

# Proposed MANET Cluster Algorithm for Stable and Reliable Cluster Groups- Improving QoS

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## Abstract

**Objective:** To maintain a stable structure and augment life of mobile nodes. We tried to formulate an Algorithm to make the network structure more stable and accessible. **Methods/Analysis:** We presented a method to achieve stability in the network, by keeping the communication between nodes as minimal as possible and upkeep the number of clusters formed. This was simulated by selection of cluster head based on probability weighted node calculation looking for the internal table of a node and records its neighbors. We also tried to reduce the overhead of route maintenance and cluster re-election by keeping a threshold value to determine the failure of the cluster head and choose for re-election. In addition to this during re-election, the battery power was also considered. **Findings:** We used the routing table information, to design our algorithm to detect groups that are stable over time. The algorithm presented for the selection of head node; we selected parameters such as-degree and relative speed of a node with respect to its neighborhood. To evaluate that the cluster formed is a stable structure, we varied the transmission range, speed of nodes and number of nodes moving towards another node. In an ideal scenario, the traffic flow decreases when there is a communication between the head nodes of the Clusters. With the help of Clustering, the chances of interference is reduced which adversely increases the efficiency and network throughput. **Applications/Improvements:** The work can be extended to enhance the cluster shaping and enhance the adaptability of the protocol.

**Keywords:** Clustering, Cluster Head, Cluster Setup, Cluster Structure, Maintenance, MANET, Stability

## 1. Introduction

Clustering divides the mobile nodes into virtual nodes. There are different rules and characteristics that establish a designation to the node. The nodes are designated as leader node (also known as cluster head), a member or gateway<sup>1,2</sup>. The capability of the nodes is that they are local coordinators or help in transmission and data forwarding. The terminology used is as described below:

- Cluster: Collection of nodes grouped logically by rules.
- Cluster Head/Master: The functionality of this node is to manage and help in discovering routes by updating the information available in the routing table and periodically update the routing table. It has a lot

of extra responsibility.

- Gateway Node/Bridge: This node acts as bridge between the clusters that has the capability of inter cluster link that helps in intercluster communication.
- Slave/Ordinary Node: All the other nodes other than head or bridges is called slave. Each slave has one master that belongs to cluster.
- State: It describes what kind of node it is i.e; either a cluster head or a gateway node or an ordinary node.

In a dense network, the propagation of control messages or the routing updates are controlled by the Cluster heads and gateways that help in reducing the routing overhead and scalability problems<sup>3</sup>.

Our direction of study and simulation algorithm

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is primarily on the Cluster setup and maintenance for MANETs, to attain stability of the nodes in the group (cluster), through the appropriate Cluster Head ( $CL_h$ ) selection. The parameters used for head node selection are: ID, degree or mobility and weight of a node.

## 2. Cluster Algorithms and Cluster Head Selection Process

### 2.1 Category of Cluster Algorithms

The cluster head selection algorithms are broadly categorized<sup>4,5</sup> into 5 types depending on various parameters and objectives. They are as depicted in the Figure 1:

- Identifier-based–In this type of classification core idea is ‘id’ of a node is maintained
- Hierarchical based/Connectivity based – This assumes the object/node is ‘nearby’
- Mobility based – the core idea is ‘stability’
- Cost based – In this core idea is ‘overhead reduction’
- Power based – As the name suggest ‘energy conservation’

### 2.2 Cluster Head Selection Process

Cluster head in a network, plays a major role. It acts as a facilitator for communication within its substructure. Each Cluster Head ( $CL_h$ ) within its cluster takes the responsibility to communicate with other cluster head ( $CL_h$ ).

The election of the Cluster head experiences through a procedure of choosing a best fit node in the cluster group. It is assigned as the head and called as Cluster head denoted by ( $CL_h$ ). It’s essential duty is to deal with all the neighbor nodes of its own cluster gathering furthermore information to furnish communication with different

nodes of the other close-by Clusters<sup>6</sup>. The communication with neighbor nodes of the cluster can be through the particular  $CL_h$  or through gateways. The approach of communication is through the exchange, compression and transmission of information amongst nodes and to the next Cluster Heads<sup>7</sup>.

As the Cluster node has to perform extra functions, the election of Head node is one of the complex tasks as various factors affect the election process. The components which in a perfect world are considered for the decision are the topographical area of the group of nodes, dependability, and portability of the members of group, vitality, limit, throughput and trusted nodes<sup>8</sup>. The accompanying Figure 2 shows the Model of a Cluster Network and the nodes assuming diverse parts i.e.; a special node termed as head, an ordinary node termed as cluster member communicating node termed as gateway node.

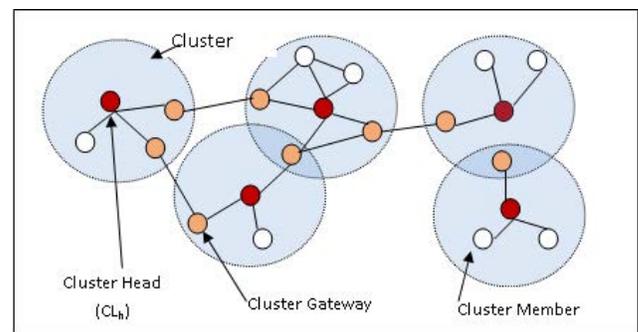


Figure 2. Model of Cluster Network and its elements.

### 2.3 Basic Clustering Algorithm of MANET

In Clustering Algorithm, the state of a node changes or transitioned into another state when the node comes in contact with the other node.

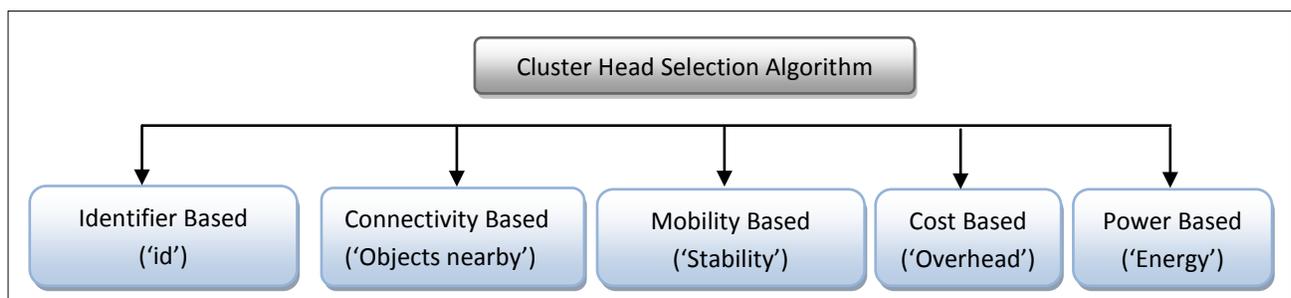


Figure 1. Classification of Cluster Head Selection Algorithms.

### 2.3.1 Initialization Step Algorithm

At first every one of the hubs are placed in none state

Let us assume that,

Master = Node with the highest degree

Slave=Lowest degree neighbor

Degree (u) = number of neighbors'

MAX\_mastdeg = MAX no. of slaves of a master.

Eff\_deg=No. of neighbors' with state *None*

$u, v = nodes$

### 2.3.2 Analysis of Initialization Step

- In the event that there is no expert/master framed by any of the principles, then the node is certainly a slave.
- Independent of the present condition of a node, if a node gets a message to, get to be expert/master, it generally turns into an expert/master. A node is set apart as bridge, if number of masters < MAX\_MASTERS or if a node gets to be slave to more than one node.

```

if (degree(u) > all its neighbors)
{
u ← Master
MAX_mastdeg ← Slaves
If (Eff_deg==0)
    u←Master
}
else
{
    while (for every neighbor (v))
    {
        if (degree(v) = highest neighbor of( v)
        {
            if u ∈ MAX_mastdeg = smallest degree neighbor of v
            {
                u←Slave of v
                lower degree neighbor (w) of (u) =greatest degree in neighborhood of w ←Master
            }
            else
            {
                Repeat for remaining 'none' neighbors
            }
        }
        else
        {
            if degree(u) is highest in neighborhood of u
                u← Master

            if degree(v) is highest in neighborhood of u
                u← Slave of (v)
        }
    }
}
}

```

### 2.3.3 Classification of Cluster Algorithms

The cluster algorithms are further classified as given in the Table 1. The process adopted in selecting the Cluster head of each of the Algorithm defined in Table 1 is described in Table 2.

**Table 1.** Category of Algorithm

Sl.No	Category of Algorithm	Type of Algorithm Classification
1.	Identifier Based	Cluster with Lowest ID (LIC)
		Cluster with Max-Mind-cluster
2.	Connectivity based	Cluster with Highest connectivity
		Cluster with K-hop connectivity ID
3.	Mobility-aware	Cluster with Mobility Based Metric
		Cluster with Mobility-based d-hop
4.	Low cost of maintenance	Least cluster change algorithm (LCC)
		Cluster with Adaptive capabilities
5.	Power-aware	Power-aware connected
		Energy conservation
		Weighted Clustering

**Table 2.** Cluster Process Adopted for the Selected Algorithm

Sl. No	Algorithm	Cluster Selection Process Adopted
1	Lowest ID Cluster (LIC)	A node with minimum ID is chosen as the cluster head.
2	Max-Min d-cluster	A node with largest ID in the d-neighborhood of another node.
3	Highest connectivity	A node with maximum number of neighbor nodes.
4	K-hop connectivity ID	A node with highest connectivity. Highest connectivity is determined by the pair node's (connectivity, identifier)
5	Mobility Based Metric	A node with low speed.
6	Mobility-based d-hop	A node with a lowest value and is stable compared with its local neighbors.
7	Least cluster change (LCC)	A node with lowest ID in its neighborhood.
8	Adaptive capability	Stage 1: A node with the highest degree. Stage 2: On arrival of a new node with cluster head capabilities.
9	Power-aware connected	A node with maximum Energy level (el).
10	Energy conservation	Nodes connected to each other in the fashion of master and slave, and the nodes that have the farthest distance is the total area of cluster considered for energy consumption.
11	Weighted clustering	A node with minimum weight.

### 3. Proposed Cluster Head Algorithm and Clustering Phases

#### 3.1 Clustering Phases

Clustering is done in two stages:

Stage 1: The cluster set-up.

Stage 2: Cluster maintenance. In the cluster set-up phase, among a set of nodes in the network a cluster head is chosen. Its role is to coordinate the process and deliver the data packets. The rest of the nodes affiliate with its neighbor cluster head to form clusters<sup>9</sup>. Re-affiliations take place within the network when the nodes move that needs a reconfiguration of clusters. This in turn heads towards the second phase of the clustering maintenance<sup>10,11</sup>. The transition states of the cluster head is shown in Figure 3.

##### 3.1.1 Cluster Setup

###### 3.1.1.1 Steps for the setup of the Cluster

The following set of sequential steps describes the set up of the cluster:

Step 1: The head is selected combining the weighted calculation algorithm and creating groups of cluster head selection that are stable over time.

Step 2: Combined weight ( $W$ ) is calculated for each node.

Step 3: Build neighborhood table of the nodes.

Step 4: Set the cluster head ( $CL_h$ ) to 1, if the node has the maximum weight among its neighbors or else set to 0.

Step 5: Broadcast the nodes weight to its neighbors.

Step 6: Repeat the weight calculation whenever a new node is added to the cluster

Step 7: Use this cross-layering information obtained from routing tables to reduce the network overhead.

###### 3.1.1.2 Parameters for Cluster Setup

To calculate the weight of each node the parameters considered as listed<sup>12-14</sup>:

- Measure of mobility denoted by ( $M_v$ )
- Power consumption of the head node denoted by ( $P_v$ ).
- Transmission Rate denoted by ( $T_x$ ).
- Transmission Range denoted by ( $T_r$ ).
- Weight of the node denoted by ( $W_v$ ).
- 

Equation to calculate  $W_v$  (i.e. weight of a node):

$$W = (w_1 * M_v) + (w_2 * P_v) + (w_3 * T_x) + (w_4 * T_r), \text{ and } w_1, w_2, w_3, w_4 \text{ taken as small constants.}$$

##### 3.1.2 Cluster Maintenance

This stage is required when the node moves outside the limit of cluster which it has a place with.

###### 3.1.2.1 Steps for the Maintenance of the Cluster

The accompanying arrangement of consecutive steps depicts the upkeep of the cluster:

Step 1: The node tries to find a new  $CL_h$ .

if (found for a certain time period) { node ← slave} else { node ← Cluster Head ( $CL_h$ )}

Step 2: if node (Cluster Head ( $CL_h$ ) is leaving), then the cluster becomes un-stable and process of re-election of new head is kicked off.

It was observed that the explanations behind vanishing of the cluster head are expected due to the below reasons<sup>15</sup>.

- Excessive battery consumption
- Relative speed of the nodes with its neighbors.

To address the delicate issue -When a cluster head ( $CL_h$ ) is to be re-chosen? , beneath are the conceivable ways that are recommended to address this issue in the accompanying segment:

###### 3.1.2.2 Parameters for Cluster Maintenance

- Degree of the Node (DN): It is characterized as number of neighbor's node present in the region of transmission range.
- Power of Battery (BP): It is defined as the amount of battery power consumed.
- Battery remaining (Br): It is the amount of threshold power a node has that will be a cluster head.
- Number of nodes moving towards the node.
- Stability.

##### 3.1.3 Modified Cluster Maintenance Steps

###### 3.1.3.1 Steps for Newly Arriving Node

- L=List the connection of the nodes that the node entered into the network.
- Look for the internal table of the node and record its neighbors.

- Determine the nodes residual energy
- For the Cluster Head ( $CL_h$ ) selection , determine the probability (node)
- If ( {probability (new node)} < {probability (current cluster head)} )
- Declare node  $\leftarrow$  Member
- else
- node  $\leftarrow$  Cluster Head ( $CL_h$ ), Introduce the cluster as head
- If( $L \leftarrow \{empty\}$ ), then form a new cluster.

### 3.1.3.2 For Re-election of a $CL_h$ Node

- V=Verify the threshold on the cluster head's probability
- If V=true  
Recursive call of the re-election of  $CL_h$   
Else  
No re-election of  $CL_h$ .

### 3.1.3.3 Conditions of a Node – Approaching Head Node

When a node approaches the Cluster Head ( $CL_h$ ), it state gets transitioned as shown in Figure 3.

### 3.1.3.4 Setup for Stable Cluster

The steadiness of a node relies on the stability of the group in which a group of peers as a whole are able to communicate over a timeframe.

In this manner, we consider around time interval 't', companion P can speak with peer Q if:

- Q receives broadcast messages sent by P since  $t-\Delta p$
- Q receives all broadcast message sent by P between  $t$  and  $t+\Delta f$

Where,

$\Delta p$ = P & Q have contact

$\Delta f$  = P & Q cannot establish contacts

t=time in seconds

- Q must be present for at least (stability threshold period), plus the number of periods when it was absent.

Given the case, that nodes meet above conditions the nodes are stable neighbors of each other.

### 3.1.3.5 Algorithm for Attaining Stability in a Cluster

The accompanying arrangement of consecutive steps depicts the stability of the cluster:

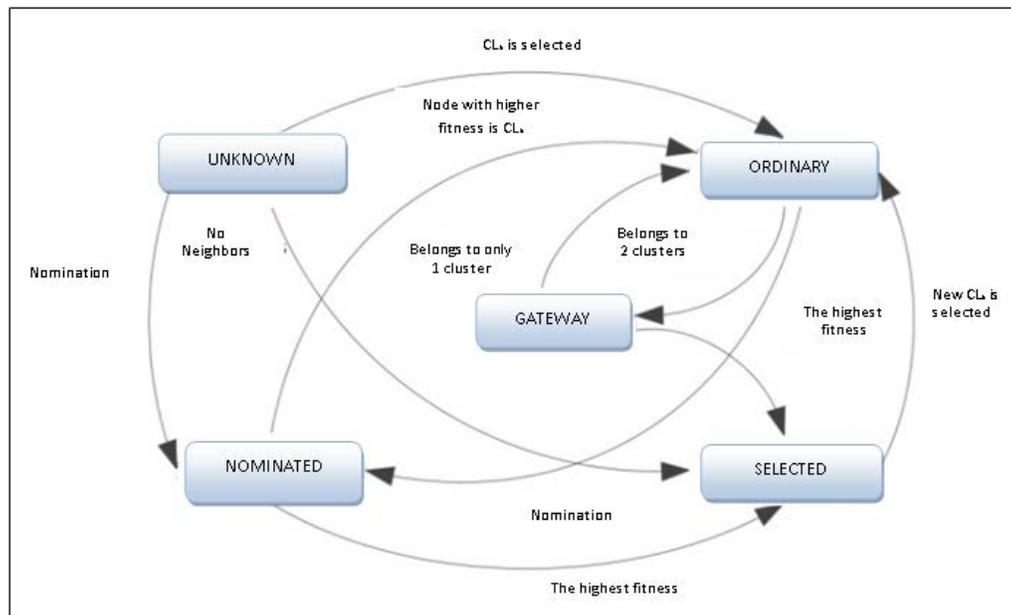


Figure 3. State Transition of a Node.

In majority of the strategies, the cluster groups get to be shaky as the group head doesn't move towards other alternate nodes of the cluster group. The nodes that lessen the overload of cluster re-election procedure are just chosen as group head. The cluster head with properties as having more neighborhoods, more rest battery power, and less average distance are considered.

```

Initialize:
Step (a): 'P', 'Q' → Nodes
Step (b): Min {Threshold} ← Initialize a value
Step (c): Max {Threshold} ← Initialize a value
Step (d): If (Q ← is heard)
    Q++ // Increment the counter till it is heard
Step (e): If (Q ← is not heard)
    Q-- // Decrement the counter till it is not heard
Step (f):
Repeat steps (d) & (e) until 'Q' reaches (Max{Threshold}
+ Q ← is not heard period)
{
if ('Q' reached the Threshold)
Declare cluster as Stable.
if ('Q' > Max(stable Threshold)
Exit the Group.}

```

In our approach we presented an optimal method combining the characteristics of other methods to reach at our algorithm.

## 4. Simulation Results and Observation

The Clustering Algorithm was implemented in NS2.

### 4.1 Simulation Profile

The test bed for the clustering simulation using NS2 is presented in Table 3.

**Table 3.** Test Bed Parameters for Clustering

Parameters	Value
Area of Network	1000 x 1000 m
Number of nodes	20, 30, 40, 50, 60, 70, 80
Range of Transmission	160, 170, 180, 190, 200, 210, 220, 230, 240 & 250 m
Simulation time	170 s
Speed of Node	0, 5, 10 m/s
$W_1$	0.25
$W_2$	0.35
$W_3$	0.20
$W_4$	0.20

Step1: Area selected for simulation (1000x1000 sqm) with randomly distributed nodes.

Step2: Configuration of nodes: 20, 30, 40, 50, 60, 70, And 80.

Step3: Weight parameter are equal:  $W_1 = 0.25$  (constant degree of the node),

$W_2 = 0.35$  (constant received power level),

$W_3 = 0.20$  (constant stationary factor) and

$W_4 = 0.20$  (constant battery level).

Step4: Scenario simulation time 170s.

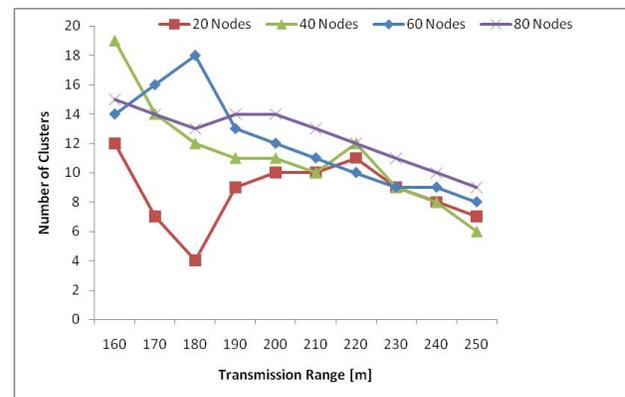
### 4.2 Efficiency of Experiment

The metrics considered for creation of numbers of Cluster for evaluation are

- Varying transmission range
- Varying number of nodes
- Varying moving nodes speed
- Nodes with Cluster head information.

#### 4.2.1 Scenario 1: Variation in Transmission Range

Figure 4 demonstrates for a different set of nodes, how there is a variation in the total number average clusters created with the variation in transmission range. We observe that with noticeable increase in the transmission range, there is a potential abatement in the average number of cluster groups assembled. This is clear sign that the node that has high transmission range covers most extreme territory.



**Figure 4.** The number of clusters vs. Transmission range.

#### 4.2.2 Scenario 2: Variation in Number of Nodes

Figure 5 shows the relationship between the numbers of clusters created aggregating a number of nodes. Here we observed that cluster group got to be steady when there is lessening of separation between the cluster member

and the head. This also leads to less number of event generations within the network.

In the graph presented, the minimum & the maximum clusters created for a group of nodes is shown. The results were also verified on different networks keeping a constant transmission range of 240 m.

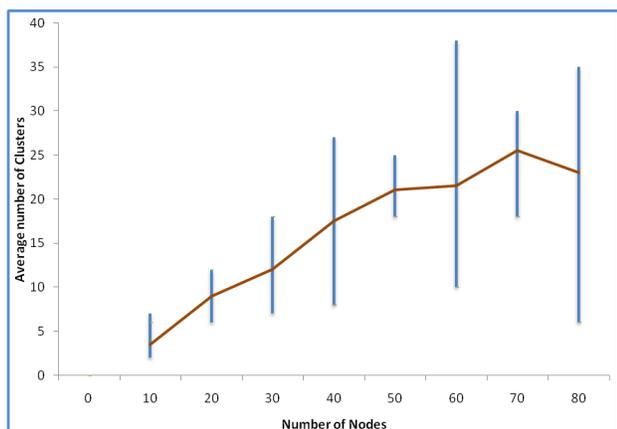


Figure 5. The number of clusters vs. Number of nodes.

#### 4.2.3 Scenario 3: Variation in Speed of Nodes

Figure 6 exhibits how the cluster size is kept up when the rate of the moving node is expanded, we analyzed the clusters created vs. moving speed. The transmission range was kept constant of 240 m. The results show that the moving speed adapts to the dynamic environment while maintaining the size of the cluster.

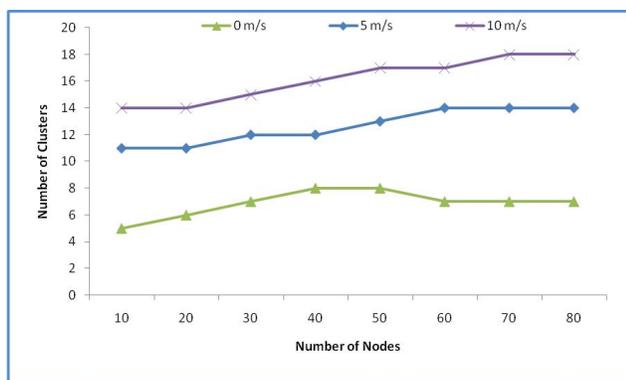


Figure 6. The number of clusters vs. nodes moving speed.

#### 4.2.4 Scenario 4: Cluster Head Awareness with at Constant Transmission Range

Figure 7 demonstrates that there is an arrangement of nodes which knows about its group head. The ceaseless

line demonstrates the most extreme value that is expected in the cluster. The transmission range was kept constant of 240 m. During simulation a time intervals is maintained to show the differences.

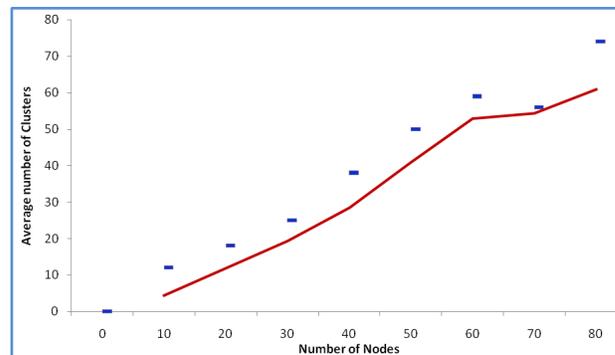


Figure 7. The number of nodes that are aware of their clusters.

## 5. Conclusion

In this paper, we have formulated a cluster head election algorithm which is stable by maintaining the topology of MANET; also making efficient resource allocation, thereby optimizing network performance for nodes. In the different phases of the algorithm, we have shown that the node is elected as cluster head that has the highest fitness. Also the process of cluster creation, election and reelection are done very efficiently. We presented through our examination that less number of events is produced when there is less amount of separation between the cluster member and the head. With this we conclude that the network is more stable and accessible. In future studies, we would like to improve the cluster shaping to enhance the adaptability of the protocol.

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