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A SMART DESIGN OF A MULTI-DIMENSIONAL ANTENNA TO ENHANCE THE MAXIMUM SIGNAL CLUTCH TO THE ALLOWABLE STANDARDS IN 5G COMMUNICATION NETWORKS

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Abstract

Since the operating range of 5G communication networks is the same as that of the previous generation, there are no difficulties in using these antennas on 5G communication networks. For any technology, the use of antennas makes it possible to bring data rates closer to maximum values. The new technology that uses separate receivers and transmitters on the same frequency band has further increased the speed of receiving and transmitting data. The design of the existing 4G modem provides for the use of antenna technology. The proposed model provides the construction of a multidimensional antenna. The other passive devices it has a one-way direction, which increases the received signal and reduces the amount of interference from the sides to the back. Therefore, the proposed model possible to increase the signal level to acceptable values, even at unstable reception levels thereby increasing the speed of receiving and transmitting the information. The undoubted advantage of panel antennas is their low cost and exceptional reliability. There is practically nothing in the design that can be broken even when falling from a great height. The only weak point is the high-frequency cable, which can break at the point where it enters the case. To extend the life of the device, the cable must be securely connected.

Keywords:

5G Communication Networks, Antenna, Data Rate, Transmitters, 4G Modem, Signal Level, Panel Antennas

1. INTRODUCTION

As we move towards fifth-generation (5G) wireless networks, the development of smart phones and new applications has led to a 100-fold increase in their required bandwidth compared to LTE [1]. The new multi-dimensional antenna design, which has received a lot of attention in recent years, is designed to significantly increase the performance of telecommunications networks [2]. Operators are attracted by the possibility of increasing bandwidth at frequencies below 6 GHz, given the scarcity of available resources and the high cost [3]. Despite the significant improvement, Massive MIMO is not perfect. Technology is actively explored in both academia and industry, where engineers seek to achieve theoretical conclusions with commercially viable solutions. Massive MIMO can help solve two key problems - performance and coverage. For mobile operators, the frequency band is a scarce and relatively expensive source, but it is the main condition for increasing the signal transfer speed. In cities, the spacing between base stations is driven by bandwidth rather than coverage, requiring larger deployments and additional costs [4]. The smart multi-dimensional antenna allows you to maximize the capacity of an existing network. In areas where there is deployment of base stations due to coverage, technology allows you to increase their range [5].

To understand the principles of operation of antenna technology, it is necessary to consider the commonalities in space. Waves emitted by various wireless radio systems above 100 MHz act like light beams in many ways. When radio waves meet a surface during propagation, depending on the material and size of the barrier, some energy is absorbed, some passes through, and the rest is reflected [6]. The ratio of the shares of energy absorbed, reflected and transmitted is affected by a number of external factors, including the frequency of the signal. Furthermore, the reflection and passing of the signal energies will change the direction of their further propagation, and the signal will be divided into several waves [7].

In dense urban environments, the absence of a line of sight between the (MS) and base station (BTS) antennas is very common due to numerous obstacles such as buildings, trees, and cars. In this case, the only way to reach the receiver's signal is through the reflected waves [8]. However, as mentioned above, there is no initial energy in the repeating reflected signal and may come with a delay. A particular difficulty is created because objects are not always static and the situation can change significantly over time. In this regard, a problem arises - one of the most important problems in wireless communication systems [9].

To combat multipath signal propagation, various solutions are used. One of the most common technologies is to get diversity. Not one, but several antennas (usually two, less than four) are used to receive the signal, which are located at a distance from each other [10-11]. Thus, the receiver has not one, but two copies of the transmitted signal that came in different ways. This makes it possible to collect more power from the original signal while the waves received by one antenna may not be received by another antenna and vice versa. Also, signals coming out of phase on one antenna may come on phase on another [12].

This radio interface system program can be called single input multiple output (SIMO) as opposed to the standard single input single output (SISO) scheme. The reverse approach can also be used: when multiple antennas are used for transmitting and receiving one. It also increases the total power of the original signal received by the receiver [13]-[14]. This program is called Multiple Input Single Output (MISO). In both projects (SIMO and MISO), several antennas are installed on the side of the base station. It is difficult to implement antenna diversity on a mobile device over a large enough distance without increasing the dimensions of the terminal equipment [15].

By enabling large-scale 5G service antennas (hundreds or thousands) synchronously and adaptively, the giant antenna is revolutionizing current practice [16]. It allows you to focus on sending and receiving signal energy to smaller locations, greatly improving performance and energy efficiency, especially when planning a large number of user terminals (tens or hundreds) at once [17]. This technique was originally designed for time fraction duplexing (TDD), but has the potential to be used for frequency segment duplexing (PDD) as well [18]. As a result of further rationality, we come to the multi-input multi-output (MIMO) scheme. In this case, several antennas are installed for transmitting and receiving [19].

However, unlike the above schemes, this diversity scheme not only deals with the multipath signal propagation but also allows getting some additional benefits [20]. By using multiple transmit and receive antennas, each transmit/receive antenna pair can be assigned a separate path to transmit information. In this case, the diversity reception will be done by the remaining antennas, and this antenna will also act as an additional antenna for the other transmission paths. As a result, in theory, additional antennas can increase the data rate by many times. However, there is a significant limit to the quality of each radio channel. A communication system is understood as a project to connect subscribers through channels, distribute resources allocated for communication and ensure high efficiency of communication between links.

2. LITERATURE REVIEW

Chen et al [1] discussed the advantages of the method are the widespread use of inexpensive low-power components, minimization of delay, and simplification of access control level, resistance to random and intentional interference. Expected performance depends on the transmission medium supplying asymptomatic orthogonal channels to the terminals, and tests performed so far have not revealed any limitations in this regard.

Saeidi et al. [2] discussed many problems will be eliminated and new ones will appear that require urgent solutions. For example, in antenna systems, it is necessary to ensure that many low-cost, low-precision components work together efficiently; collecting channel-level data and allocating resources to newly connected terminals.

He et al. [3] discussed it requires using the extra freedom provided by service antennas, reducing internal power consumption to achieve overall power efficiency, and discovering new deployment displays. For growth in the number of 5G antennas involved in antenna activation, it is usually necessary to go to each base station and change the configuration and wiring. Initial deployment of the LTE antenna required the installation of new equipment.

Karmakar et al. [4] discussed the made it possible to create a 2×2 antenna configuration of the original antenna standard. Further changes to the base stations are only made as a last resort, and higher sequence processes depend on the operating environment. Another problem is that antenna function results in completely different network behavior than previous systems, which introduces some scheduling uncertainty. Therefore, operators tend to use other designs first, especially if they can be used with software upgrades.

Hong et al. [5] discussed in light of the release of new wireless devices with support for antenna technology, especially with the release of Uni-Fi AC HD (UAP-AC-HD), there is a need to clarify what it is and why older hardware is not supported. Aeronautical networks generally assign a single frequency to transmit and receive, and communicate in a simplex manner when transmission and reception are interchangeable. Elements of terrestrial communication networks: subscriber units, channels and communication nodes.

Boursianis et al. [6] discussed the communication nodes in the United States help to distribute information across lines and communication channels that lead to different geographical points. The principle for creating wireless communications is radial-nodal, i.e., the main nodes of the GUS are provided, merging groups of regional nodes and connecting channels with the main nodes and connecting to each other.

Shadid et al. [8] discussed the policy ensures high efficiency and communication reliability because solutions can be used. The channels of national communication networks are widely used when creating terrestrial communication networks. Ground telecommunications in civil aviation facilitates communication between airports, and administrative and operational controls. A landline telephone communication network is also organized.

Yang et al. [9] discussed the mainstream radio is an element of radio communications - a radio network. Radio Network - A set of RSs installed where interactive reporters (in the control room and on the plane) are located and integrated by common radio channels operating on common radio frequencies. As a rule, radio networks are organized on a radial basis. The radio network enables the exchange of information between the controller and crew of each aircraft, as well as the transmission of data to all aircraft simultaneously. Radio networks are created depending on the number of ATC ports. The most important element that ensures continuity is the streamlined process of switching radio networks.

3. PROPOSED MODEL

To increase the efficiency of the communication channel between the receiver and the data transmitter, a signal processing system was developed when reception and transmission were performed to different antennas. Electromagnetic waves can have different directions compared to the ground plane. This is called polarization. Mainly vertical and horizontal polarized antennas are used. To exclude mutual influence among them, the antennas differ from each other by polarization at a 90° angle. The polar planes of each are rotated 45° so that the impact of the earth's surface is the same for both antennas are associated with the floor. Thus, if one of the antennas has a polarization angle of 45 degrees, the other is 45°, respectively. The corresponding displacements are required 90°.

The polarity of the antennas should be the same as the base station. The rules for installing antennas are no different from conventional ones. The main condition is the absence of barriers between the client and the base stations. Growing wood, the roof of a neighboring building, or worse, and an electrical connection acts as a reliable shield against electromagnetic waves. Also, if the frequency of the signal is high, more mitigation will be introduced due to obstructions in the path of transmission of radio waves. Depending on the mounting type, the antennas can be mounted on the wall of a building or mounted on a mast. There are two types of antennas:

- ***Mono-block Antenna***: The mono-block already has two configurations inside, installed with the required polarity
- ***Spacing Antenna***: The two antennas that must be mounted separately, each of which must be properly operated at the base station.

There are no fundamental difficulties in self-production. The ability to work with metal, the ability to hold a soldering iron in your hands, the desire and precision you need. An unavoidable condition is the strict adherence to the geometric dimensions of all parts, without exception. The geometric dimensions of high frequency devices must be observed to the nearest millimeter and more accurately. Any deviation leads to performance distortion. The gain decreases and the relationship between the antennas increase.

Eventually, instead of amplifying the signal, its weakness will be noticed. Unfortunately, exact geometric dimensions are not widely available. Exceptionally, the products available on the web are based on repeating certain factory designs and are not always copied with a given accuracy. Therefore, you should not rely too much on the plans, descriptions and methods published on the internet. On the other hand, if super strong amplification is not required, an antenna can be manufactured independently, according to the indicated dimensions, to give a positive effect, even if not larger. The cost of materials is low and the time spent in the presence of skills is not high. In addition, after testing many options, no one interferes with the selection of one that is acceptable according to the test results.

The fabricated structure should be placed in a plastic box. Metal cannot be used because in this way the antenna is wrapped in an electromagnetic shield and does not work. The proposed antenna technology allows multiple simultaneous downtimes, providing simultaneous service to multiple devices at the same time, which improves the overall network performance. The proposed antenna has a positive effect on the delay, providing a quick connection and the overall customer experience. In addition, the features of the technology allow you to connect a greater number of customers simultaneously to the network than the previous version of the standard.

To certain conditions (low power, low noise count, etc.) for using the 160 MHz channel width can provide a great performance boost when sending large amounts of data. In comparison, the 802.11n channel can deliver speeds of up to 450Mbps, while the new 802.11ac Wave 1 offers up to 1.3Gbps, while the 802.11ac Wave 2 with 160MHz channel offers channel speeds of up to 2.3Gbps. In the previous generation of the standard, the use of 3 transceiver antennas was allowed; the new modification adds a 4^{th} stream. This change improves the range and stability of the connection. There are 37 channels in the 5 GHz band used worldwide.

Some countries have a limited number of channels, some countries do not. 802.11ac Wave 2 allows for more channels, and allows devices to work simultaneously in the same place. In addition, 160 MHz wide channels require more channels. The new standard receives the standards introduced from the first release. As before, the speed depends on the number of streams and the channel width. Maximum modulation remained unchanged - 256 QAM.

Previously requiring 866.6Mbit 2 streams and 80MHz channel width, this channel rate can now be achieved using a single stream, while increasing the channel rate to two - 80 to 160MHz. As you can see, nothing major has happened. With the support of 160MHz channels, the maximum channel speed has also been increased - up to 2600 Mbps. In practice, the actual velocity of the channel is approximately 65% (PHY ratio).

$$P_b = \exp\left[-x\left(\frac{2\pi}{y}\right)\sin\sigma_r\left[\omega_f\cos\left(\varepsilon_y\right)+\delta_y\sin\left(\varepsilon_y\right)\right]\right] \quad (1)$$

where, P_b = Communication antenna efficiency, σ_r and ε_y are the segment changes of an antenna at the communication band ω_f and δ_f.

Using 1 stream, 256 QAM modulation and 160 MHz channel, you can reach real speeds of 560 Mbps. Accordingly, 2 streams will offer a transfer rate of ~ 1100 Mbps, 3 streams - 1.1-1.6 Gbps. In practice, Waves 1 and Waves 2 operate exclusively on the 5 GHz band. The frequency range is subject to regional restrictions, typically 5.15-5.35 GHz and 5.47-5.85 GHz bands are used. In the high speed communication, there is 580 MHz band is allocated to 5 GHz wireless networks. 802.11ac, as before, can use channels at 20 and 40 MHz, while achieving better performance using 80 MHz or 160 MHz.

Since it is not always possible to use a continuous 160 MHz band in practice, the standard provides 80+80 MHz mode, which divides the 160 MHz band into 2 different bands. All of this adds more flexibility. An implementing standard on IEEE waves as technology advances. This approach allows the industry to launch new products immediately without having to wait for this or that aspect to be completed. The first wave of 802.11ac made a significant step forward from 802.11n, laying the foundation for future development.

$$TE=2\{10\log(a)-[\log(E_p)+\log(E_q)+5\log(F_p)+5\log(F_q)]\} \quad (2)$$

$$A = 2E_a\left[\cos^{-1}\left(\frac{E_a}{\left(E_a+f_p\right)}\cos\left(\varnothing\right)\right)-\varnothing\right] \quad (3)$$

where, TE = Transmission efficiency of an antenna, a = angle division among the transmission antenna and receiver antenna and E_a = Earth-surface design

In the case of the new standard, the general trend of previous years is preserved – smart phones and laptops are made with 1-2 streams, 3 streams are designed for more demanding tasks. There is no practical sense in implementing the full functionality of the standard on all devices. The first wave allows up to 3 streams and channels up to 80 MHz, in this area, client devices and access points are fully compatible. To enable second-generation features (160 MHz, MU-MIMO, 4 streams), both the client device and the access point must support the new standard. The next generation access points are compatible with 802.11ac Wave 1, 802.11n and 802.11a client devices. Therefore, using additional features of the second-generation adapter does not work with the first-generation dot, and vice versa. The access point distributes time equally to all customers. When working with the first client, Point uses 100% of its capabilities because the client supports.

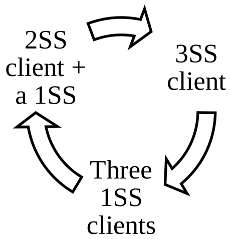

Fig.1. Total utilization of the proposed model

The remaining 75% of the time, point works with three clients, each using only the available 1 in 3 streams (1SS). At the same time, the access point uses only 33% of its capabilities. In one specific example, the average channel speed is 650 Mbps:

$$(1300+433.3+433.3+433.3) / 4 = 650$$

In practice, this would mean an average speed of 420 Mbps at 845 Mbps. Let us now look at an example using multi-dimensional antenna. We have a second-generation dot using 3×3 multi-dimensional; the channel speed remains the same - 1300 Mbps for 80 MHz channel width. That. At the same time, customers, as before, cannot use more than 3 channels. The total number of customers is now 7 and the access point divides them into 3 groups shown in Fig.1:

- A 3SS client;
- Three 1SS clients;
- A 2SS client + a 1SS;

As a result, we get 100% implementation of AP capabilities. One client from the first group uses 3 streams; another group's clients use one channel, and so on. The average channel speed is 1300 Mbps. As you can see, it doubled the output. It provides standard for simultaneous maintenance of up to 4 devices. The total number of texts can be up to 8. Depending on the configuration of the equipment, different options are possible shown in Fig.2:

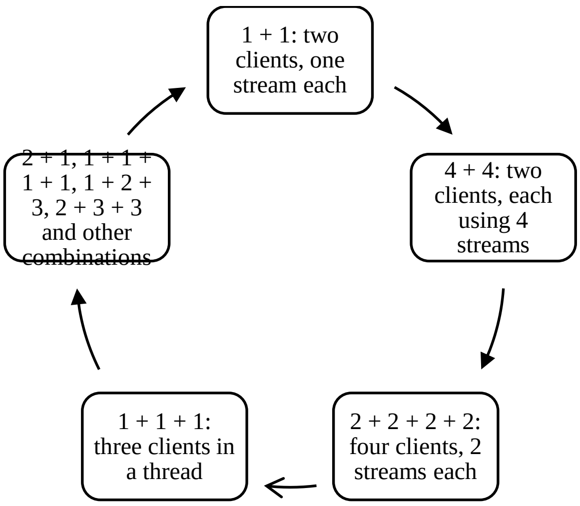

Fig.2. Proposed multidimensional antenna design

- 1+1: two clients, one stream each;
- 4+4: two clients, each using 4 streams;
- 2+2+2+2: four clients, 2 streams each;
- 1+1+1: three clients in a thread;
- 2+1, 1+1+1+1, 1+2+3, 2+3+3 and other combinations.

It all depends on the hardware configuration; usually devices use 3 streams, so the point is to be able to serve up to 3 customers simultaneously. It is also possible to use 4 antennas in the antenna 3×3 configurations. In this case there is a fourth antenna addition, which will not activate the extra stream. In this case, 1+1+1, 2+1 or 3SS can be provided simultaneously, but 4 is not possible. Channel bandwidth is the maximum value of the data transfer rate in this channel. That is, classifies the potential for bandwidth communication. Connection performance is measured in bits per second (bps).

It can be seen from the relationship that if the signal strength is not limited, the performance will be infinite. The bandwidth is zero when the signal-to-noise ratio R_c/R_w is equal to zero. As this rate increases, performance increases indefinitely. This expression presents a physically unattainable range, above the information exchange rate, because its derivative made the assumption of an optimal error-correction coding system, and its processing requires infinitely longer communication time.

4. RESULTS AND DISCUSSION

The proposed multi-dimensional antenna design (MDA) was compared with the existing Vehicle-to-everything model (V2X), salp swarm algorithm (SSA), whale optimization algorithm (WOA) and genetic algorithm design (GAD). Here the matlab is the simulation tool is to enhance the performance parameters.

4.1 ENHANCEMENTS IN BANDWIDTH

The Bandwidth development has a positive effect on applications that are sensitive to bandwidth and delays within the network. This is primarily the transfer of streaming voice and video content, as well as an increase in network density and an increase in the number of customers. As the Wi-Fi connection speed increases, so it was increased wireless network bandwidth shown in Table.1.

Table.1. Comparison of Bandwidth Enhancements

Signal input	V2X	SSA	WOA	GAD	MDA
100	67.32	77.68	53.86	65.14	91.27
200	68.81	79.65	56.28	67.34	93.26
300	69.61	80.78	56.69	68.14	94.46
400	71.91	81.91	58.29	68.81	94.94
500	72.95	82.36	60.61	70.24	96.37
600	73.59	83.81	61.86	71.33	96.53
700	74.25	84.29	64.59	71.81	98.30

As devices deliver faster, the network has more time to serve more client devices. Thus, multi-directional antennas can greatly improve the performance of wireless networks with a greater number of connected devices such as high traffic or public Wi-Fi networks. This is great news as the number of smartphones and other mobile devices with Wi-Fi connectivity is likely to continue to increase.

4.2 ENHANCEMENTS IN BEAMFORMING

Although beamforming technology is available as an option with the 802.11n standard, most manufacturers have implemented proprietary versions of this smart antenna design shown in Table.2.

Table.2. Comparison of Beam Forming Enhancements

Signal input	V2X	SSA	WOA	GAD	MDA
100	78.12	72.22	73.38	68.67	90.14
200	78.01	71.72	73.38	67.58	89.88
300	77.95	70.97	72.55	66.44	89.31
400	77.90	70.97	73.28	66.80	90.45
500	77.86	72.02	74.39	68.33	91.47
600	77.83	72.30	74.79	68.97	91.71
700	77.81	71.58	74.22	68.39	91.06

These vendors still offer proprietary implementations of the technology on their devices, but now if they want to support proposed model in their 802.11ac product line they need to add a simplified and standardized version of the directional signal technology.

4.3 ENHANCEMENTS IN ACCESS POINTS

In an effort to ease the need for end-user devices, developers of smart antenna sought to shift most signal processing work to access points. This is another step forward from smart antenna, where the load of signal processing was mostly on user devices shown in Table.3.

Table.3. Comparison of Access Points Enhancements

Signal input	V2X	SSA	WOA	GAD	MDA
100	74.65	64.52	75.32	71.48	96.40
200	72.23	62.32	73.33	69.99	94.43
300	71.82	61.52	72.13	69.19	93.30
400	70.22	60.85	71.65	66.86	92.09
500	67.90	59.42	70.22	65.85	91.72
600	66.65	58.33	70.06	65.21	90.19
700	63.92	57.85	69.29	64.55	89.69

Again, this will enable client device manufacturers to save energy, quantity and other costs on the production of their product solutions with multi-directional antenna support, which should have a very positive effect on popularizing this technology.

4.4 ENHANCEMENTS IN TRANSMISSION DEVICES

Although Wi-Fi devices must have antenna support to use this technology, even client devices that do not have such support may indirectly benefit from operating on a wireless network where a router or access points support a multi-directional antenna shown in Table.4.

Table.4. Comparison of Transmission Device Enhancements

Signal input	V2X	SSA	WOA	GAD	MDA
100	82.83	61.05	58.35	74.94	94.43
200	82.72	61.07	58.18	74.67	93.93
300	82.70	61.95	58.91	74.97	94.05
400	85.80	64.78	62.25	78.48	97.28
500	87.00	66.10	62.98	79.80	97.66
600	87.61	66.93	63.87	80.34	98.23
700	88.02	67.33	63.95	80.64	97.93

The proposed model keeps the data transfer rate on the network directly depends on the total time the subscriber devices are connected to the radio channel. If multi directional antenna allows you to service some devices quickly, access points on such a network will mean more time to serve other client devices.

4.5 ENHANCEMENTS IN CHANNEL WIDTH

One way to expand the Wi-Fi bandwidth is to connect two adjacent channels into one channel that is twice the width, which doubles the speed of the Wi-Fi connection between the device and the access point shown in Table.5.

Table.5. Comparison of Channel width enhancements

Signal input	V2X	SSA	WOA	GAD	MDA
100	84.21	60.58	60.70	78.13	90.27
200	85.84	62.32	62.28	79.55	91.56
300	86.32	64.66	64.48	80.81	92.57
400	87.61	65.47	66.11	82.80	93.46
500	89.72	67.76	67.25	85.27	93.83
600	91.21	69.69	69.45	86.71	95.47
700	93.02	71.42	70.60	88.43	95.84

The 802.11n standard provided support for channels up to 40 MHz wide, while in the original specification of the 802.11ac standard, the supported channel width was increased to 80 MHz. The updated 802.11ac Wave 2 standard supports 160 MHz channels.

5. CONCLUSION

The Beamforming allows you to change the radiation pattern, adapting it to a specific client. During operation, the point analyzes the signal from the client and enhances its radiation. An additional antenna may be used during the beamforming process. Possible, new generation access points can handle such traffic flow. The proposed MDA was compared with the existing V2XM, SSA, WOA and GAD. In a saturation point, the proposed multi-dimensional antenna achieved 94.94% of the bandwidth enhancements, 90.45% of the beamforming enhancements, 92.09% of the Access point's enhancements, and 97.28% of the transmission device enhancements and 93.46% of the Channel width enhancements. The actual performance depends on a number of factors, including the number of streams supported, the range of communication, the presence and interruption of interruptions, the quality of the access point, and the client volume. The choice of operating frequency depends only on local law. The list of channels and channels is constantly changing.

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