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REVIEW ON ENERGY EFFICIENT GREEN COMMUNICATION NETWORKS FOR WIRELESS AND MOBILE COMMUNICATION

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ABSTRACT

Recent advancements in Personal Digital Assistant (PDA), such as smart phones, smart watches, smart glasses, personal wearable communication and healthcare devices, have changed us to move towards the smart society. By strengthening the mobile and wireless networks, two or more devices can communicate with each other and exchange information and display necessary information anytime anywhere. However, the rapid development in wireless communication technology leads to imbalance of the resource utilization and also increases the unnecessary energy consumption of the PDA's greatly. The emerging technologies are efficient only when they are consistent and compatible with our living planet nature. So, the environment should be utmost priority while developing technologies for communication system in wireless communication which is the most creative and arising field for PDA's. Green communication helps in balancing the resources, sharing information, routing adaption and spectrum efficiency. Thus, green communication had become emerging research area for future mobile and wireless networks. So this article demonstrates the review of various green communication techniques adopted in wireless communication. This article also describes energy efficient methodologies used in wireless communication.

Keywords: green communication, wireless networks, green antennas, green electronics, green handovers, green codes, multiple input multiple output.

1. INTRODUCTION

A secret communication system was co-patented in the year 1941 by an actress Hedy Lamar and George Antheil which allowed torpedoes radio channels which cannot be easily discovered, decoded or blocked. The system proposed [1] have been adopted the frequency hopping and avoided detection and interference i.e. being suppressed or blocked. The radio frequencies had changed rapidly that literally hop in the radio spectrum. The objective of the authors [1] was frontwards but not implemented in the US until 1962. Later US military ships used this system first and then the system was used by Cuba when Cuba got blockade, and now the Frequency Hopping Spread Spectrum (FHSS) has become popular techniques in communication systems. The development of wireless communication has changed the way of human living standards. Due to the advancement of PDA's even the capability of the users to transmit data when they are away from their work place has been improved. Not only at work places but these types of systems are used in mission-critical industrial applications and even in the military applications. The wireless communication is one of the most reliable systems when compared wired system due to their chance of damage in buried cables which leads to instant repairs. Whereas the wireless systems are free from repairs, easily maintained and rarely demand repair service after once installed. Technical issues in wireless systems can be detected remotely and maintenance is provided that save time and money. These systems last maintenance free for years only when they are installed and designed in optimal way. Due to the advancement of the wireless systems, the manufacturers providing latest updates and solutions throughout its product life span to minimize replacement, maintenance and stocking costs.

Many researches on wireless system have omitted the significance of environmental responsibilities i.e. designing energy inefficient system which causes harm to the planet earth. This kind of activities may leads to rapid growth of greenhouse gases in the atmosphere which was not initially predicted. The overheat occurring in the atmosphere due to Radio Frequency is carried down to the surface by normal convection which further leads to global warming. These radio frequencies [2] improve mitochondrial receptive oxygen species era by human spermatozoa, diminishing the motility and imperativeness of these cells while animating DNA base adducts development and, at last DNA discontinuity. Accordingly the induction of oxidative stress in these cells irritates their ability for treatment as well as adds to sperm DNA harm. This has been combined with poor virility, an expanded occurrence of miscarriage and morbidity in the posterity, including adolescence tumor.

To address these kinds of issues raised by wireless technologies, the researchers are motivated towards "green wireless communications" which helps reducing environmental impact and even improves energy efficiency. Green communication technique can be adopted in order to degrade the greenhouse gases production due to wireless systems. The regular use of mobile and the growth of internet and wireless technologies increase the emission of CO_2 and it could be continued until the networking technologies attain a good energy efficiency system. As IP-based network consumes more energy, the green telecommunication will help in development of energy efficient system with many

considerations [3] such as safe telecommunication waste disposal, greening of telecommunication networks and atmosphere friendly design of telecommunication buildings. The green renewable energy sources such as Green power amplification systems, Green base transceiver stations, Green codes, Green electronics, Green antennas and Green handover, can build ecofriendly green wireless communication system. This article demonstrates the various aspects adopted for the development of green wireless communication systems to preserve the nature of mother earth.

1.1 Green communication standard's terminology

Green handover: When the base station completely switches off its radio communication and associated processing when they are not involved in an active call is known as green handover.

Green codes: The code which attempts to minimize the total energy per-bit required to communicate across a noisy channel is called as green code.

Green electronics: Green electronics analyze compounds of natural agent and endowing economically powerful track for the production of synthetic materials which have relevancy in environmentally safe biocompatible devices and becomes environment friendly electronics and the integration of such electronic circuits with living tissue in particular system [4].

Green antennas: Green antennas were initially proposed with non-planar ground plane and Suspended Plane Antenna (SPA) elements. Each element in SPA has been excited with fundamentals of hail TM mode through L-Probe. For practical experimentation of the research, U-shaped ground plane antennas which also demonstrate the phenomenon of light reflecting surface for solar cell panels. The U-shaped antennas can significantly increase the output voltage of solar cell panels [5]. This kind of U-shaped antennas with solar cell panels demonstrates the behavior of green antenna and these antennas surely enable the future generation wireless technologies.

Green base station standards: It is equipped with the regenerative energy sources like wind power and photo voltaic energy to reduce the power consumption, whenever sunlight or wind is present. During operation times when wind power and solar energy are not sufficient to feed the BTS, additional energy is supplied from the public mains grid.

Downlink and uplink: The communication path established to the ground from a satellite is called as downlink, and the communication established to a satellite from ground is called as Up-link. When spacecraft receives the uplink at the same time Earth receives downlink, the communication is called two-way.

1.2 Green communication standards

The basic structure of green communication revolution and emerging techniques are described in Figure-1.

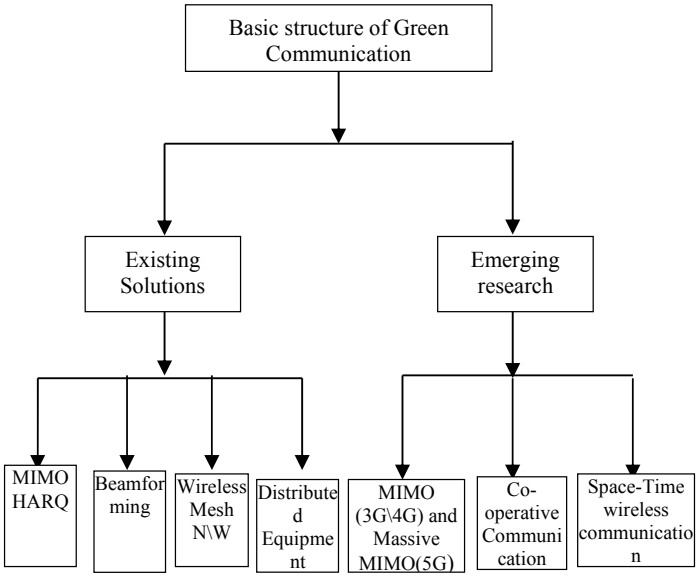

Figure-1. Green communication standards.

The Figure-1 demonstrates the existing solution for establishing communication between wireless and mobile communication systems. These techniques are independent and have their own significance in the area of wireless communication to establish efficient communication between wireless devices. There are emerging techniques adopted and proposed by researchers to achieve energy efficient and environment friendly communication in wireless communication domain. These existing solutions are demonstrated in section 2 and then the emerging research approaches are described in section 3.

2. EXISTING SOLUTIONS FOR ENERGY EFFICIENT WIRELESS COMMUNICATION SYSTEM

The researchers in literature have been proposed various efficient communication methods for development of efficient wireless systems. The popular and existing wireless communication systems are presented in the following subsections.

2.1 MIMO HARQ(3G\4G)

In radio communication, MIMO estimates the intensity of a radio link using several transmitting and receiving antennas in order to achieve multipath propagation. The MIMO is an insistent technique for establishing wireless communication which utilizes wireless communication standards such as IEEE 802.11ac (Wi-Fi), HSPA+ (3G IEEE802.11n (Wi-Fi)), Long Term Evolution (LTE-4G) and Wi MAX (4G). Now days, the hypothesis of MIMO has been compelled to power-line communication for three-wire installations as part of ITUG.hn standard and Home Plug AV2 specification. The MIMO helps in adoption of required number of antennas at the transmitter and the receiver. In recent systems, the MIMO can support transmission and reception of more than single data signal synchronously through same radio channel by utilizing multipath propagation. As compared to many smart antennas, the MIMO is basically peculiar that adds performance to a single data signal in terms of diversity and beam forming. The MIMO techniques can have 3 levels such as pre-coding, spatial multiplexing and diversity coding.

Pre-coding: Pre coding is a fixed terminology used for multi stream beam forming. This technique increases the signal power at the receiver input which was the signal emitted from each of the transmitter antennas with same gain and phase. The transmitted signal from different antennas will curtail the multipath fading effect which further increase the receiver signal gain and can be considered as a main advantage of beam forming. Beam forming has an explicit directional pattern when it is in line-of-sight. Conventional beams are determined by multipath propagation because it doesn't have good relation with cellular network. Pre-coding with multiple streams is often favorable only when the receiver end has multiple antennas and the transmitter beam forming can't increase the signal strength at the receiving antenna. Ensure that the pre-coding requires the knowledge of Channel State Information (CSI) at both transmitter and receiver ends.

Spatial multiplexing: Spatial multiplexing utilizes MIMO configuration for multipath communication. In spatial multiplexing, high-rate data signals are sampled into low-rate multiple data signals and then each low-rate signal is transmitted through MIMO channel architecture with same frequency. The transmitted low-rate data signals are received at the receiver end using different spatial signatures with accurate Channel State Information (CSI) and these received signals are separated and then processed through parallel channels. So this spatial multiplexing method is a powerful method which increases channel capacity even though Signal to Noise Ratio (SNR) of data signal is optimum. The maximum number of spatial stream signals, i.e. low-rate signals, is directly proportional to number of antennas in MIMO channel architecture. In spatial multiplexing CSI is used for encoding but it is not used at the transmitter. Contemporary transmission to multiple receivers with the help of spatial multiplexing is known as space-division multiple access or multi-user MIMO, in which CSI is required at the transmitter. Good signal can be obtained while arranging receivers with different spatial signatures.

Diversity coding: The diversity coding can be used when channel knowledge is not known at the transmitter. The diversity coding can utilize space-time coding techniques for coding the signal and transmit the signal stream unlike multiple streams in spatial multiplexing. The full or near orthogonal coding can be used for signal broadcasting from each of the transmitting antennas and achieve independent fading that strengthens signal diversity in the multiple antenna links. The diversity coding can't help in estimation of beamforming and array gain whenever there is no knowledge on transmission channel. The diversity coding and spatial multiplexing together estimates the channel information at the transmitting end.

2.2 Beamforming

Beam forming is a technique which is used in sensor arrays for directional signal transporter or response. Connecting elements in a phased array when that particular angle is in effective conflict while others practice disastrous interference then Beam forming can be attained. To manage contiguous decision it can be used at both the transmitting ends and receiving end. When the improvement is compared with uni-directional transmission\ reception is known as the directivity of the element. A Radio or sound waves uses beam forming. Some of the major applications of beam forming are in seismology, wireless communications, radar, sonar, acoustics, radio astronomy and biomedicine. For revealing and valuating the signal-of-interest at the output of a sensor array by means of optimal spatial filtering and interference rejection Adaptive beam forming is used. The phase and relative amplitude of the signal at the transmitter is controlled by beam former in order to create pattern of productive and catastrophic intrusion in the wave front when it shift the path of the array while transmitting.

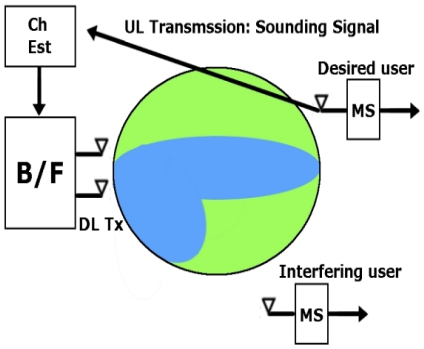

Figure-2. Beamforming.

The expected pattern of radiation is conversely observed when information is received from different sensors is combined. Beamforming techniques are two types called conventional Beamforming and Adaptive Beamforming.

In the conventional beam forming technique, the beam is formed by assigning the weights and phases to the signals coming from sensors array and combines them into single signal. These weights and phases of the signal obtained from a sensor hold the information about that sensor position and orientation in the space. Before combining the acquired signals from sensors, the conventional Beamforming technique removes the undesirable signals acquired in other directions of the sensor and it can be processed in either the time or frequency domain.

In Adaptive beamforming technique, the beam is formed by consequently adopt the response of the signals from sensors in various positions. The adopted signals are then processed through noise minimization techniques in frequency domain and then the minimal noise adopted signal is presented as signal for beamforming.

Mobile phone avail Beam forming approach which have progressive through the generations to make use of more complicated systems to resolve terrific density cells, with greater throughput.

Passive mode: adapted solutions

Direction of arrival (DOA) based beamforming is supported by Wideband Code Division Multiple Access (WCDMA).

Active mode: essential standardized solutions

2G - Transmit antenna selection as an elementary beamforming

3G - WCDMA: Transmit antenna array (TxAA) beamforming

3G evolution - LTE/UMB: Multiple-input multiple-output (MIMO) pre-coding based beamforming with partial Space-Division Multiple Access (SDMA)

Beyond 3G (4G, 5G …)- More advanced beamforming solutions to support SDMA such as closed loop beamforming and multi-dimensional beamforming are expected.

2.3 Wireless mess networks

The configuration of Wireless Mesh Networks (WMN) is shown in Figure-3 and in which all the radio nodes are standardized in a mesh fashion arrangement. Here the network is extemporary. The WMN is designed with mesh routers, gateways and mesh clients. In this network, PDA's are mesh clients and traffic can be controlled by mesh routers trough gateways either in the presence or absence of the internet. The area covered by different nodes that works as a single network is called as mesh cloud which in turn builds a radio network. It is decisive and tenders repetition. With the help of intermediate nodes, the nodes communicate each other directly or indirectly even though single node is at rest position. Wireless mesh networks can be seldom and self will. WMN need not be confined to any one technology or protocol but can be carried out with different wireless technologies such as 802.11, 802.15, 802.16 cellular technologies.

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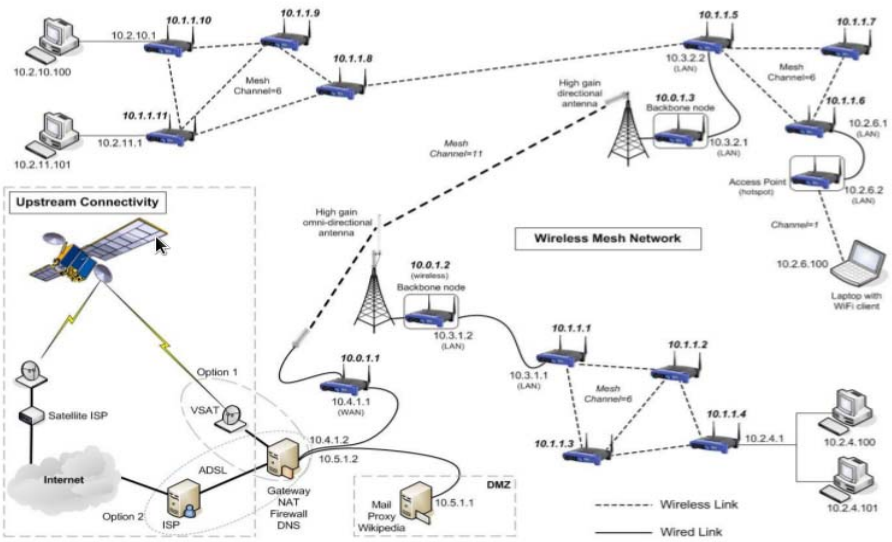

Figure-3. Configuration of a wireless mesh network, connected upstream via a VSAT link.

2.4 Distributed equipment

All the wireless interconnections that can access by IEEE802.11 network are entitled by wireless distribution system. Without using any wired system, the distributed equipment expands the wireless network with some access points. The cross the links between accesses points WDS helps in preserving MAC address of the client frames. In distributed equipment, a main base station is typically connected to the (wired) Ethernet. Data among remote base stations, wireless clients, or other relay stations, to either a main, or another relay base station can be done by a relay base station. A remote base station accepts connections from wireless clients and passes them on to relay stations or to main stations. Connections between "clients" are made using MAC addresses. After the first retransmission (hop) is being made the supreme wireless impressive throughput may be bisect. For example, if we consider 2 APs linked through WDS, and information can be exchanged between a computer which is connected to the Ethernet port of AP-A and a laptop which is wirelessly connected to AP-B. The throughput is bisected, because between two phases, the AP-B has to again transmit the information during the transfer of information, the throughput is not bisected in the case of transfer of information between a computer which is connected to the Ethernet port of AP-A and a computer which is plugged into the Ethernet port of AP-B because retransmission is not necessary. But this problem can be avoided by Dual band/radio APs, by connecting two clients on one band/radio, and making a WDS network link with the other. Encryption keys are usually not supported when WDS connections are dynamically rotated and appointed. This means that in many cases dynamic Wi-Fi Protected Access (WPA) and other dynamic key assignment technology cannot be used, though WPA using pre-shared keys is possible. Upcoming 802.11s standard resolves the lack of standardization in this field. WDS connection uses only static WPA or WEP keys may be used, including any WDS imitating AP that are associated by STAs.

3. EMERGING AREAS FOR GREEN COMMUNICATION SYSTEM

This section presents the emerging methods which can be adopted for green wireless communication.

3.1 MIMO (3G\4G) and massive MIMO(5G)

Multiple-antenna (MIMO) technology is becoming sophisticated for wireless networks and been integrated with wireless broadband standards like Wi-Fi and LTE. As the number of antennas increases, the performance of the signal path will also increase in terms of link reliability and data rate. Thus cost of Wireless Communication Network is increased due to the complexity of the hardware and energy consumption of the signal processing at both transmitter and receiver ends. In massive MIMO, the research challenges include appraisal of criticality of coherent channels propagation. Abolition for massive MIMO in present context could also be conceivably calculated on experimental basis for channel orthogonality. These challenges are can be taken care in further implementation of lower costs in the context of hardware power consumption in each of the antennas. Considering recent scenario 5G has many advantages over 4G and which are described below.

- En bloc in space
- Directional antennas
- Rational angle spread of the propagation

There is less number of antennas in MIMO employing single-user [8] which fit for current standard of cellular communication. But massive MIMO has no limit if Time Division Duplex (TDD) is integrated for enabling

channel depiction. This contingent scenario has massive MIMO's application which control the multiple antennas distributed in which a small town or university campus or city could be exploit.

3.2 Co-operative communication (D2D communication)

"Three-terminal communication channel" is nothing but a wireless cooperative network which has the three node network, was first introduced by van Der Meulen, which can be seen in Figures 4(a) and 4 (b). Cooperation happens when a direct communication between a source (S) and a destination (D) is improved due to the help provided by a neighboring node.

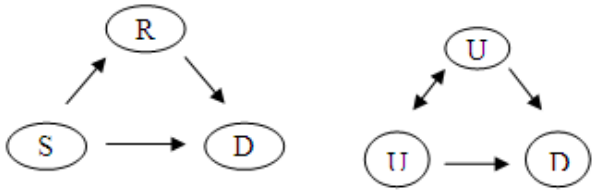

Figure-4(a). The cooperative relay network, also known as the relay channel. 4 (b) A wireless cooperative network with user cooperation.

The Figure-4(a) shows the basic network topology in which cooperation can be used. The relay (R) node can be seen as any node which can "hear" the transmission of the source and, its own transmission can reach the destination (D) node. The Figure 4(b), the relay has data of its own to transmit and it becomes an active user of the network. Depending on what type of signal processing is being done at the relay, or what type of transmission protocol is used, a lot of characteristics of the relay network take form. Metrics that can be used to analyze the relay channel are rate, capacity, bit-error-rate (BER) and diversity order.

3.3 Space-Time wireless communication (O-STBC, STTC)

Space Time Coding (STC) [9] is a wireless system that engages several transmit antennas and a single or many receiver antennas. Information theory helps in demonstrating how remodeling can be done in wireless channels from precise to ample data pipes through multiple antennas that have the potential to greatly increase attainable bit rates. Instead of enlarging the total transmitted power STC will recognize the gain by prefacing physical and structural correlation of the signal from different antennas. There might be some diversity gain which results from different paths between base station and user terminal, and a coding gain that results from the symbols that are correlated across transmit antennas. Two antennas at the base station and one or two antennas at the user terminal and with simple receiver structures significantly increase in throughput. Further increase system capacity through interference suppression can be done through the second antenna at the user terminal.

4. CHALLENGES OF GREEN COMMUNICATION

The challenges and measuring parameters of wireless communication to preserve the environment is described as stated below.

Cell breathing and switching off layout: Maximum work should be done in the technique that allows the management of scattered/accumulate mechanisms at large-scale networks.

Macro/ femto cells networks: To grasp the network fluctuations there are clear facet on assignment and executives mechanisms.

Relays: Relays helps in energy effectual mechanism only if the power used by relaying is abundantly low. The provision of protocols and mechanisms to have helpful methods of relaying is an open theme.

RRM, energy efficient transmission and mechanisms: improve new mechanisms in perspective of the all diverse factors isn't mild theme. And to recognize the best operation point is ambitious task.

CR, cognitive radio: The CR is intensely useful device in 6environment, it extract clash of concerns and information that is not shared amongst nodes. It should change software and also the hardware to advance the aspects which CR might fetch to energy efficient techniques.

Component approach: before allowing for the other approaches for energy efficient wireless network should check whether the energy efficient components are available or not. It attains higher components efficiencies [7].

5. SUMMARY OF ENERGY EFFICIENT GREEN COMMUNICATION NETWORKS AND DISCUSSIONS

Green communication technique / Existing solutions	Wireless communication standard	Communication system methodology	Discussion and enhancements
MIMO HARQ (3G\4G)	Wi MAX (4G), IEEE802.11n (Wi-Fi), HSPA+ (3G), LTE-4G, IEEE 802.11ac (Wi-Fi)	Pre-coding: Pre-coding is multi-stream beam forming techniques for fixed terminology. Spatial multiplexing: In spatial multiplexing, high-rate data signals are sampled into low-rate multiple data signals and then each low-rate signal is transmitted through MIMO channel architecture with same frequency. Diversity coding: Diversity coding technique is used when there is no channel knowledge at the transmitter.	MIMO is used for calculating the intensity of a radio link using several transmitting and receiving antennas to attain multipath propagation.
Beamforming	WiMAX, Wi-Fi and WPAN standards	Conventional beamformers: The beam is formed by assigning the weights and phases to the signals coming from sensors array and combines them into single signal Adaptive beamformers: the beam is formed by consequently adopt the response of the signals from sensors in various positions.	The phase and relative amplitude of the signal at the transmitter is controlled by beam former in order to create pattern of productive and catastrophic intrusion in the wave front when it shift the path of the array while transmitting.
Wireless Mess Networks	IEEE802.11, IEEE802.15, IEEE802.16	The network in which all the radio nodes are standardized in a mesh type arrangement called as Wireless Mesh Network.	The WMN is designed with mesh routers, gateways and mesh clients. In this network, PDA's are mesh clients and traffic can be controlled by mesh routers trough gateways either in the presence or absence of the internet.
Distributed equipment	an IEEE 802.11	Wireless bridging: WDS APs communicate only with each other and don't allow wireless stations to access them. Wireless repeating: APs communicate with each other and with wireless STAs.	All the wireless interconnections that can access by IEEE802.11 network are entitled by wireless distribution system. Without using any wired system this system helps in expanding the wireless network with some access points.
Emerging Research			
MIMO (3G\4G) and Massive MIMO(5G)	LTE-4G,5G, IEEE802.11n (Wi-Fi), Wi MAX (4G), IEEE 802.11ac (Wi-Fi), HSPA+ (3G)	Multiple-antenna (MIMO) technology is becoming sophisticated for wireless data transmission and has been integrated into wireless standards like Wi-Fi and LTE. LTE: The LTE uses Orthogonal Frequency Division Multiple Access (OFDM) methodology. TDD and FDD can be used by LTE system. SAE (System Architecture Evolution): SAE uses very high data rate and low delay requirements for 3G LTE; it helps in improving the performance.	As the number of antennas increases, the performance of the signal path will also increase in terms of link reliability and data rate. Thus cost of Wireless Communication Network is increased due to the complexity of the hardware and energy consumption of the signal processing at both transmitter and receiver ends.
Co-operative communication (D2D communication)	LTE (Long Term Evolution) advanced standards, Wi MAX	LTE advanced standards use Orthogonal Frequency Division Multiple Access (OFDMA) with Single Channel Orthogonal Frequency Division Multiple Access (SC-FDMA). Advanced standards use this type of technology though the basic scheme is OFDM.	"Three-terminal communication channel" is nothing but a wireless cooperative network which has the three node network, was first introduced by van Der Meulen.
Space-Time wireless communication (O-STBC, STTC)	UMTS and CDMA2000 mobile standards.	UMTS is based on data collection which can be done through drive testing and extended to other cellular data services. in USA, Melbourne, FL this approach is demonstrated through a drive test data collection which is conducted on a live cellular network	Space-time coding (STC) is a [9] wireless systems that engage several transmit antennas and a single or many receiver antennas. Information theory helps in demonstrating how multiple antennas have the potential to greatly increase attainable bit rates, thus remodeling wireless channels from precise to ample data pipes.

6. CONCLUSIONS AND FUTURE SCOPE

The wireless networks are effective only when they have consistent and compatible with nature of mother earth. So, the researchers should give utmost priority to environment while developing technologies for wireless communication which is an emerging field for PDA's. The study findings on emerging wireless communication techniques are concluded as follows.

The MIMO HARQ(3G\4G) technique establishes effient radio link for multipath propagation through several transmitting and receiving antennas. The MIMO HARQ(3G\4G) technique utilize the wireless standards like Wi MAX (4G), IEEE802.11n (Wi-Fi), HSPA+ (3G),

LTE-4G, IEEE 802.11ac (Wi-Fi) for establishing communication.

The Beamforming is a technique in which antennas are connected in phased array fashion to achieve optimal direction signals for transmission. The Beam forming is effective in WiMAX, Wi-Fi and WPAN standards.

In Wireless Mess Networks, the PDA's are mesh clients and traffic can be controlled by mesh routers trough gateways either in the presence or absence of the internet. WMNs are efficient when they are established using wireless standards like 802.11, 802.15, 802.16.

MIMO (3G\4G) and Massive MIMO(5G) is an emerging technique that utilizes LTE-4G,5G, IEEE802.11n (Wi-Fi), Wi MAX (4G), IEEE 802.11ac (Wi-Fi), HSPA+ (3G) as communication standards for establish communication between two wireless systems.

Space Time Coding (STC) [9] is an emerging wireless system that engages several transmit and receive antennas and also demonstrating how multiple antennas have the potential to greatly increase attainable bit rates at optimal energy consumption.

Form the review and discussion of various efficient wireless communication standards, it is very much necessary to develop wireless communication methodologies in which multiple antennas can be reused effectively through STC technique. In future, there is need of research on development of Space Time Coding based wireless communication networks in order to achieve green communication standards which could compatible with nature of mother earth.

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