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Analysis of MIMO Performance for 5G

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Abstract
MIMO stands for multiple input multiple output, is considered as one of the pillars for the cellular communication networks. In MIMO technology, multiple antennas are placed at both transmitter and receiver. The primary goal of the MIMO is to enhance the capacity, coverage and throughput of the wireless communication systems. MIMO also controls the overall antenna pattern for interference reduction. For its ability to deliver a larger spectral efficiency, MIMO is considered as key technology for cellular networks. Constructing antenna arrays at both transmitter and receiver side will also improve the directivity, thereby the long distance communication is possible. In this work, 2x2, a 4x4bandb8x8 MIMO configuration was implemented. Simulations are carried out using Keysights's SYSTEM VUE which is system level designing tool. Preceding is done using MATLAB. Quality of service (QoS) parameter such as Bit error rate (BER) is analyzed for each case.

Keywords: *MIMO, System VUE, 5G-Technology, Bit error rate (BER), Flexible OFDM, D2D Communication, millimeter wave.*

INTRODUCTION

In recent days, the expanding in the mobile devices makes the issue of accomplishing higher data rates. In worldwide cellular memberships may extends up to 9.2 billion by 2020. It is likely hard to accomplish larger capacity and coverage of the wireless communication systems and to achieving lower power consumption is additionally troublesome. This builds the interest for 5G technology. 5G means to give information rates up to 1Gbps and latency lower than 1msecs. This is usually less than LTE. The 5G is proposed to convey information rate of 20Gbps as compared it to 1Gbps by 4G. The architecture of 5G is encourages us to give the diverse efficient innovations for example IoT-Internet of Things, MIMO-Multiple Input and Multiple Output, mm wave and heterogeneous network.

5G operates at millimeter waves ranges which gives higher data transmission than the presently available. User networks are furnished with frequencies above 6 GHz, which is utilized for the first time. In 2020, the (3GPP)- Third Generation Partnership project is required to convey the 5G standard determination. 5G is still in a creating, it experiences numerous issues and difficulties.

One of the significant favorable circumstances of 5G is to maximize the transmission capacity to give a high information rate that can be accomplished by using MIMO antenna system. MIMO is considered as one of the important parameter for fifth era (5G) cellular communications. MIMO is a technology that uses multiple antennas at both transmitter and receiver. The primary inspiration driving the utilization of MIMO in 5G innovation is to build the throughput and spectral efficiency. It additionally enhances the capacity and coverage of the wireless cellular system. It can be worked by utilizing minimal effort and low power parts. To improve the quality and reliability of a wireless link, antenna diversity technique is utilized. It will help in minimizing the propagation losses, increases capacity and improve information speed for a similar channel. The features like energy efficient algorithm and ability to serve large number of users at the same time in the same cell and at the same frequency spectrum will attract the researcher.

5G TECHNOLOGY

The fifth generation of wireless communication standards is the next evolution that is expected to hit the markets by 2020. 5G is the wireless broadband technology based on the IEEE802.11ac standard. An important goal of fifth generation cellular communication is to erase the differences between Inline and wireless networking to accommodate the growing mobility of network users. 5G will provide better speeds and coverage than the present 4G technology. 5G operate with a 28 Ghz signal and is set to offer speeds up to 10 Gb/s. 5G also increases network expandability up to hundreds of thousands of connections. The advanced technologies of 5G have been improved for greater coverage as well as spectral efficiency.

The key characteristics of 5G are expected to include lower latencies, faster network data rates and support for a massive increase in network connections. The two requirements that could be classified a revolutionary and generation-defining for 5G are the near-zero latency and data rates of 1–10 Gbps. The seven key characteristics that will be required of a network for it to be classified as a 5G network are:

Data rates: Supports data rates of 1–10 Gbps, which is a step change for mobile networks and is expected to facilitate a high quality and a more seamless user experiences. By comparison, 4G networks provide advertised data rates of between 2–100 Mbps.

Low latency: Reduced latency to 1msec. This is likewise a stage change for versatile systems. By examination, 4G systems can hypothetically accomplish a minimum latency of 10 m/s.

Bandwidth: Provide 1000 times transmission capacity more per unit region than available on existing mobile networks. This will bolster quicker information rates and increment organizes ability to help information escalated applications in both the uplink and downlink.

Connections: Support the development of between 10 to 100 times more associated gadgets than is presently upheld by existing networks. This is likewise hypothetically conceivable on advancing 4G systems and mass availability is recognized as a key empowering influence for the IoT.

Energy usage: Reduce network energy usage by 90 per cent.

Battery life: Supports up to 10 years of battery life for low power, machine type gadgets. Both the energy usage and battery life necessities are hypothetically achievable utilizing developing 4G advances and are gone for guaranteeing future systems are financially cost effective for arrange administrators.

Features of 5G

- Greater speed
- Greater capacity
- Reduced Latency
- Provide high resolution and larger data transfer capacity
- It will gather networks on one stage
- Lower battery consumption

- Simultaneous connections can cooperate
- Provide uninterrupted and steady availability
- Allow access to parallel numerous administrations
- Remote place access grant.

KEY TECHNOLOGIES FOR 5G

Device to Device communication:

To enhanced information rates of up to 10 Gbps and lessened latencies underneath 1ms, this advancement guarantees to empower a system of associated machines, devices that work in conjunction with consistent subscribers. This will present new communication technologies, such as device to device communication.

In earlier cellular communications, the greater part of communication happens amongst BSs and devices. Despite the fact that two clients are in their range of direct communication, the connection must be set up through the Base Station, which isn't productive for ongoing administrations requiring high information rates and low latency. With a specific end goal to improve spectral efficiency, coordinate device communication was proposed at first to make multi-hop transfers among devices in cellular systems. From that point forward, a few Device to device communication utilize cases have been broadly explored as a component of the LTE-Advanced systems, in both authorized cell spectrum and unlicensed groups. The 5G systems are relied upon to keep supporting applications that expect devices to set up coordinate communication joins with their companions. The applications incorporate file sharing, gaming, and long range interpersonal communication.

Millimeter wave technology

The millimeter wave area of the electromagnetic range is generally thought to be the scope of wavelengths from 10 millimeters (0.4 inches) to 1 millimeter (0.04 inches). This implies millimeter waves are longer than infrared waves, but shorter than radio waves or microwaves. The millimeter-wave region of the electromagnetic spectrum compares to radio band frequencies of 30 GHz to 300 GHz and is sometimes called the Extremely High Frequency (EHF) range. The high frequency of millimeters waves as well as their propagation characteristics makes them valuable for an assortment of uses including transmitting a lot of PC information, cellular communications, and radar.

Massive MIMO

The interference is the primary constraint of wireless networks. Communications engineers have strived to exploit the properties of multipath wireless channel with a specific end goal to enhance the execution of communications models through an expansion of the radio link capacity. Several interference lessening methods, for example, multiuser MIMO, multicellular processing, and interference arrangement. However, these systems can't be utilized to achieve the high information rates anticipated from future advancements. Network densification is one solution.

One method for applying this system is by cell measure contracting. This should be possible by introducing femto or little cells, yet this expands interference and includes cost of extra hardware. Another alternative is that by taking huge interest in wireless communication is the utilization of very large MIMO antennas or large scale antenna systems, known as MIMO.
For the most part, a single antenna component has a poor directivity with wide and wide radiation pattern. For 5G innovation, high directivity is strongly required. This can be accomplished through building arrays of antenna, in an appropriate

electrical and geometrical setup, without the requirement for improving the extent of antenna components, which is the inspiration driving the utilization of MIMO. Since it was first presented, the utilization of massive antennas has been accepting vital enthusiasm in wireless technology. A portion of the work concentrated on the quantity of antenna components expected to accomplish improved execution, other researched recognition techniques that can additionally upgrade the gain.

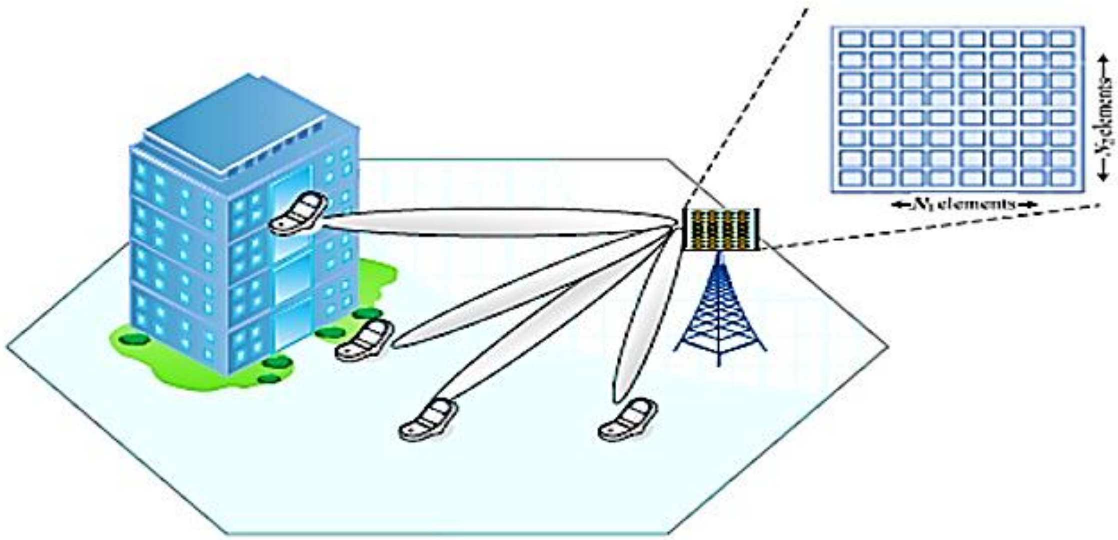

Fig: 1. *MIMO system with planar antenna array.*

MIMO antennas elements are set at the Base Station. These largely sized antenna arrays can adjust adaptably to complex condition, and by scaling up the order of MIMO system and applying beam forming techniques, the signal transmitted from the Base Stations can be exceedingly engaged into little areas of interest, towards every user, bringing about significantly decreased interference. As a result, the spatial multiplexing in each time-frequency block, along with multi antenna diversity and beam forming is relied upon to enhance the transmission rate, the multiplexing capacity, the spectrum effectiveness, and expand the signal-to-noise-plus-interference ratio.

A fundamental target behind the utilization of MIMO in 5G innovation is to control the overall pattern of the antenna for interference reduction and communication for long distance over higher frequency. This pattern is profoundly influenced by the array design, the isolating separation between the antenna components, the phase and amplitude of the excitation of various components, and the comparing patterns of each.

In the plan procedure, the picked design ought to be studied in terms of the aggregate number of antenna components, the subsequent radiation characteristics: radiation pattern, beam width and gain. Diverse antennas can be used in such clusters, for example, printed or patch antennas, horn, and dipoles antennas. The decision of the component compose relies upon the application close by, the execution required, the general size of the system.

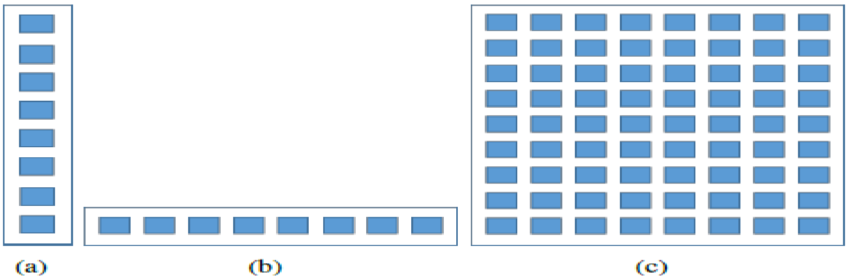

Fig: 2. *(a) Horizontal array, (b) Vertical array, (c) Planar or Rectangular array*

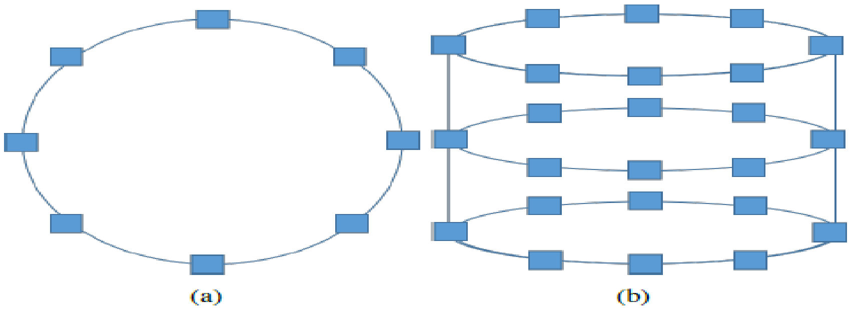

Fig: 3. *(a) Circular array, (b) Cylindrical array*

MIMO antennas could be arranged at the base station in the form of uniform linear, square, circular, or cylindrical shaped arrays. They can be conveyed geographically or introduced on the substance of a building. Planar Array- In linear arrays, the components are situated along a straight line, vertically or horizontally. This topology is called uniform linear arrays (ULAs) when the between component dispersing is uniform. Circular and Cylindrical Arrays- In circular arrays, the antenna components are arranged in a circular ring, called UCA. This design as a rule gives wider angle radiation.

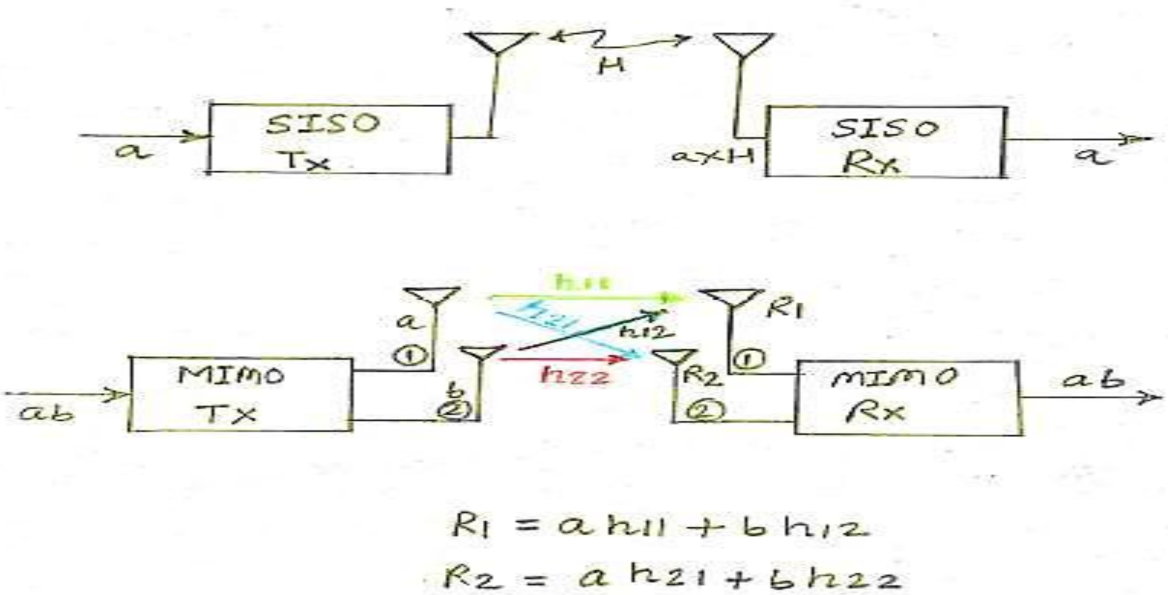

Fig: 4. *Spatial Multiplexing*

- R1, R2 → received symbol on the 1st and 2nd antenna,
- h11 → channel from 1st transmit antenna to 1st receive antenna,
- h12 → channel from 1st transmit antenna to 2nd receive antenna,
- h21 → channel from 2nd transmit antenna to 1st receive antenna,
- h22 → channel from 2nd transmit antenna to 2nd receive antenna,
- a and b → transmitted symbols.

Flexible OFDM

A flexible OFDM frame comprises of idle, preambles- Preamble 1 and Preamble 2 and payload data- Data 1 and Data 2. By utilizing diverse design, clients can get distinctive OFDM frames as indicated by their prerequisite. In Flexible OFDM EVM show, Preamble1 is utilized for synchronization and the default information of Preamble1 are the same in various antennas. On the off chance the information of Preamble1 are not the same in various antennas, synchronization execution corruption would show up. Preamle2 or Pilots could be done channel estimation. Preamble 2 can be turned ON or OFF. Information 2 (Payload 2) likewise can be switched ON or OFF. There are just the Information 1 (Payload 1) and the Preamble1 which ought to be dependably nearer to receiver.

In Flexible OFDM technique, distinctive Users in OFDM structure are transmitted on various frequency sub groups with various subcarrier interims. So users are never again symmetrical. The yield of Flexible OFDM MIMO Source is associated with VSA programming from which we can see the range and demodulation execution in VSA custom OFDM framework. Parameter ought to be steady with that in VSA. Setup records created by Flexible OFDM MIMO can make the association with VSA significantly less demanding.

Supported Features

- Support adaptable beamforming structure, including full advanced beamforming, hybrid beamforming and full RF/analog beamforming
- In OFDM MIMO, advanced beam forming procedure can be switched on or off.
- A MIMO channel is given supporting client characterized situation per MIMO standard and NYU situation for millimeter wave frequency.
- Support custom antenna component design import and RF hindrance, when custom antenna component design is transported in, parameters Bearing Angle, down tilt Angle and Slant Angle can be set likewise to turn the antenna component pattern to proper organize framework.
- Support BER estimation and received constellation plotting.
- Supports Flexible arrangements by the Digital, RF and Hybrid beam forming architecture.

Common parameters

FFT Size= 64, Bandwidth = 2GHz,
Carrier Frequency= 28.5GHz. Transmit antennas=16, receiver antennas = 4.
MIMO channel is set to NYU use defined with 1 or 2 predefined AOA and AOD. 1 OFDM symbol for Preamble 1 for sync. Multiple OFDM symbols for Preamble 2 for RF beamforming training. In information section, one pilot is allotted per each three subcarriers for channel estimation. The aggregate number of information images is configurable.

BLOCK DIAGRAM

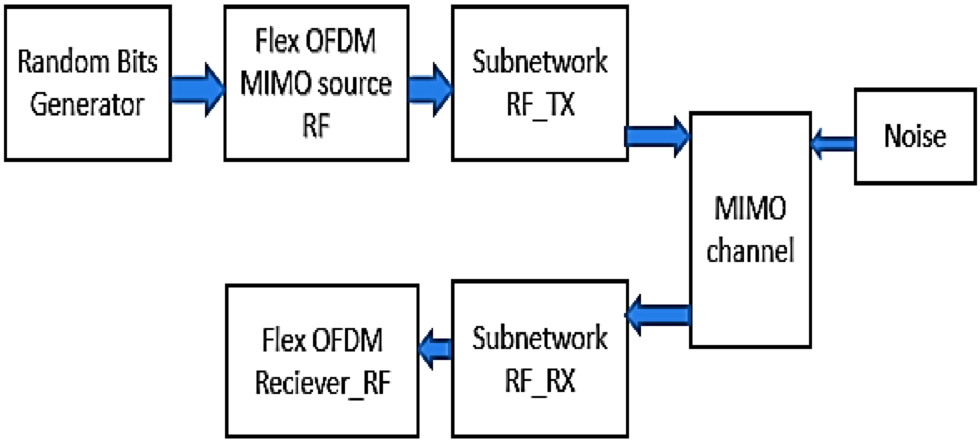

Fig: 5. *Block diagram*

Tools Used: System Vue ESL Software

System Vue is a focused electronic design automation (EDA) environment for electronic system-level design. It enables system architects and algorithm engineers to advance the physical layer of remote and aviation/safeguard interchanges frameworks and gives special incentive to DSP, RF, and FPGA/ASIC implementers. As a devoted stage for ESL outline, System Vue replaces broadly useful advanced, simple, and math conditions. The System Vue communications architect is the center condition, with fundamental test systems and libraries. It incorporates numerous abilities that are not found in other ESL devices, or are just accessible as included cost alternatives.

Key Benefits of SystemVue are:

- RF fidelity among the present baseband/physical situations – permits baseband architects to virtualize the RF and eliminates the abundance edge.
- Superior joining with Test quickens true development and streamlines your model-based outline stream, from Architectures to Verification.
- Priced for arranged workgroups to expand plan re-utilize and profit by Baseband and RF cooperative energies.

RESULTS: MIMO 5G

4x4 Configuration at 5G frequency= 28.5 GHz

Table: 1. *SNR V/S BER for* 4x4

Index	Parameters_SNR_Swp	B1_BER
1	4.01	0.054
2	6.01	0.02
3	8.01	4.913e-3
4	10.01	520.8e-6

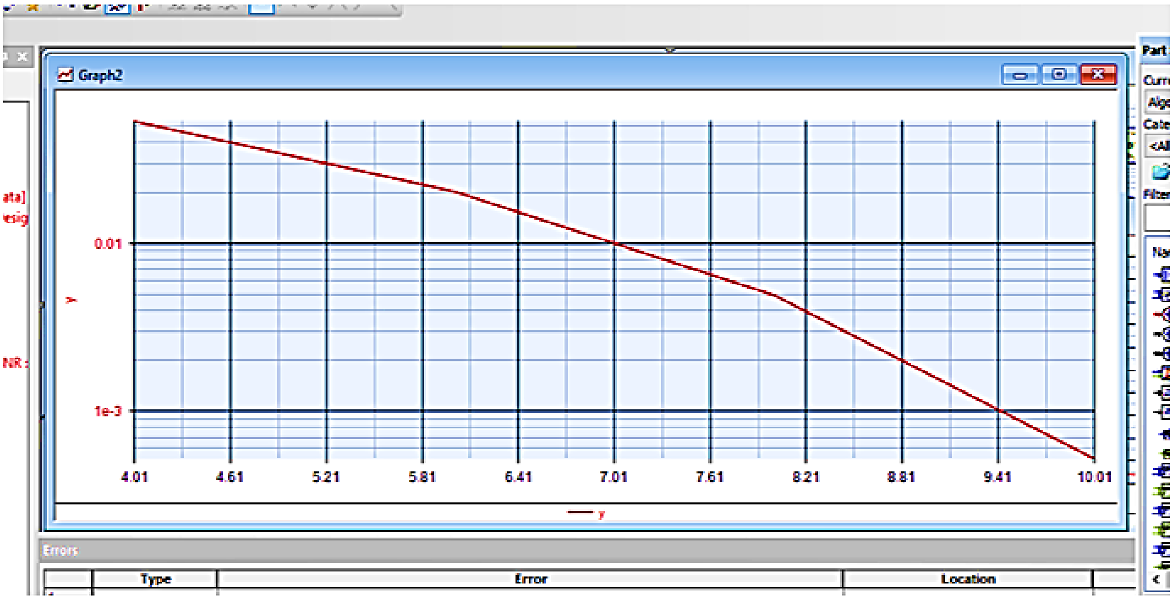

Fig: 6. *Plot of SNR V/S BER.*

X-axis: SNR, Y-axis: Logarithmic of BER.

BER Computed values for different configurations:

For 5G frequency: Fc= 28.5 GHz

Table: 2. *BER computed values of 5G for Different configurations*

Configuration	2x2	4x4	8x8
SNR			
4	0.063	0.054	0.023
6	0.021	0.02	191*e-6
8	5.095*e-3	4.913*e-3	60.76*e-6
10	685.8*e-6	520.8*e-6	0

For 4G frequency: Fc= 2 GHz

Table: 3. *BER computed values of 4G for different configurations*

Configuration	2x2	4x4	8x8
SNR			
4	0.504	0.15	0.042
6	0.384	0.111	0.026
8	0.081	0.079	7.432*e-3
10	1*e-3	0.058	1.063*e-3

QAM V/s QPSK BER Comparison for 5G 4x4 Configuration:

Table: 4. *QAM V/S QPSK*

QAM	QPSK
0.131	0.054
0.072	0.02
0.026	4.913*e-3
3.563e-3	520.8*e-6

CONCLUSIONS

For future wireless communication networks, high directivity is strongly required. This can be accomplished by developing antenna arrays at both transmitter and receiver side, which is only MIMO innovation. MIMO additionally enhances the capacity, coverage and throughput of the wireless communication networks when contrast it with SISO. A different configuration for MIMO is designed i.e., 2x2, 4x4 and 8x8. Bit Error Rate is examined for every cases at 5G frequency range. 2x2 exhibits higher bit error rate when it compared to 8x8 configurations. It was inferred that as we go for higher and higher antenna configurations, the BER will diminishes consequently the efficiency of the communication system will increase. The same is analyzed for 4G Frequency range and BER values are tabulated. BER analysis for QPSK and QAM modulation techniques is also made and it showed that QAM has higher BER than QPSK.

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