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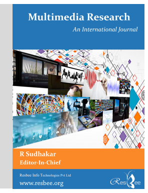

Channel Estimation in MIMO-OFDM by Improved Crow Search Algorithm

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Abstract: Multiple Input Multiple Output (MIMO) is exploited by the current mobile telecommunication systems with the cooperative of Orthogonal Frequency Division Multiplexing (OFDM) that is renowned as MIMO-OFDM to present sturdiness as well as superior spectrum effectiveness. In this case, the main significant confront is to attain a precise channel estimation in order to recognize the information symbols, if the receiver should possess Channel State Information (CSI) in order to balance as well as the procedure the received signal. Therefore, a competent approach is developed by developing the Improved Crow Search algorithm (ICSO) to enhance the MIMO-OFDM system performance in multimedia applications. Additionally, in the MU-MIMO system user admission control is performed by exploiting the priority-based scheduling based on Cat and Mouse Optimization algorithm (CMO) approach which is combined in the STBC-MIMO-OFDM system for competent power allocation to make sure energy effectiveness. In addition, the fitness metrics like priority, power, throughput, and Proportionally Fair are calculated. The simulation is performed in diverse fading environments with three modulation strategies, such as QPSK, BPSK, and QAM with the performance measures, like BER and throughput. The proposed model outperforms the conventional models with minimum BER and maximum throughput.

Keywords: BER, Channel estimation, MIMO, OFDM, Throughput

Nomenclature

Abbreviations	Descriptions
OFDM	Orthogonal Frequency Division Multiplexing
DCT	Discrete Cosine Transform
QAM	Quadrature Amplitude Modulation
JLCRZF	Joint Low-Complexity Regularized ZF
QPSK	Quadrature Phase Shift Keying
ADSL	Asymmetric Digital Subscriber Line
FDM	Frequency Division Multiplexing
DST	Discrete Sine Transform
AM	Amplitude Modulation
BS	Base Station
ISI	Inter symbol Interference
BER	Bit-Error-Rate
ML	Maximum Likelihood
BPSK	Binary Phase Shift Keying
SISO	Single Input Single Output
ASK	Amplitude-Shift Keying
DFT	Discrete Fourier Transform
SIC	Successive Interference Cancellation
DWT	Discrete Wavelet Transform
DVB	Digital Video Broadcasting
CSI	Channel State Information
PTS	Partial Transmit Sequence
CFO	Carrier Frequency Offset
PAPR	Peak-to-Average Power Ratio
DAB	Digital Audio Broadcasting
SLM	Selective Mapping
MMSE	Minimum Mean Square Error
BSS	Blind Source Separation
ZF	Zero Forcing
FPGA	Field Programmable Gate Array
MIMO	Multiple-Input Multiple-Output system

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1. Introduction

The main definition of wireless communication is the communication among two or numerous devices generously without any physical media such as wires or cables and so on. The transmitted signals are broadcast via air as a transmitting medium as well as therefore there presents numerous un-preferred transitional sources which occur fading as well as distortions in the transmitted signals [1].

OFDM is an approach in which the generally transmitted signal is spread in excess of a great number of subcarriers. In the existing FDM, the carriers are divided using the protector intervals that so affect the effectuality of bandwidth. While OFDM presents orthogonal subcarriers that are intimately spaced and overlap with no ISI. Therefore, as overlapping is probable without ISI this set up the effectuality employ of the entire spectrum. At present, OFDM is exploited for several applications such as DVB and DAB and as well as for VDSL and ADSL broadband access for maximum data rate wired links [2].

MIMO comprises Multiple transmit as well as Multiple receive antennas that present spectrally competent signal transmission by creating the MIMO channel. While compared with the conventional model MIMO, as well as SISO, attains maximum spectral effectiveness. The system capacity rises with rises in the number of antennas, linearly rising channel throughput. In addition, the amount of transmitting antennas should be equivalent to or higher than the amount of receiving antennas [3]. Therefore, MIMO wireless technology is a highly significant wireless approach to be used. The MIMO coupling with OFDM as MIMO-OFDM furthermore enhances the performance of the system.

The OFDM is represented as a highly significant technology for the spectrum effectuality as well as maximum alleviation of ISI. The DFT can be exploited to execute OFDM modulation rather than modulators bank. The frequency selective fading channel is transformed by the OFDM system to parallel flat fading channels. The OFDM system possesses two performance deprivation sources such as CFO on the receiver side as well as PAPR on the transmitter side [11]. The PAPR issue restricts the operating area of the power amplifier. In addition, the rising amount of DFT bins outcomes in high alleviation of ISI as well as enhance the performances of BER, however, raises the PAPR. There are diverse approaches that are exploited to alleviate the PAPR like coding, PTS, as well as SLM approaches. Conversely, the CFO happens from 2 sources the misarranging among the transmitter as well as the receiver local receiver as well as oscillators motions (Doppler Shift) [4]. The orthogonality among induces ICI as well as sub-carriers obliterates the CFO. To CFO the OFDM system is sensitive as well as these reasons to maximum degradations in the performance of BER. Here, diverse approaches are exploited for the estimation of the CFO. Therefore, to exploit the benefits of the OFDM system, the PAPR must be alleviated as well as the CFO should be compensated [5].

For the Blind channel estimation, the BSS was recommended for a basic procedure of the MIMO-OFDM system, whereas the BSS vagueness was solved using a convolutional pre-coding method. For a while, the convolutional code was optimized to encompass utmost effectuality performance regarding the BER, as well as Stone BSS, which was exploited for complication respite in blind MIMO-OFDM receiver. By taking into consideration of particular circumstances for a blind MIMO-OFDM system a precoding model was presented without spectral transparency for an ICA-based blind equalizer. For the current technology drift of visible light communications, the BSS-based blind MIMO-OFDM system was exploited in that concurrently presents the enlightenment as well as data communications [3].

The main objective of this paper is to model the channel estimation model in the MIMO-OFDM system. The major objective of this paper is to formulate an Improved Crow Search optimization approach to estimate the channels in MIMO-OFDM systems. At first, the STBS-MIMO-OFDM system experiments with multiple users. Then scheduling approach is developed by taking into consideration of QoS as well as power allocation constraints on the basis of the user admission protocol that is modeled by exploiting priority-based scheduling. Moreover, priority-based scheduling is done on basis of the CMO in order to grip the power requirement as well as QoS. An aforesaid user admission protocol with the optimization approach enabled the scheduling algorithm which is combined with the STBC-MIMO-OFDM system to assure energy effectiveness.

2. Literature Review

In 2021, Syeda Sumayya Mujeeb and M. Jyothsna [1], worked on the MIMO-OFDM system and it was renowned for its wideband transmission of data to extenuate the interference and improve the capacity of the system. To calculate data symbols transmission, at the receiver side, MMSE, and ZF approaches, were exploited as the MIMO-OFDM detection models. Furthermore, the V-BLAST approach was executed to produce maximum accuracy in a combination of MMSE and ZF approaches. This approach identifies the highly influential signals and evades their effect on the received signal.

In 2019, J. Karthika et al [2], discussed the most important disadvantages of the MIMO-OFDM system, and that was maximum PAPRfor a high number of subcarriers. It reasons for solemn degradation in the performance. The renowned PAPR minimization models for MIMO-OFDM systems were chosen as mapping SLM models. Here, the MIMO-OFDM system computational complexity was minimized by augmenting the mapping signal series to the OFDM signal series. Additionally, it will raise the minimization of PAPR of MIMO-OFDM system performance.

In 2021, Yali He et al [3], worked on the implementation of the channel estimation as well as the MIMO-OFDM system, and signal detection approaches in order to select a superior approach. The experimentation validation exhibit that the optimal recognition approach possesses optimal performance, however, its complication was exponentially associated with the number of antennas and modulation order. On the basis of the FPGA device, the dense texture analysis model was adopted that was the basic engine for maximum speed image processing.

In 2020, Mahdi Khosravy et al [4], presented an enhancement to Stone's BSS accuracy, sturdiness, and computation load and its application to blind MIMO IoT multi-nodes IoT data recognition, interference channel estimation, separation as well as recognition in a MIMO-OFDM IoT network. Stone's BSS was on basis of the complication conjecture showing independent sources possess superior predictability to mixtures. The adopted enhancement to Stone BSS was using a probabilistic enhancement for short-term predictability advantage by attaining coefficients of prediction.

In 2020, K. Ramadan et al [5], presented JLCRZF equalizers on the basis of the SIC for OFDM. The performance of the BER of the OFDM system model was examined by exploiting diverse transforms like DST, DFT, DCT, and DWT. The adopted JLCRZF-SIC equalizers jointly carry out equalization as well as the CFO compensation process with minimum complexity by exploiting the banded-matrix estimate.

3. System Model

The MU-MIOMO includes multiple users in order to share the basic channel by taking into consideration of individual mobile terminals (MTs) p, BS D, as well as antennas q. In the MIMO system, the capacity of the channel is proportionate to $\mathrm{Min}\ (m \times n)$ with a spatial degree of freedom [12] $\mathrm{Min}\ (m \times n)$. S_i. P_g Moreover N represents the total count MTs available in the network to indicate received signal at D^{th} BS, as well as channel gain amid D as well as g^{th} user is referred as A_g^v with s^{th} user, wherein $(1 \le g \le s)$. Moreover, eq. (1) and (2) represent the signal received at BS wherein, y_v refers to preservative "white Gaussian noise with '0' mean at receiver". Eq. (3) indicates downlink channel P_g^b represents the signal received by the user g, A_g^b denotes channel gain amid user g as well as D of downlink, as well as Q signifies transmitted signal from BS.

Let MU-MIMO downlink comprising BS with 2 transmit antennas, as well as N users equipped with 2 receiver antennas. Moreover, BS D uses delayed CSI for MUS. Suppose that A_g be channel gain of g^{th} the user, subsequently user channel gain g with delay α is stated as A_g^{α}.

$$P_g = A_1^v Q_1 + A_2^v Q_2 + \ldots + A_s^v Q_s + y_v \tag{1}$$

$$P_g = \begin{bmatrix} A_1^v & A_2^v & \ldots & A_s^v \end{bmatrix} \begin{bmatrix} Q_1 \\ Q_2 \\ . \\ . \\ . \\ . \\ Q_s \end{bmatrix} + y_v \tag{2}$$

$$P_g^b = A_g^b Q + y_v \tag{3}$$

In eq. (4), the correlation coefficient between elements in the matrix, wherein, α_g simplifies feedback delay, U_0 simplifies the zero-order Bessel function, as well as r_g simplifies the maximum Doppler frequency of g^{th} user. Here, B_g simplifies the channel error matrix in that elements are identically distributed, as well as are self-governing. Moreover, by exploiting the optimization-based scheduling method the users are scheduled. The most important contribution is to render the complete diversity which is based on the STBC which comprises 2 transmit as well as m receive antennas to attain $2m$.

Additionally, Alamouti's STBC is used to transfer two symbols at 2-time intervals, as well as attains a complete rate of $V=1$.

In Alamouti's STBC, rows, as well as columns, indicate different time instants, as well as by exploiting the transmitting antennas the symbols are transmitted. The antenna-1 is used to transfer the symbols r_1 and r_2^*, wherein the antenna-2 transfers the symbols r_2 and r_1^* while time at $(\alpha+S)$ and l.

$$J_g = 2U_0 \pi r_g \alpha_g \tag{4}$$

$$A_g^{\alpha} = J_g A_g + \sqrt{1-Q_g^2}\, B_g \tag{5}$$

In eq. (6), fading coefficients are constant for two transition symbol instants. Subsequently, eq. (7) indicates the received symbols for $d=1,2$ as well as $e=1,2,..,m$

$$\varpi_{d,e}^{\alpha} = \varpi_{d,e}^{\alpha-1} = \varpi_{d,e} \tag{6}$$

$$a_1^1 = \varpi_{1,1} r_1 + \varpi_{1,2} r_2 + h_1^1 \tag{7}$$

$$a_1^2 = -\varpi_{1,1} r_2^* + \varpi_{1,2} r_1^* + h_1^2 \tag{8}$$

$$a_2^1 = \varpi_{2,1} r_1 + \varpi_{2,2} r_2 + h_2^1 \tag{9}$$

$$a_2^2 = -\varpi_{2,1} r_2^* + \varpi_{2,2} r_1^* + h_2^2 \tag{10}$$

The formulation of integrated signals is stated as below:

$$\overset{\wedge}{r_1} = \varpi_{1,1}{}^* a_1^1 + \varpi_{1,2}{}^* a_1^2 + \varpi_{2,1}{}^* a_2^1 + \varpi_{2,2}{}^* a_2^2 \tag{11}$$

$$\overset{\wedge}{r_2} = \varpi_{1,2}{}^{**} a_1^1 + \varpi_{1,1} . a_1^{*2} + \varpi_{2,2}{}^* a_2^1 + \varpi_{1,1} . a_2^{*2} \tag{12}$$

In eq. (11) and (12), substitute the eqs. (7), (8) as well as (9), wherein, $v_{d,e}$ denotes the fading channel coefficient $\varpi_{d,e}$. At last, signal pair (r_1, r_2) is selected from signal constellation on basis of ML detector so that distance for each and every probable value of r_1 as well as r_2 is minimized. The detector objective is stated as follows:

$$\overset{\wedge}{r_1} = \left[v_{1,1}^2 + v_{2,1}^2 + v_{1,2}^2 + v_{2,2}^2\right] r_1 + \varpi_{1,1}^* . h_1^1 + \varpi_{1,2}\, h_1^{*2} + \varpi_{2,1}^* a_2^1 + \varpi_{2,2} h_2^{*2} \tag{13}$$

$$\overset{\wedge}{r_2} = \left[v_{1,1}^2 + v_{2,1}^2 + v_{1,2}^2 + v_{2,2}^2\right]. r_1 - \varpi_{1,1}\, h_1^{*2} + \varpi_{1,2}^* h_1^1 - \varpi_{2,1}\, a_2^{*2} + \varpi_{2,2}^* h_2^1 \tag{14}$$

$$\left|\left[\sum_{d=1}^{m}\left(a_d^1 . \varpi_{d,1}^* + a_d^{*(2)} . \varpi_{d,2}\right)\right] - r_1\right|^2 + \kappa |r_1|^2 \tag{15}$$

$$\left|\left[\sum_{d=1}^{m}\left(a_d^1 . \varpi_{d,2}^* + a_d^{*(2)} . \varpi_{d,1}\right)\right] - r_2\right|^2 + \kappa |r_2|^2 \tag{16}$$

$$\kappa = -1 + \sum_{d=1}^{m}\sum_{e=1}^{n}\left|\varpi_{d,e}\right|^2 \tag{17}$$

Fig 1 demonstrates a block diagram of MIMO-OFDM. In this figure, at first, the signal from the antenna is encoded to assure the assortment stated on the basis of the transmitted antennas which pursue with the QAM mapping. Subsequent to this, the mapped signals are broadcast as well as modulated over channel pursued by means of receiving as well as decoding at receiving end. Additionally, by adopting an optimization approach priority-based scheduling is carried out. By exploiting the constraints such as power as well as QoS the users are prioritized wherein the users are disclosed to the antenna. In addition, by exploiting the ICSO the channel estimation is performed.

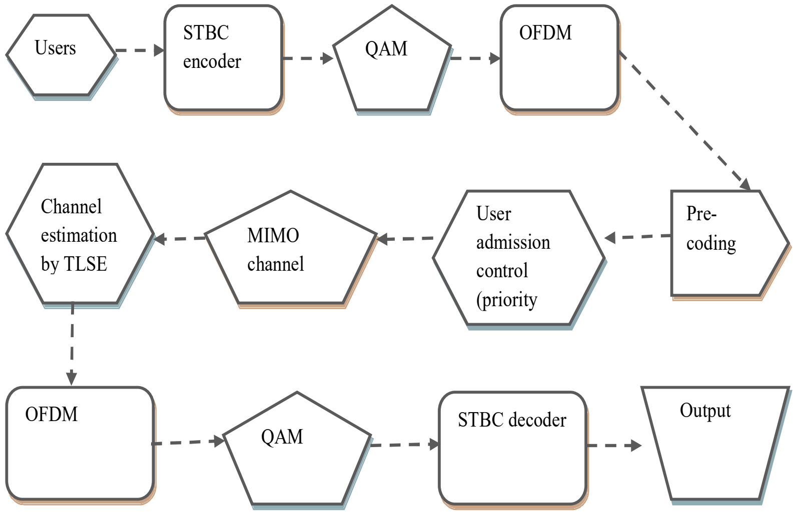


Fig.1. *Block diagram of MIMO-OFDM*

4. Adopted Channel Estimation

On basis of the MU-MIMO system user admission control is performed on basis of priority-based scheduling by exploiting an optimization approach. Additionally, employing the priority-based scheduling which is done by optimization approach is used for the user admission protocol. It is combined with the STBC-MIMO-OFDM system for effectual power allocation to assure energy effectuality. Moreover, another optimization algorithm is exploited for the channel estimation in order to enhance the system performance.

4.1 Transmitter Model

The QAM mapping, encoder, OFDM as well as precoding as well as user admission control is performed on the transmitter side.

i) Encoder, QAM mapping

In order to encode the bits, the signal from the antenna is subjected to an encoder subsequently they are transformed into QAM mapping. The name QAM comes from a digital modulation approaches family and an associated relation of analog modulation approaches extensively exploited up to date telecommunications in order to transfer the information. It suggests two analog message signals else two digital bitstreams by altering or modulating amplitudes of two carrier waves by exploiting the digital modulation model of ASK or analog modulation model of AM. The two carrier waves of similar frequency are out of phase with each other using '90°', a circumstance called quadrature else orthogonality By augmenting the two carrier waves with each other the transmitted signal is formed. The two waves can be logically alienated (demodulated at the receiver due to their orthogonality property. One more important property is the modulations which are very low bandwidth/low-frequency waveforms that are evaluated with a carrier frequency that is called narrowband supposition.

ii) Precoding and OFDM

The OFDM is considered a multicarrier modulation model which is selected as the modulation model for the generation transmission communication systems. One of the most important and well-known broad wireless communication systems is OFDM because of the resistance to multipath fading as well as its capability to send high data rates with rationale computational complexity. If mapping is performed, the transformation of parallel to serial as well as modulated into the carrier to be transferred over the air via the wireless channel.

iii) User admission control

With a superior spectral effectuality as well as data rate by means of the advancement of novel technologies the user admission control is started in obtainable usage transmitters. To assign users in present transmitters is not like scheduling on the basis of arranging users in the ascending order for priority-based scheduling. Via the priority scheduling the scheduling time is minimized that schedules users regarding power constraints as well as QoS, as well as the user admission control model is combined with the STBC-MIMO-OFDM system to allow effectual power allocation with superior energy effectuality. It set up the time as well as space variety with multiple antennas to improve transmission reliability. By exploiting the optimization approach, the user admission control is performed regarding the objective function such as priority, proportionally fair, throughput, as well as power.

Here, the Cat and Mouse Optimization Algorithm (CMO) is exploited [6]. In the adopted model, the search agents are partitioned into 2stages of cats as well as a mouse which scans the issue search space with arbitrary movements.

The modification of the location of cats is designed on the basis of the cat's natural behavior as well as movement toward mice.

$$C_j^{new} = c_{j,d}^{new} = c_{j,d} + r \times \left(m_{k,d} - I \times c_{j,d}\right) \& \ j = 1 : N_c,\ d = 1 : m, k \in 1; N_m \tag{18}$$

Where, C_j^{new} represents the new position of the cat; $m_{k,d}$ represents d^{th} dimension of k^{th} mouse; $c_{j,d}^{new}$ represents the new value of the d^{th} problem.

In the developed algorithm, the second stage is exploited to evade the mice. The havens locations for every mouse as well as mice take a safe haven in these havens. The location of havens is arbitrarily formed based on patterning locations of diverse members of the approach in the search space. This stage of updating the location of mice is mathematically formulated by the below formulations:

$$M_i^{new} : m_{m,d}^{new} = m_{j,d} + r \times \left(h_{i,d} - I \times m_{i,d}\right) \times \text{sign}\left(F_i^m - F_i^H\right) \& \ i = 1 : N_m,\ d = 1 : m, \tag{19}$$

F_i^H represents the objective value; M_i^{new} represents the new status of the mouse.

4.2 Receiver Side

a) Improved Crow Search Algorithm for channel estimation

Here, the ICSO approach is used for channel estimation [10]. Occasionally Crow Search Algorithm traps into the local optima and it is considered an insufficiency. These issues occur untimely convergence because the crow population's difference was minimized although CSA is an approach on the basis of the population with immense diversity. Therefore, approach diversity is minimized and, in a few scenarios, causes premature convergence. To overcome this issue, an enhancement is exploited in this paper. Initial enhancement is the introduction of the opposition-based learning (OBL) model using the below equation:

$$\tilde{X}_i = X^i + \overline{X}^i - X^i \tag{20}$$

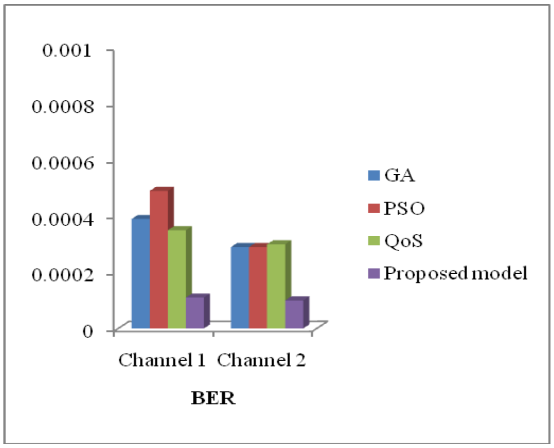
$$Y_j^{i+1} = \begin{cases} \dfrac{m\left(X^{i-1}\right)}{m\left(X^{i-1}\right)}, Y_j^i, m\left(X^i\right) \geq m\left(X^{i-1}\right) \\ Y_j^i \qquad m\left(X^i\right) < m\left(X^{i-1}\right) \end{cases} \tag{21}$$

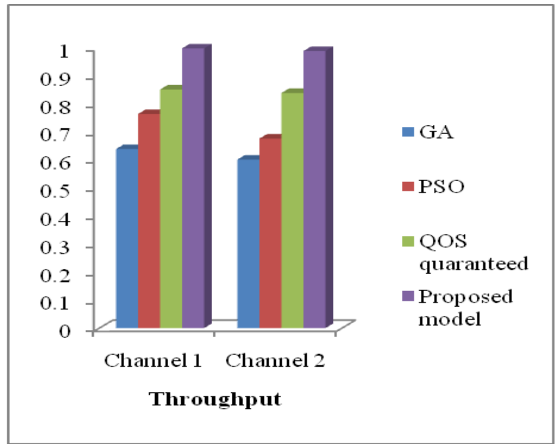
Where, $m\left(X^i\right)$ denotes the merit function.

5. Result and Discussion

The experimentation of the adopted model effectuality by exploiting the throughput as well as Bit Error Rate (BER), was discussed in this section. Here, the proposed model was compared with the conventional models such as GA, PSO, and QoS guaranteed models.

Fig 2 illustrates the performance analysis of the proposed and conventional models regarding the BER as well as Throughput for channels 1 and 2. Here, the throughput and the BER of the proposed model are minimal. The overall analysis states that the proposed model is superior to the conventional models.





(a) (b)

Fig.2. *Performance analysis of the proposed and conventional models (a) BER (b) Throughput*

6. Conclusion

The major objective of this work was to propose a technique for channel estimation in MIMO-OFDM systems by exploiting the adopted Improved Crow Search optimization approach. In the MU-MIMO system user, admission control was performed on basis of priority enabled scheduling with help of an optimization approach. Moreover, the user admission protocol was on the basis of the priority-based scheduling approach, which was incorporated within the STBC-MIMO-OFDM system for competent power allocation to assure energy effectiveness. Additionally, channel estimation was performed on the basis of the adopted optimization technique to enhance system performance. The fitness constraints, like BER, and throughput, were calculated for channel estimation, to prioritize users in using the multiple antennas in the system to assure energy effectiveness of the communication channel. Therefore, the adopted model calculates channels effectually in the MIMO-OFDM system. To evaluate communication channel was communicated by means of the media like text, image as well as audio, and the channels are taken into consideration for the evaluation such as Rician as well as Rayleigh channels. The proposed model outperforms the conventional models with minimum BER and maximum throughput.

Compliance with Ethical Standards

Conflicts of interest: Authors declared that they have no conflict of interest.

Human participants: The conducted research follows the ethical standards and the authors ensured that they have not conducted any studies with human participants or animals.

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