Advances, and Future Trends, 2015). One can also say that the wiretap channel of the MIMO networks is a broadcast channel. In MIMIO networks, the source can send private data to the legitimate destination and unintentionally to unauthorized users. The security of the MIMO system can only be perfect when source and destination communicate at a positive rate while no information transfer between the unauthorized eavesdroppers becomes zero. To get to the problem of the issue, researchers have converted the wiretap channels in MIMO into a broadcast channel in which the number of antennas is arbitrary for both the source and destination i.e. legitimate destination and eavesdropper. It was found out that by maximizing the covariance matrix, the wiretap channel's secrecy capacity is equal to the difference between the capacity of source and legitimate destination and source and eavesdropper (Jameel, Asymptotic Analysis of Secrecy Capacity in Industrial Wireless Sensor Networks, 2016).

III. PERFORMANCE AND COST GAINS IN MIMO WIRELESS NETWORKS

Multiple antennas have been used at one side of the network for improving the performance of interference problem, diversity and array gain with the help of coherent combing. MIMO introduces the use of multiple antennas on both sides of the wireless network. It helps to gain spatial multiplexing which improves spectral efficiency (Mohammadi, 2015). Spatial multiplexing increases capacity linearly as compared to the wireless networks using single antennas at one or both ends with no additional bandwidth or power expenditure (Prasad & Velez, 2010). The advantages of the MIMO can be realized in wireless networks when the propagation channels show rich scattering and transmission of independent data streams using same frequency simultaneously. The capacity gains are realized by the receiver by manipulating the differences in the spatial signatures added by a MIMO channel on a multiplexed data stream to identify different signals.

Another important advantage of the MIMO wireless networks is the diversity. It leads to the improved link reliability (Prasad & Velez, 2010). This renders the channel "less fading" and co-channels the interferences to improve the robustness. The data signals are transmitted over the several fading dimensions of space, time, and frequency independently while combined properly on the receiving end for diversity gains. No extra transmission time or bandwidth cost is incurred in case of spatial diversity as compared to the frequency or time diversity which makes it extremely attractive. MIMO's space-time coding helps in spatial diversity gain in wireless networks by using multiple transmitting antennas without the need of channel knowledge by the transmitter.

The advantage of array gain can also be utilized by both transmitting and receiving end (Prasad & Velez, 2010). For coherent combing, the channel knowledge is needed which helps to increase the average receive signal-to-noise ratio (SNR). Thus the coverage of the wireless network is improved with MIMO. Furthermore, the co-channel interference is reduced or cancelled out by using multiple antennas at one or both end of the wireless network. Hence the cellular network capacity is improved.

To improve the cost of the MIMO wireless network, different approaches have been proposed by the researchers for energy conservation. Hardware level optimization is achieved to minimize the energy consumption (Ding Z. e., 2015). While at the destination node, the energy consumption is minimized by using the low rank equalization. Without degrading the channel capacity of the network, reducing the order of the transmit antenna selection at both the sender and receiver node also minimizes the cost of the network. MIMO can also help to improve the lifetime of the sensor networks. The sensor networks have a central fusion center equipped with multiple antennas. It can use the antenna for focusing RF energy on the sensors and charging the sensors wirelessly. Thus MIMO gives a more energy efficient solution as compared to the single antenna transmitters (Amarasuriya, Liu, & Poor, Wireless energy harvesting massive MIMO relays, 2016). The relay can also harvest energy using the signals from the sender node. It then uses the harvested energy to send the data to the destination node in a wireless network. It not only facilitates the efficient use of signals in a network but also open new horizons for combining energy and information in the wireless networks (Ding Z. e., 2015). A wireless network consists of many active and non-active users. The inactive devices in the network having MIMO features can be used as relays to help the active users in the network. Therefore, the use of the MIMO relays can help to manage multiple sender-receiver pair simultaneously. At the same time, it will also not reduce the battery of the inactive devices. It helps to improve the performance and is an

optimal trade-off between the harvested energy and information rate (Lu & al, 2015). Furthermore, to improve the energy consumption, it is also proposed to convert MIMO system into a set of SIMO links where each transmitter is activated individually and channel performance is estimated
for each SIMO system.

IV. CONCLUSION

The MIMO wireless networks are an improved and enhanced concept to improve the performance and coverage of the traditional wireless network. The technology offers an energy efficient solution with no additional cost. The multiple input multiple output uses multiple antennas to send and receive signals over the internet. It can be very easily incorporated in the wireless network as the network is already made up of multiple routers. Furthermore, the technique helps to improve the security of the physical layer by providing three techniques i.e. beamforming, power allocation and transmit antenna selection. Each technique offers an innovative way to improve the secrecy of the network. Furth more, there are many performance gains of the MIMO wireless network as compared to the conventional networks as it does not have any additional bandwidth or transmission cost. The system works perfectly on the same bandwidth as the conventional networks. Therefore, the network does not have to bear any additional costs. Furthermore, the MIMO architecture proposes an energy efficient solution for the wireless networks where each node helps to improve the performance of the network and helps to fully utilize signals for energy efficiency.

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