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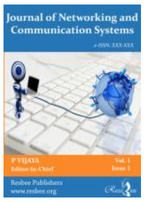

# LA Based Optimal Path Selection for Mobile Adhoc Network

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**Abstract:** MANET (Mobile Ad hoc Network) comprises the nodes, which are self-energized and might be capable on accommodating restricted energy levels, and normally the nodes do transmit their data via the intermediate nodes to the destination. However, the choosing of an optimal path is a complex issue in MANET. This paper introduces a novel mechanism for selecting the route by Lion Algorithm (LA) to enhance the Quality of Service (QoS) in MANET. On the basis of LA, the best or optimal route for data delivery is chosen using the pheromone value of the path. The performance of the proposed model is analyzed by means of throughput and packet drop probability as well by comparing other conventional methods. The proposed model obtains the throughput of 1.23, while the remaining models obtain minimum throughput of 0.65 by FF, 0.68 by DA, 0.98 by PSO, and 0.34 by GA, respectively.

**Keywords:** MANET; Routing protocol; LA; Throughput; Quality of Services

**Nomenclature**

| Abbreviation | Description |
|---|---|
| MANET | Mobile Ad hoc Network |
| QoS | Quality of Service |
| LA | Lion Algorithm |
| SNR | Signal-To-Noise Ratio |
| GA | Genetic Algorithm |
| PSO | Particle Swarm Optimization |
| DSR | Dynamic Source Routing |
| MCNR | Multi-Criteria Node Rank |
| AODV | ad-hoc on-demand distance vector routing |
| EELAM | Energy Efficient Lifetime Aware Multicast |
| ACO | Ant Colony Optimization |
| MBMA-OLSR | Multipath Battery And Mobility-Aware Routing Scheme |
| DS-SVR | Destination Sequenced Distance Vector Routing |
| QG | Quantum Genetic |
| RRP | Representative Routing Protocols |
| D-MANET | Dynamic MANET |
| AECM | Adapting Evolutionary Computation Model |
| RPSA | Random Path Selection Algorithm |

## 1.Introduction

A MANET is a type of wireless ad hoc network, which is broadly utilized at present. It comprises of a bunch of mobile nodes, which doesn't rely on one infrastructure including base station or access point. This MANET is normally utilized for enabling communication when common communication infrastructure is not available. Moreover, MANETs are utilized in different applications, including in military applications. This has become a more prescribed area of research since its usage in a broad range of applications. The network node includes two functions: Since the router for data packets organized for another node and because of producer and consumer of the data packet flow.

Still, the restrictions on battery life and node mobility are major challenges in MANET [23]. The MANET topology could be altered effectively and rapidly. Further, the beneficiaries of utilizing this network type are its ability to work independently. This has also been linked to huge Internet-scale. The utilization of MANETs is also become common between scholars from 1990s as of the maximizing popularity of laptop computers and Wi-Fi networks. Every node in the MANET includes two purposes. Each node could be the source to transfer data or be an intermediate node for routing information for some other nodes. The MANET nodes transfer arbitrarily and freely, and they could leave and unite to the network any time it wants. The network topology vigorously alters given the mobile nature of its nodes. Hence, an appropriate routing protocol is needed for enabling the network for adapting modifications in topology. However, the problem needs to be addressed is how the network routing adapted to the intricacy produced by the following movement and modifies the network topology [26] [27]. Numerous routing protocols like DSR, DS-DVR, and AODV were developed so far by different researchers.

Further, Routing protocols are classified into three major types: reactive, proactive, as well as hybrid. Here, in proactive routing protocols, they maintain the up-to-date network topological map. Here, the routes are already available while the packet is required to transfer from the source to the destination. The reactive routing protocols are also termed as on-demand driven routing protocols, where the route is sporadically available. Hence, when there is a requirement of data transmission from source to destination, a route discovery process is introduced by transmitting query requests that flood in network. More hybrid protocols are also introduced by combining two or three protocols. The main aim of any routing mechanism is the selection of the shortest path or optimal path. Some research works are in the progress of introducing different algorithms to solve this issue. Particularly, optimization concepts play a major role in selecting the optimal paths in MANET. Some of the common algorithms are GA, DA [27], PSO [24], etc. This research work introduces a new optimal path selection model in MANET [25] using LA algorithm that is the renowned optimization model.

The remaining section of this research work is structured as: The literature works undergone under this subject are depicted in Section 2. Section 3 details the proposed MANET routing model. Section 4 explains the Lion-based route selection. Section 5 explains the results of each of the analysis and Section 6 provides a strong conclusion to this research.

# 2. Literature Review

## 2.1 Related Works

In 2018, Dipika et al. [1] have stated that the choosing of an optimal path was a complex issue in MANET. They have introduced a novel model for selecting the route combining AODV protocol with ACO for enhancing the QoS in MANET. On the basis of the mechanism of ant colony along AODV, the best route was chosen by pheromone value of the path. On the basis of the path's end to end reliability, congestion, count of hops and remaining energy of the nodes, the pheromone value of a route was evaluated. The data packet was transmitted via the path having the highest pheromone value. The resultant acquired from the proposed model exhibited the superiority of the proposed scheme over AODV, DSR, and Enhanced-Ant-DSR routing algorithms.

In 2018, De-gan et al. [2] have proposed QG-OLSR as an extension of the QG model by means of combining the characteristics of OLSR. The proposed model had optimized the MPR selection and had overcome the scarcity of the usual protocol. The simulation outcomes of QG-OLSR routing protocol had revealed the enhancement of the proposed model over the existing one in terms of transmission performance and also the feasibility and applicability of the proposed protocol were exhibited.

In 2018, DaehoKang et al. [3] have reviewed RRP and has evaluated their concert by NS-3 simulations for identifying their major weaknesses. On the basis of the observations, they have developed a reliable as well as the sensible opportunistic routing protocol for MANETs termed ORGMA. They have adopted the gradient forwarding model, in which the transmitter broadcasts a packet and the receivers to make the decisions of routing. The proposed contributions have included the usage of instantaneous SNR for the cost of routing and the introduction of light-weight cost management that was on the basis of flooding. This has enabled the ORGMA for attaining high packet delivery ratio on D-MANET environs. Under NS-3 simulations, they have evaluated ORGMA by comparing other routing models, and the outcomes have shown that ORGMA greatly outperformed the conventional routing models, and also has attained the performance nearer to the ideal routing scheme having global data.

In 2017, N.Papanna et al. [4] have proposed the EELAM Route Selection model for MANETs, which was developed by the adaptive genetic model. EELAM has worked on the basis of the tree topology, which has differentiated to some-other tree based on multicast routing via AECM defined as GA.

The optimal intermediate nodes were chosen on the basis of the higher residual energy and lower energy usage. The fitness function, which has worked out for the adaptive GA was targeted to enhance the ratio of energy consumption, enhancing the battery life and also has improved the multicasting scope. The progression and the approaches that were adapted contemporary and was varied to the conventional GAs, and yet the outcome as portrayed in the experimental outcomes reflect the fact that the EELAM was effective, which could do support in dealing the restrictions in the current solutions and move towards overseeing enhanced route discovery.

In 2017, Waheb et al. [5] have proposed an MBMA-OLSR, which was on the basis of MP-OLSRv2. Particularly, the study has exploited an MCNR measure that includes the remaining battery energy and the node's speed as well. On the basis of the link assessment function, the link stability was ranked with consideration in their usage. The link assessment function also aids in selecting the most effective and stable paths to the target node. Further, an Energy and Mobility Aware model was also proposed for setting the willingness of nodes for contributing MPRs for flooding topological data. Benefits of the innovative model have also verified and validated with respect to different simulation areas on the basis of varied mobility parameters. The simulation outcomes have provided proof of the superiority of the proposed model, particularly at the time of high mobility scenarios with traffic load.

## 3. Proposed MANET Routing Framework

Consider a typical MANET network comprising $N$ count of sensor nodes as manifested in Fig. 1. The sender node depicted as $S$ is the one which forwards the message and the message is received by the receiver $\mathrm{R}$. Since the sensor nodes in the network are dynamic, they are said to have different neighborhood condition, which makes it complex to transfer data directly from sender to receiver. Thus, to overcome this drawback, in the proposed model, the sender $\mathrm{S}$ broadcast the message or data to all the existing nodes in the network. The message from $\mathrm{S}$ is received by all the $n$ neighbor nodes which are within the range of $\mathrm{S}$ and identifies the nearest nodes for transmitting the message to $\mathrm{R}$. Thus a new route depicted as $\mathrm{c}$ is established in between sender $\mathrm{S}$ and receiver $\mathrm{R}$ with minimal delay, minimal congestion, and minimal power consumption as well. In between $\mathrm{S}$ and $\mathrm{R}$, there exist huge routes, thus it is essential to select the most optimal route having the shortest path for the message transmission. It also includes other potential links for the message transmission. Thus, a routing model is needed to select the shortest optimal path.

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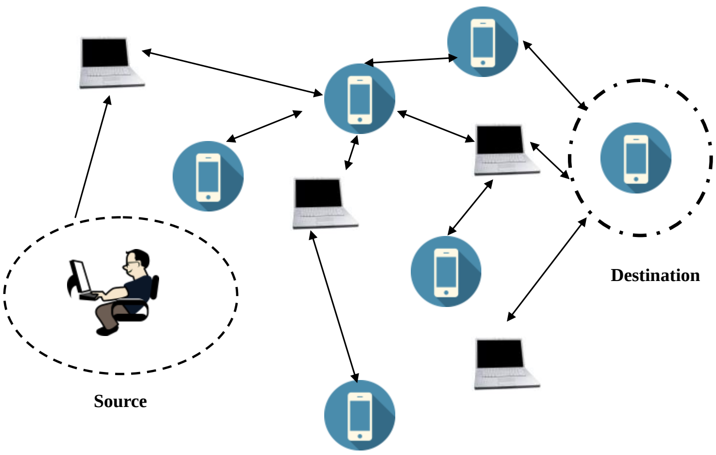


***Fig. 1.*** *Typical MANET model*

This paper has proposed RPSA on the basis of LA with the intention of routing the data packets via more node disjoint routes for improving MANETS security. Typically, the transmission of data takes place via a path. The data can be read by the node in the path and reduces the confidentiality and security of data. This research work intends to evaluate the disjoint paths between sender $\mathrm{S}$ and receiver $\mathrm{R}$. Further, different routes are used by different nodes in transmitting data. When all the selected paths are utilized once, again the succeeding packets get started to transmit via the chosen paths again in arbitrary. Consider there have 5 node disjoint routes among sender and receiver and having 25 packets to get transmitted among them. Only 5 packets are transmitted via every path that is also in random (here and there) manner. The source and destination are depicted as $\mathrm{S}$ and $\mathrm{D}$, respectively. Among $\mathrm{S}$ and $\mathrm{D}$, the Set of Node-Disjoint Paths are indicated as $\mathrm{P}$. Where $\mathrm{P} = \{\mathrm{P1}, \mathrm{P2}, \ldots. \mathrm{Pm}\}$. In between the sender $S$ and destination $D$, the count of disjoint paths is represented using the notation $m$. The term $m$ is also utilized for denoting the array sizes. In addition, the term $R$ is an array to save the history of paths taken by data.

During the implementation, initially, the count of the disjoints paths existing between sender $S$ and destination $D$ need to be finalized (Suppose $P1, P2, ....Pm$). There exist several algorithms to identify the node-disjoint paths. Declared an array at the source node that is of size $m$.

**Process of sending data:** Send the packet1 via any node from $P$. Suppose, if it is transmitted via $P3$. Subsequently, store $P3$ in $R$, where $R$ is any data structure of length $m$. Transmit the succeeding packet through any paths from $P$ rather than the paths saved in $R$ (other than $P3$). Save the next chosen path in $R$. Repeat the process still all packets are transmitted or $R$ is full. If the packets are transmitted, the work is done. If $R$ is full, make the clearance of memory and do the process of transmitting and continue until all the message gets transmitted. If all the packets transmit through a single path, there has the chance of attacker in this route for getting all the data. The proposed model utilizes various paths for data transmission to achieve security. If number of paths are selected, one can send the packets by all of them.

## 4. Lion Algorithm based Optimal Path Selection

LA [18] includes six processing phases namely, (a) Pride generation, (b) fertility evaluation, (c) mating, (d) territorial defense, (e) territorial takeover, and (f) termination.

Pride generation is the initial process, which is similar to the initial process of many of the swarm-based optimization and evolution algorithms. New lions are produced from parent lion through the fertility evaluation, and that is the second phase. The phase comprises most responsible progression, which is termed as mating. Comparing to other algorithms, Territorial defense and territorial takeover are concerned to be the distinctive process due to the precise inspiration by social behavior of Lion. The major role of the LA algorithm is purely on the basis of two steps to find the optimal solution from huge search space. The termination process proceeds at the end of the iteration/generation.

**Problem Formulation:** Let Eq. (1) be the objective function. From the Eq. (1), the continuous uni-modal and multimodal function are specified as $f(\bullet)$ that has the solution space with size $^{m}$, in which the real numbers are indicated by , $z_i : i = 1,2,.....,m$ is concerned as the $i^{th}$ solution variable and the solution vector dimension is specified as $m$, $z_i^{max}$ and $z_i^{min}$ are the maximum and minimum limits of $i^{th}$ solution variable, correspondingly.

$$P^{opm} = \underset{z_i \in (z_i^{min}, z_i^{max})}{\arg\min} \; f(z_1, z_2, ...., z_m); \qquad m \geq 1 \tag{1}$$

The optimal/target solution to be found from the provided optimization algorithm is specified as $P^{opm}$ and is indicated by Eq. (3). The determination of solution space size of $f(\bullet)$ is defined in Eq. (2).

$$\Re^m = \prod_{i=1}^{m} (z_i^{max} - z_i^{min}) \tag{2}$$

$$P^{opm} = P : f(P) < f(P' \big| P' \neq P : z^r{}_i \in \; (z_i^{max}, z_i^{min})) \tag{3}$$

Here, the solution vector is indicated as $X$ with the representation of $P = [z_1, z_2, ..., z_m]$. Eq (1) defines the objective function, which is the one to be solved as a minimization function.

**Pride generation:** According to the pride definition, it is initialized with the nomadic lion $P^{nmad}$, territorial lion $P^{male}$, and its lioness $P^{female}$. Further, the lion's length is specified as $Lm$, which is given in Eq. (4).

$$Lm = \begin{cases} m; & m > 1 \\ \bar{n} & \text{otherwise} \end{cases} \tag{4}$$

whereas, the integers for deciding the lion's length is determined as $m$ and $\bar{n}$. While $m = 1$, the searching is done on the binary encoded lion and thus the vector element generation is made by 0 or 1, which is defined in Eq. (5) and (6).

$$gen(z_{lm}) \in (z_{lm}^{min}, z_{lm}^{max}) \tag{5}$$

$$\bar{n}\%2 = 0 \tag{6}$$

Where

$$gen(z_{lm}) = \sum_{lm=1}^{Lm} z_{lm} 2^{\frac{Lm}{2} \; lm} \tag{7}$$

Here, Eq. (5) as well as (7) assures that the generated binary lion is in the solution space and Eq. (6) assures that the number of binary bits before and after the decimal point is equivalent.

**Fertility Evaluation:** This fertility evaluation helps in skipping this local optimal solution. Here, $P^{male}$ turns to laggard and $Lg_r$ that is the laggardness rate is increased by one, when $P(P^{female}) > f^{reff}$, where $f^{reff}$ indicates the fitness of reference. If $Lg_r$ value goes beyond the greatest limit $Lg_r^{max}$, then the territorial defense happens. In $P^{female}$, the fertility is assured using the sterility rate $St_r$ and after crossover, it increased by one. The updating is done as per the Eq. (8) for $P^{female}$, when $St_r$ go beyond the $St_r^{max}$. The mating process is done when the updated female $P^{female+}$ is considered as $P^{femle}$ due to its enhancement. Contrast to this, until the female generation $gen_c$ count attains $gen_c^{max}$. Throughout the process of updating, if there is no $P^{female+}$ to replace $P^{female}$, it is assigned as the female is fertile for generating the cubs.

$$P_{lm}^{female+} = \begin{cases} z_h^{female+} & ;\text{if } lm = h \\ z_{lm}^{female} & ;\text{otherwise} \end{cases} \tag{8}$$

$$z_h^{female+} = \min\left[z_h^{max}, \max(z_h^{min}, \nabla_h)\right] \tag{9}$$

$$\nabla_h = \left[z_h^{female} + (0.1rd_2 - 0.05)(z_h^{male} - rd_1 z_h^{female})\right] \tag{10}$$

Where, $l^{th}$ and $k^{th}$ vector elements of $P^{female+}$ are given as $z_{lm}^{female+}$ and $z_h^{female+}$, respectively, the random integer is indicated as $h$ and is generated that ranges in $[1, Lm]$, the female update function is defined as $\nabla$, the random vectors are specified as $rd_1$ and $rd_2$, which is produced between the range [0,1].

**Mating:** This LA does the mating process by two fundamental steps crossover and mutation process. $P^{male}$ and $P^{female}$ gives birth to cubs by using the crossover and mutation process, where the derivation of the solution is done from the elements of $P^{male}$ and $P^{female}$. The crossover process gives four cubs.

**Lion operators:** By applying a winner-take-all approach, the simplification of the nomad coalition process takes place for identifying $P^{e-nmad}$. Subsequently, when the criteria are given in Eq. (11), (12) and (13) are met, $P^{e\ nmad}$ is chosen.

$$f(P^{e-nmad}) < f(P^{male}) \tag{11}$$

$$f(P^{e-nmad}) < f(P^{male\_cub}) \tag{12}$$

$$f(P^{e-nmad}) < f(P^{female\_cub}) \tag{13}$$

After conquering the position of $P^{male}$, the pride gets updated. Whereas, once the position of $P^{e\ nmad}$ is conquered, the nomad coalition updating is done. The algorithm is provoked by the territorial takeover to update the $P^{male}$ and $P^{female}$, when $P^{male\_cub}$ and $P^{female\_cub}$ is matured. That is the age of cubs that goes beyond the maximum age of cub maturity $AG_{max}$.

**Termination:** The termination of this algorithm is done when one of the following criteria in Eq. (14) and (15) met.

$$Num_{gen} > Num_{gen}^{max} \tag{14}$$

$$\left|f(P^{male}) - f(P^{opm})\right| \le er_{th} \tag{15}$$

where, $Num_{gen}$ is the count of generations that is initially at zero and then maximized by one if the territorial takeover happens. Further, $er_{th}$ and $Num_{gen}^{max}$ are defined as the error threshold and maximum count of generations, respectively and the absolute difference is given by $|\bullet|$. The pseudo code of conventional LA is given in Algorithm 1.

| **Algorithm 1:** Conventional LA Algorithm |
| --- |
| **Step 1:** $P^{male}$, $P^{female}$ and $P^{nmad}$ are initialized |
| **Step 2:** compute the values of $f(P^{male})$, $f(P^{female})$ and $P_1^{nmad}$ |
| **Step 3**: Assign $f^{reff} = f(P^{male})$ and $Num_{gen} = 0$ |
| **Step 4**: Store $P^{male}$ and $f(P^{male})$ |
| **Step 5:** Fertility function is performed |
| **Step 6:** Execute mating and produce cubpool |

| | |
|---|
| **Step 7:** evaluate gender clustering and gain $P^{male\_cub}$ and $P^{female\_cub}$ |
| **Step 8:** Initialize $AG_{cub}$ as zero |
| **Step 9:** Evaluate cub growth generation |
| **Step 10:** Execute the territorial defense when defense results in zero, go to step 4 |
| **Step 11:** When $AG_{cub} < AG_{max}$ , go to step 9 |
| **Step 12:** Formulate territorial takeover and gain the updated $P^{male}$ and $P^{female}$ |
| **Step 13:** $Num_{gen} = Num_{gen} + 1$ |
| **Step 14:** Go to step 4, if the termination criteria not met |
| **Step 15:** Terminate the process |

# 5. Results and Discussions

## 5.1 Simulation setup

The proposed work on MANET was implemented in MATLAB using different count of nodes. In the simulation platform, MANET nodes are fixed in the area of 150mx150m. Then, the performance evaluation was on the basis of evaluation metrics by comparing other conventional models like GA [19], PSO [20], DA [21] and FF [22], respectively.

## 5.2 Performance Evaluation under Throughput

This section describes the performance of proposed LA-based shortest path selection over other conventional models with respect to throughput for different times to 1, 2, 3, and 4. From the analysis, it is observed that the proposed model attains high throughput when compared over other conventional models. When time=1, the proposed model attains the throughput of 1.23, whereas the remaining models attain less throughput of 0.65 by FF, 0.68 by DA, 0.98 by PSO, and 0.34 by GA, respectively. Similarly, the performance of proposed work under the throughput is analysed for all the time-2, 3, and 4, which are shown in Table 1-4.

***Table 1.*** *Performance of proposed over conventional models with respect to throughput when Time=1*

| Methods | Throughput |
|---|---|
| **GA [19]** | 0.34 |
| **PSO [20]** | 0.98 |
| **DA [21]** | 0.68 |
| **FF [22]** | 0.65 |
| **LA [18]** | 1.23 |

***Table 2.*** *Performance of proposed over conventional models with respect to throughput when Time=2*

| Methods | Throughput |
|---|---|
| **GA [19]** | 0.57 |
| **PSO [20]** | 0.69 |
| **DA [21]** | 0.54 |
| **FF [22]** | 0.36 |
| **LA [18]** | 1.68 |

***Table 3.*** *Performance of proposed over conventional models with respect to throughput when Time=3*

| Methods | Throughput |
|---|---|
| **GA [19]** | 0.14 |
| **PSO [20]** | 0.36 |
| **DA [21]** | 0.87 |
| **FF [22]** | 0.42 |
| **LA [18]** | 1.69 |

**Table 4.** *Performance of proposed over conventional models with respect to throughput when Time=4*

| Methods | Throughput |
|---|---|
| **GA [19]** | 0.56 |
| **PSO [20]** | 0.97 |
| **DA [21]** | 0.57 |
| **FF [22]** | 0.36 |
| **LA [18]** | 1.87 |

### 5.3 Performance Evaluation under Packet Drop Probability

Table 5-8 shows the analytical performance of the proposed model over other algorithms in terms of packet drop probability. Here, from the tables, it is observed that the proposed model attains less packet drop when compared to other models, From Table V, it is proven that the proposed model attains the minimal packet drop of 0.23 when time=1, whereas the remaining methods have high packet drop. Similarly, for all the other time variation, the proposed model attains less packet drop while the others have more packet drop.

***Table 5.*** *Performance of proposed over conventional models with respect to Packet drop Probability when Time=1*

| Methods | Packet Drop Probability |
|---|---|
| **GA [19]** | 1.00 |
| **PSO [20]** | 0.99 |
| **DA [21]** | 0.98 |
| **FF [22]** | 0.56 |
| **LA [18]** | 0.23 |

***Table 6.*** *Performance of proposed over conventional models with respect to Packet drop Probability when Time=2*

| Methods | Packet Drop Probability |
|---|---|
| **GA [19]** | 1.68 |
| **PSO [20]** | 0.99 |
| **DA [21]** | 0.78 |
| **FF [22]** | 0.69 |
| **LA [18]** | 0.31 |

***Table 7.*** *Performance of Proposed Over Conventional Models With Respect To Packet Drop Probability When Time=3*

| Methods | Packet Drop Probability |
|---|---|
| **GA [19]** | 1.69 |
| **PSO [20]** | 0.69 |
| **DA [21]** | 0.87 |
| **FF [22]** | 0.69 |
| **LA [18]** | 0.14 |

***Table 8.*** *Performance of proposed over conventional models with respect to Packet drop Probability when Time=4*

| Methods | Packet Drop Probability |
|---|---|
| **GA [19]** | 1.25 |
| **PSO [20]** | 2.36 |
| **DA [21]** | 0.78 |
| **FF [22]** | 0.98 |
| **LA [18]** | 0.14 |

## 6. Conclusion

This paper has introduced a new mechanism for choosing the route by LA for enhancing the QoS in MANET. On the basis of LA, the best or optimal route for data delivery is chosen using the pheromone value of the path. The performance of the proposed model was analyzed by means of throughput and packet drop probability as well by comparing other conventional methods. From the results, it was observed that the proposed model attains high throughput and minimal packet drop that proves the betterment of proposed work. The proposed method obtains the throughput of 1.23, while the remaining models obtain minimum throughput of 0.65 by FF, 0.68 by DA, 0.98 by PSO, and 0.34 by GA, respectively.

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