GA-LORD: Genetic Algorithm and LTPCL-Oriented Routing Protocol in Delay Tolerant Network

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Abstract In communication systems, there are a number of challenges that make the reliable delivery of data difficult to achieve. In the traditional wireless system, if there was any problem such as disconnection between the intermediate nodes or nodes getting drained off because of low energy, then there was high probability of data getting lost. To solve these problems in delay tolerant network (DTN), we propose two new protocols, viz. the Licklider transmission protocol convergence layer (LTPCL) and a protocol formulated by combination of metaheuristic approaches, viz. genetic algorithm and ant colony optimization: GAACO to select the shortest path for transmission of the packets from source to destination by consuming less energy, less delay, less number of hops, but at the same time delivering high throughput.

Keywords MANET · DTN · LTPCL · Buffer memory size · Bundle · GAACO

1 Introduction

DTN, which is popularly referred to as disconnected or disrupted network, is the network that addresses the challenge of accomplishing optimized routing in networks where there is no live end-to-end connection. This is in stark contrast to the existing transmission control protocol/internet protocol (TCP/IP)-based Internet protocols deployed in the networks that operate on a principle of providing end-to-end live communication using a concatenation of potentially dissimilar

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link-layer technologies. The concept of retransmission in TCP/IP-based Internet does not work well in the environment where communication is not reliable and there are many reasons that lead to disconnection in the link (such as the intermediate nodes were getting drained off or the nodes moving out of the transmission range). Some common problems encountered in DTN are: (a) discontinuous connectivity, (b) long or variable delay, (c) asymmetric data rates, and (d) high error rates.

The paper is organized as follows: Sect. 1 discusses the merger of DTN-MANET environment, Sect. 2 discusses DTN Routing issues, Sect. 3 discusses motivation, Sect. 4 discusses related work, Sect. 5 discusses the proposed algorithm(s), Sect. 6 discusses the experimental setup and simulation parameters, Sect. 7 discusses comparison of results, Sect. 8 discusses analysis of results, and Sect. 9 discusses the conclusion followed by acknowledgment and references.

1.1 Merger of DTN-MANET Environment

If information about the destination is deleted from the source routing table, then the message follows the usual approach as applicable in MANET, that is, the first route discovery is performed and then message transmission to the destination node as shown in Fig. 1 is achieved. If information about the destination is not present in source routing table, then the DTN nodes transmit the message to other connected components and ultimately the message reaches to the remote destination.

There are two modes the nodes follow (MANET and DTN) according to different problems occurring in different environments. Some common problems beings: limited transmission range of nodes, noise leading to disconnection of the communication, power management issues, and the frequent movement of in-between (intermediate) nodes. We have addressed these concerns in our problem statement and solved them using two newly proposed protocols, viz. LTPCL and GAACO.

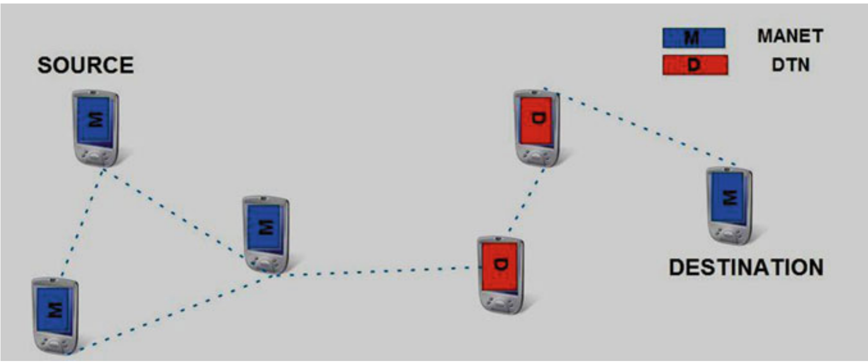

Fig. 1 Switch mode scenario

2 DTN Routing Issues

The DTN approach provides flexibility for routing and forwarding at the bundle layer of OSI Model for unicast, anycast, and multicast information as depicted in Fig. 2. When a significant amount of queuing and buffering occurs in the network, the advantage provided by the information may be significant for taking routing decision. An essential element of the bundle-based forwarding in DTN is that bundle has a place to wait in a queue until next hop link becomes available. It highlights the following assumptions:

- Storage is available and uniformly distributed over the network.
- Storage is sufficiently persistent and robust to store bundles until forwarding.
- The "store-and-forward" model followed in DTN is a better choice than attempting to effect continuous connectivity or other alternatives.

For a network to effectively support the DTN architecture, these assumptions must be held as necessary. Node storage in essence represents a new resource that must be managed and protected.

In a situation if there exists live connection between the source and destination, the intermediate nodes forward the packets to the next hop node. But if disconnection arises for some reason as detailed in Sect. 1.1, then the intermediate node would store and buffer the data packet till the connection is restored or reestablished or simply by choosing the different or alternate path.

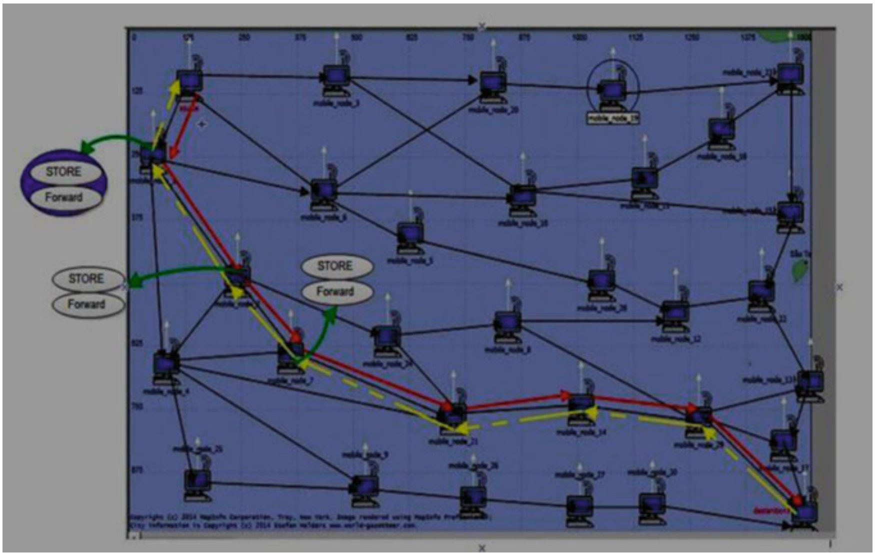

Fig. 2 Broadcast of the packet by the source node

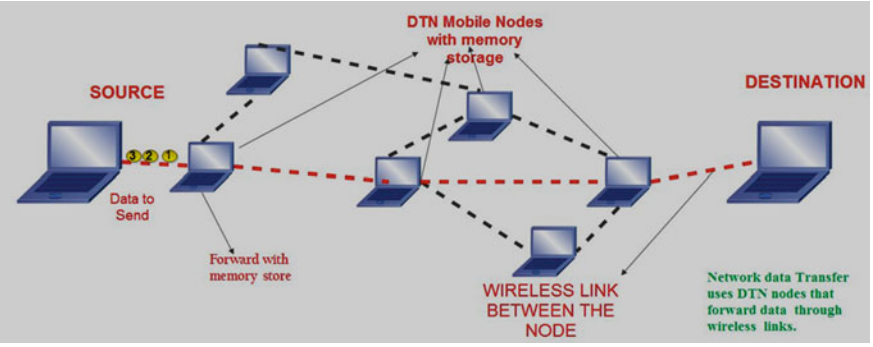

Fig. 3 LIVE connection between source and destination with mobile nodes

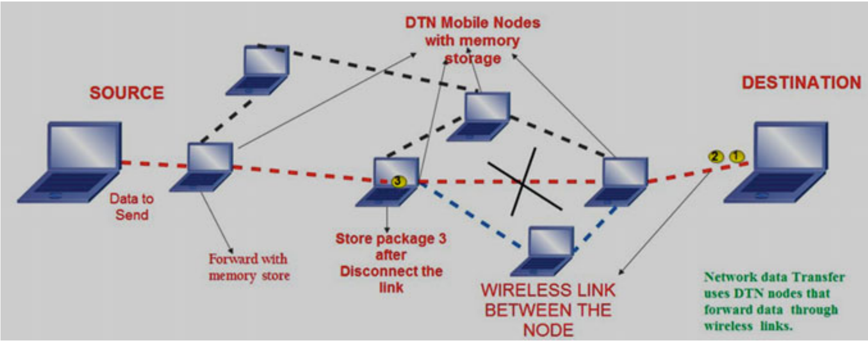

Fig. 4 Package storage at the node

In Fig. 3, after successful route discovery the connection is established between the source and destination. We observed that the source send package to destination by the selection of this path because of less number of hops on this route as well as due to the reason that the nest hop node possesses large quantum of buffer space. In this situation the source delivered the package to the destination, but after some time while the source still dispatched the package by this path as shown in Fig. 4, there developed some problem(s) in the path. The path disconnected because of one of the following reasons:

1. The buffer space of one of the intermediate nodes was not enough to store the package after which the node moved out of the range of the previous node.
2. Due to noise or signal interference between the two nodes which caused the disconnection of the path between the source and destination.

So after the selection of another path, the package stayed there for some time due to some delay, but the packages were buffered/preserved and all the packages were successfully received later by the destination node.

3 Motivation

We have studied and analyzed the MANET, and detected that there are some weak features in MANET that can be improved by the DTN approach. By combining MANET and DTN approach, we used biological principle(s) to build two new protocols LTPCL and GAACO in MANET. The user's density was kept high to provide efficient communication between the nodes, but it is not always high in some environments. The efficiency of MANET decreases to improve the network efficiency. We used DTN approaches with our two newly introduced protocols.

In Sect. 8 we propose a simulation scenario wherein we allow the nodes to send the packages to target user in different situation, such as, if there arises any disconnection between source and destination because of low battery or less memory buffer, according to these parameters, the protocols (LTPCL and GAACO) would change the path dynamically to select new path to complete the remainder transmission of the packet.

4 Related Work

In [1–4] the authors demonstrate that the mobility is not uniform and a pattern in encounters is observed. The Probabilistic Routing Schema utilizes the individual probabilities of nodes to successfully delivery a message. The SimBet routing algorithm uses ideas from social networking and contact patterns to predict paths to destinations to improve message delivery ratio in the shortest amount of time. Bubble Rap routing scheme extends their work by allocating nodes into social groups based on direct and indirect contacts. In [5, 6] author(s) describes a utility function for a node to decide whether to forward the message to an opportunistic contact or to a scheduled contact. In [7] author(s) proposes a new approach routing in MANET using cluster-based approach (RIMCA), which consists of mobile wireless nodes moving randomly within boundary of cluster. In [8, 9] author(s) propose a metaheuristic-based search technique termed as volume adaptive search technique (VAST) to determine an optimal path from source node to destination node in densely deployed mobile ad hoc network. In [10] authors propose a new approach which uses genetic algorithm driven routing principles to meet with the routing needs of the DTN nodes in the group and then exhibit the results after carrying out extensive simulations in MATLAB using different membership models. In [11] authors introduce a new metaheuristic oriented routing protocol GAACO that utilizes the optimization techniques of genetic algorithm and ant colony optimization to find the path between source and destination. In [12] authors apply a metaheuristic(s) method to propose a routing mechanism for Delay Tolerant Networks to find the optimized path with maximum throughput by carrying out the experiments on simulated networks using agent-based modeling tool named NetLogo.

5 Proposed Algorithm(S)

We have designed our own algorithm(s) for optimized routing in DTN, but before detailing them for the sake of completeness we reproduce the algorithm 1–3 of GAACO [11] and then remaining new algorithms: algorithm 4–7 exclusively designed for LTPCL Protocol

Algorithm 1: Initial broadcast GAACO

1: *Ants:(A — Z), Within area(N),* Pheromones (P),Food (F).
Route (R) , Colony (C).
Trigger-
2: **if** all(A to Z) move in different R then
3: all (A-Z) deposit same P
4: **if** F within N then
5: Some of the (A-Z) select different R
6: **else**
7: Select +- R
8: **end if**
9: **end if**

Algorithm 2 : Optimization of the routes in GAACO

1:If more than one R has f been found within N
Then Optimized paths will be:
a) A ,B ,C ,D and E for example ,select different R.
b) A transfer the F within R1 (30m) then deposit P+1.
c) B transfer the F within R2 (20m then deposit P+1.5.
d) C transfer the F within R3 (10m) then deposit P+2
e) D transfer the F within R4 (10.1 m) then deposit P+2.1.
f) E transfer the F within R4 10.2 m then deposit P+2.2.
Trigger-
2: **while** F !=0 do
3:**for**i=A;i<=Z;i++do
end for
4: **if** F deliver to C then
5: P++
6:**else**
7: P
8: **end if**
9:**end for**
10: **end while**

Algorithm 3 : Output of ACO approach as input to GA technique.

1: Some O/P of ACO R
near to each other that output will be input for GA.
Initial Selection more than R.
Each R is identified by P.
Numbers of R as input from ACO
Trigger-
2**: if** R=1 then
3: fittest path R
4: else
5: S: Source select current hop= next hop
6: for i=A;i<=Z;i++ do
7: **if** next hop= 1joule || next hop = 0 kB
then
Current hop= next hop++
8.else
9: Apply Crossover between
10.Rs path l= R1*R2
path2= R2*R1
11.end if
12.end for
13. end if

Algorithm 4: Initial broadcast LTPCL

Trigger-
1: **S** broadcast g within N for all m
2: if d within S(T) then
3: **S send g to d**
4: **else**
5: m(s) update routing Table
then forward g to next hop
6: **end if**

Algorithm 5: Table Routing update in LTPCL

1: For routing Table update **then**
R=number of Current hop= next hop++ routes.
Trigger-
2: **if** R *is* available
then
3: S Source sends the data
4: **else**
5: S: Source select current hop= next hop
6: **for** i=A:i<=Z;i++ do
7: **if** next hop= 1 joule || next hop = 0 kB
8: **else**
9: Apply Crossover between
Rs path l= R1*R2
path2=R2*R1
10: **end if**
11: **end for**
12: **end if**

Algorithm 6: send the data in LTPCL

Route(R),valid (1),invalid (0)

Trigger-

S broadcast g within N for all m
if R=1 then
$S \longrightarrow d$
S send g using MANET mode
else
m(s) update routing Table
then forward g to next hop
end if
if next hop= 1 joule || next hop = 0 kB
S select nearest m to store g
then forward it to d (DTN mode)
end if
if R=0 then
All g store in m(s)route path
end if

6 Experimental Setup

For effective simulation, we designed a network area of dimension 537 m * 100 m, with 31 mobile nodes. Like MANET here too, the source needs to take the help of multiple number of in-between nodes to send the package to the destination node. All mobile nodes moved randomly within simulated network area. The simulations of the two newly proposed protocols, LTPCL and GAACO, were carried out using ns2 as simulator. The protocols worked with DTN agent not with TCP agent. In the Analysis section we have compared these two protocols on the basis of various parameters (shown in Table 1) such as number of hops, throughput, energy, end-to-end delay and package-size versus delivery–ratio, and packet delivery fraction (PDF).

6.1 Simulation Parameters

See Table 1.

7 Comparison of Results

See Table 2 and Figs. 5, 6, 7 and 8.

Table 1 Simulation parameters

Simulation used	Network simulation version 2 (NS2)
Code	TCL, OTCL and C++
Simulation time	30.0 s
Discovery routing time	Start from 0:0–1.5 s
Time to send package	Start from 1.5–30 s
Simulation area	537 * 100 m
Application traffic	Voice application
Number of nodes	31 mobile node
Performance parameter	Routing discovery time, end-to-end delay, package-size versus delivery-ratio, package-size_versus_throughput, protocols Energy, number of hop, energy of nodes
Routing protocols	TPCL, GAACO
Network type	Store and forward
Interface priority queue (ifq)	Drop tail
Antenna model	Omni antenna
Transmission range of the nodes in cluster	250 m
Size of the message getting generated	512 kB
buffer size of the nodes in the network	Maximum packet in ifq 50

8 Analysis of Results

We have implemented two new protocols (LTPCL and GAACO) in the same environment network with the same number of mobile nodes with different parameters (as mentioned in Table 2) to compare which protocol is more efficient and at what cost. So after analysis, we deduced the final result with different scenario (such as the in-between nodes, dead nodes, the in-between nodes which moved outside the transmission path or when the memory buffer of in-between nodes was full). We observe that the GAACO protocol is more efficient than the LTPCL protocol by means of graph as shown in Figs. 5, 6, 7 and 8 because the GAACO protocol consumes less resource(s) such as memory buffer and energy. The GAACO protocol's fast response changes the path when the disconnection arise(s) between the nodes due to factors such as noise, weak signal; in-between nodes have less energy or nodes having less memory/buffer size.

Table 2 Comparison of result

Protocols	Average channel accessing delay (ms)	Total energy consumption	Energy consumption per node (J)	Overall residual energy	Residual energy per node (J)	Packet delivery ratio	Average throughput (kbps)
LTPCL	40.7418	121.031Avg.	3.90422	33.9693Avg.	1.09578	0.9953	82.04
GAACO	37.6893	98.3506Avg.	3.1726	56.6494Avg.	1.8274	0.9976	82.23

Number of packet loss: 2 number of packets sent: 425 number of packets received: 423 for LTPCL
Number of packet loss: 1 number of packets sent: 425 number of packets received: 424 for GAACO
Total energy = 31 (nodes) * 5 J = 155 J

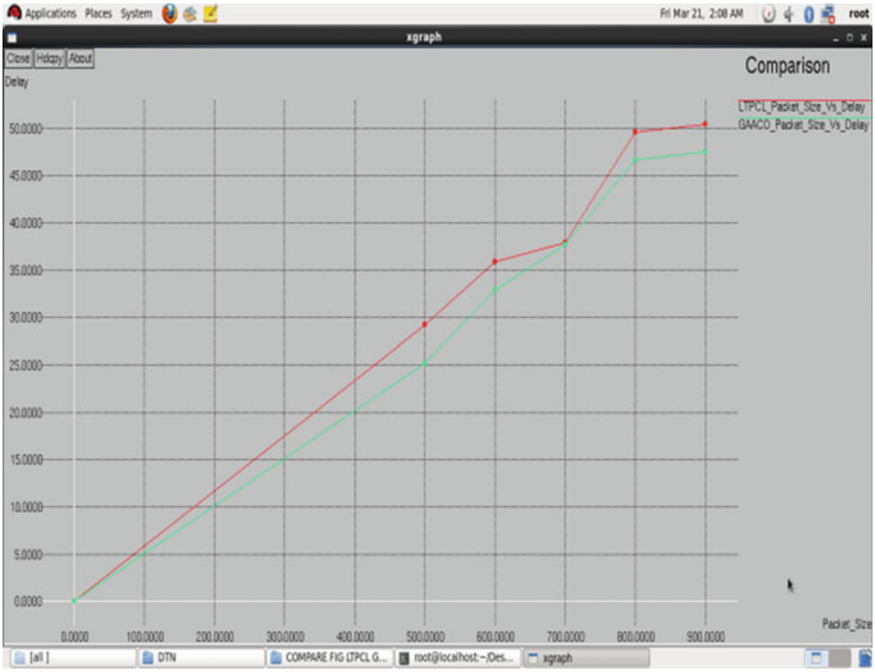

Fig. 5 Packet size versus delay (*L*)

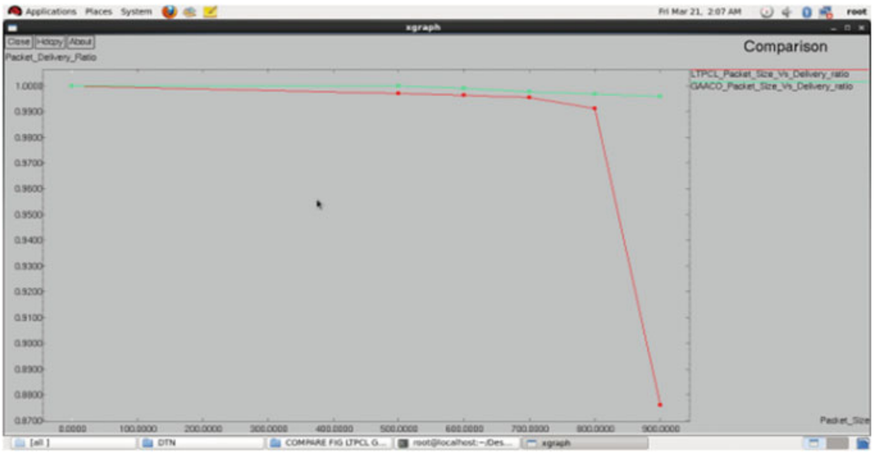

Fig. 6 Packet size versus delivery ratio (*R*)

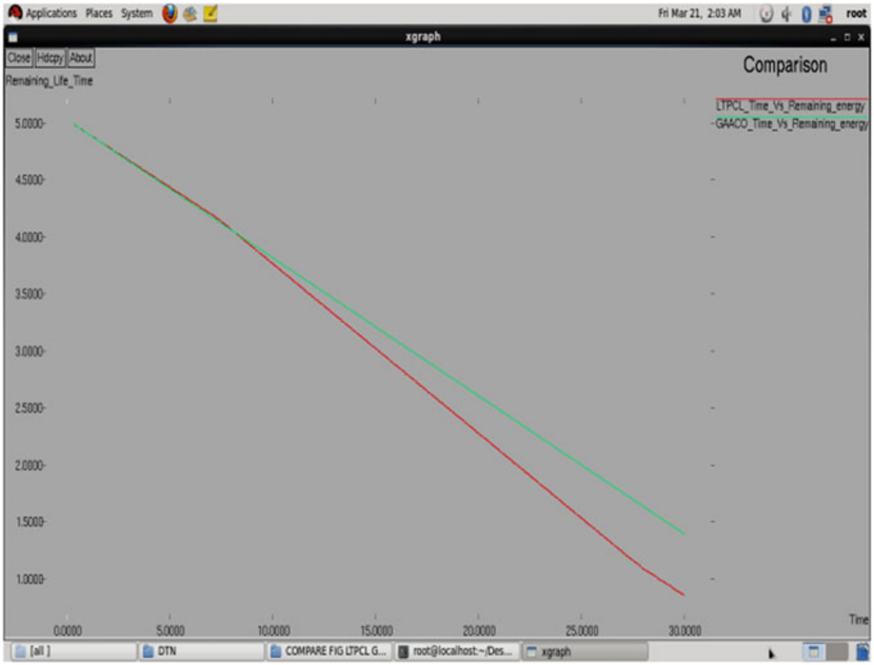

Fig. 7 Comparison of energy consumption

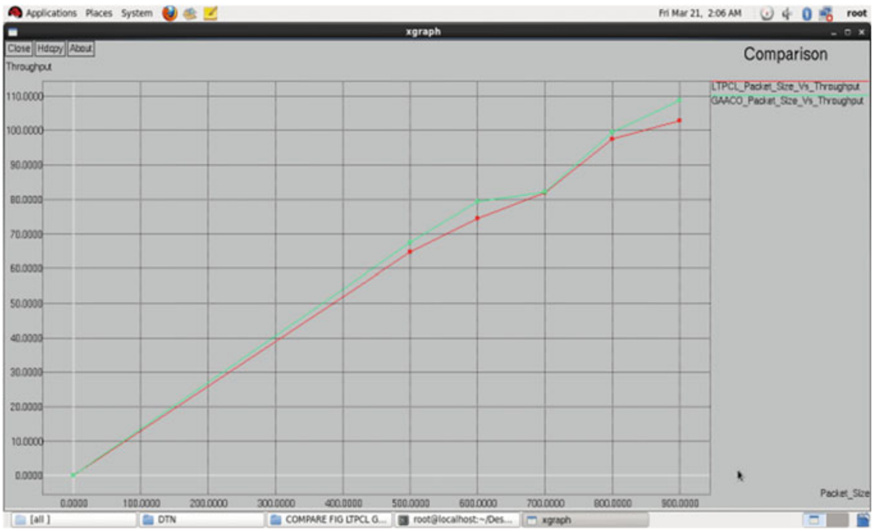

Fig. 8 Packet size versus throughput

9 Conclusion

We developed two new protocols (LTPCL and GAACO) that worked well with DTN agent in NS2. In MANET network, the biggest challenge is the battery backup, so we tried and let the mobile nodes move at slow speed. In our paper, we have programmed these two new protocols to change the route when the energy of the node comes near 2 joules to ensure the node(s) store-carry-forward the package if any disconnection occurs in communication between source and destination. The DTN approach is suitable for different environments where the signal is not strong and data can get lost due to reasons such as noise or the low level of battery of some nodes.

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