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COMPARATIVE STUDY OF GEOGRAPHICAL ROUTING APPROACHES FOR VANET SCENARIOS

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ABSTRACT

Vehicular Ad hoc Network (VANET) is one of emerging technology in which routing is one of the challenging task in vehicular communication systems. VANETs are a type of mobile wireless ad hoc network made up of vehicles and roadside units without central access point. In VANETs, Vehicular nodes are highly mobile that results in frequent topology changes and frequent link disconnections. In this paper, a study one various routing strategies for Vehicular Ad hoc network have been done. This paper highlights a few geographical routing protocols with their characteristics and different parameters considered to make comparison between them. In this paper, we define some of open issues related to research areas of few geographical routing protocols by comparing them on the basis of parameters used by them. Routing in VANET network is very complex due to high dynamics and frequent change in topology. In this paper, we present some future perspectives related to geographical routing protocols used in VANET scenarios.

Keywords: **Vehicular Ad hoc Networks, Localization, Routing Protocol, Geographical Routing, IVC.**

I. INTRODUCTION

ROUTING is one of the challenging tasks in ad hoc network as it needs movement of packet from source to destination node using optimal path. Vehicular communication has recently become an increasingly popular research topic in the area of wireless networking as well as the automotive industries. The goal of VANET research is to develop a vehicular communication system to enable quick and cost efficient distribution of data for the benefit of passenger's safety and comfort. It also provides future enhancements in automobile technology with new concepts by building up a mobile Internet access to passengers such as projects like FleetNet.

VANET is a subclass of mobile ad hoc networks that integrates ad hoc network, wireless LAN and cellular technology to achieve better inter vehicle

Communication [4] and to enhance the safety and efficiency of vehicles on road [1][2][3]. Intelligent transportation system is one of the applications of VANET.As the growth of wireless products get increased, then the demand for vehicle to Vehicle (V2V) and Vehicle to roadside (VRC) or Vehicle to Infrastructure (V2I) will also increase that is example of car 2 car communication consortium (C2C-CC)[12]. A Vehicular ad hoc network (VANET) is a network consisting of a set of wireless mobile nodes that communicate with each other

without centralized control or established infrastructure. Vehicle nodes that are within each other's radio range can communicate directly, while distant nodes rely on their neighboring nodes to forward packets. Each node acts as either a host or a router in itself. In VANET environment, vehicle nodes are free to join or leave the network at any point of time, resulting in a highly dynamic topology network environment compared to wired network. The main considerations about developing routing protocols for VANET are computation-restricted, bandwidth constrained, and energy-constrained [5].

Vehicular Ad Hoc Networks (VANETs), also known as Vehicle to Vehicle Communication (V2VC) or Inter-Vehicle Communication (IVC) networks are a specific case of Mobile Ad Hoc Networks (MANETs). VANETs [6] tend to exhibit a drastically different behavior from the usual MANETs [7]. VANET is similar to MANET as it involves the process of self-organization, self-management, and low bandwidth and shared radio transmission, but it does-not mean that VANET resembles all the characteristics of MANET as it has following differences as shown in table1 below.

Table 1

Characteristic Comparison of Manet And Vanet

	MANET	**VANET**
Number of nodes	**Usually 100 to 1000**	**Unbounded, can be up to millions of vehicles**
Movement area	**Usually million square meters**	**Unbounded, can be up to the area of a nation**
Mobility	**Low to medium**	**High**
Trajectory of nodes	**Random waypoint/ group pursuing**	**Mostly one-dimensional**
Distribution of nodes	**Random and even**	**Sparse and uneven**

VANET has certain specific characteristics that make it appropriate topic to study for many researchers in VANET [8] in terms of designing various routing protocols like dynamic topology, frequent disconnected network, sufficient storage and energy, communication environment variation, geographical type of communication, mobility modeling and prediction ,need hard delay constraints and equipped on board sensors.IVC require the solution of the problem of message routing where the location of the destination node is unknown due to high mobility and absence of any adequate infrastructure in VANET, this problem is known as *node localization*, which becomes complex for any network. When a person requires information from a specific geographic region such as road condition, traffic flow etc. are supported by geocast routing [9].Geographic routing considers the location information of nodes to forward the packet between participating nodes. Various position based routing protocols can be DTN (Delay Tolerant network) [10][11]& (Non-delay Tolerant network) types[12][13][14].

The rest of the paper is structured as follows: In Section II gives a short overview of related work in the field of VANET environment and discusses various routing strategies for VANET. Section III presents the brief

description of various geographical routing used in VANET scenarios. Section IV gives comparison of various geographical routing protocols on the basis of some parameters used by them. Finally, Section V presents the conclusions and future work.

II. RELATED WORK

Earliest studies on VANET and NC was started by TSK Japan in early 1980's After that California path and European project Car Talk 2000 have demonstrated the technique of coupling two or more vehicles and to investigate the problems related to inter vehicle communication.

Vehicular communication System includes Inter-vehicle communications (IVC), Hybrid vehicle communications (HVC) and roadside vehicle communications (RVC). As the growth of wireless products get increased, then the demand for vehicle to Vehicle (V2V) and Vehicle to roadside (VRC) or Vehicle to Infrastructure (V2I) will also increase that is example of car 2 car communication consortium (C2C-CC)[15]. Research projects in the US and Europe determined the wireless LAN improvement as basis for realizing short to medium range communication services in vehicular environments.

Contrary to this approach and widespread centralized infrastructure-based wireless solutions like cellular networks, European research from the outset focused on self-organizing, decentralized multi-hop ad hoc networks. These networks operate without any central instance that coordinates resource allocation and medium access or which is permanently aware of communication links between the network nodes. But rather each station simultaneously acts as a sender, receiver and relay node and is in charge of maintaining the required information on the network.

As yet recent European projects like FleetNet [16] or CarTalk2000 [17] concentrated on the evaluation and development of algorithms for position-based routing and forwarding [18]. The protocols imply a position-awareness of the nodes and were intended enable networking over multiple hops to a destination node or a target area, even in environments with high node mobility. Each C2X-node regularly broadcasts so-called beacon messages that include position information to inform neighboring nodes about their presence and location. Network protocols used for VANET communication are topology-based and location-based routing protocols.

VANETS routing protocols can be divided into two categories: Topology based routing protocols and location based routing protocol or geographical routing protocol. Topology based routing protocol can further be classified into three types like Proactive Routing Protocol is table driven routing where routing information is maintained in form of tables at each node irrespective of communication requests. Common proactive routing protocols are FSR (Fish Eye State Routing)[19],DSDV (Destination Sequenced Distance Vector) [20], OLSR (Optimized link state routing)[21], WRP (Wireless routing Protocols)[22]. Reactive Routing Protocols or the on demand routing protocols involve AODV (Ad hoc on demand distance vector routing)[23], DSR (Dynamic Source Routing)[24] and Hybrid Routing Protocols includes ZRP (Zone Routing Protocol) [25] and HARP (Hybrid Ad hoc Routing Protocol)[26].

Geographic routing considers the location information of nodes to forward the packet between participating nodes. Location based routing maintains only local information about the node such as current position of the node. They do not require any establishment and maintenance of routes in storing tables and updating them. A location service is used by the sender to get the position of destination node for communication. Location-

Aided Routing (LAR) [27] and Greedy Perimeter Stateless Routing (GPSR) [28] are some location based routing protocols. We will discuss basic concept of geographical routing and some geographical routing protocols used in VANET environment along their few characteristics in next session.

III. BRIEF DESCRIPTION OF GEOGRAPHICAL ROUTING

Geographical routing or the location based routing is based on the location information of nodes and the packet forwarding strategies. Location based routing is routing scheme in which we do not need the longer routing tables and repeated time consuming route discovery procedures. That's why, it is considered better than the location based routing schemes. Position-based routing stands on top of a number of assumptions that includes nodes can determine their own position and location of their neighbors. Final assumption states that nodes can determine the position of the destination. Location based routing protocols such as LAR and GPSR leads to the increase in the efficiency and the scalability of wireless ad hoc network routing. They provide the new approach to utilize the location information by using the GPS are GPS less services. Location based routing is better than topology based routing as the packet loss is less due to use of the location information, time as well as energy consumption is reduced as it does not need the maintenance of the routes and further route discovery, they perform better in case of more scalable network which is main property of the VANETs and efficient due to better performance than topology based routing protocol by delivering more packet delivery ratio. Advantages of the location or the position based routing over the topology based routing are location based routing reduces the burden of maintaining routing tables and do not need establishment of routes for all the nodes which is required by caching based routing protocols. Moreover, it reduces the overhead of maintaining topology based information, enhances the scalability and performances in terms of success rate as compared to topology based approaches. Position based routing protocols are better than reactive and proactive routing protocols as they have neither to store routing tables nor to transmit messages to keep routing tables up to date. Now come to the basic strategy behind the growth of geographical routing protocols which is shown in following subsections. After this, we have shown the problems with the traditional routing protocols.

3.1 Basic Idea behind Geographical Routing

Basic idea here reveals the initial phenomenon on which geographic routing was based. Here, we represent a brief discussion on this topic by reviewing few geographical routing protocols that are purely based on the location service to deliver the packets towards the destination. Geographical routing ,as the name suggest is based on the geography of a particular location as well as geographical information related to the node participating in the information traversal. The basic idea behind geographical routing is represented in following figure1.We can see the difference between topology based routing where we do not have to consider forwarding strategy as we have to use flooding to send the packet information from source to the destination and each node have to remember the necessary information regarding all other nodes participating in the network formation.

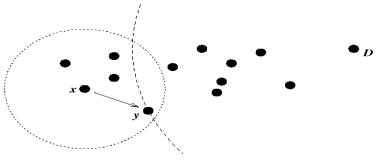

Figure 1: Greedy Forwarding Example: x forwards to y, its neighbor closest to D.

This figure [27] gives the clear picture of the geographical routing in which large number of nodes are distributed in the geographical region .Here, x act as the source node and D as destination node. The nodes within the dotted circular region are considered to be present within the transmission range of that node; y is one of these nodes. x will transmit the packet towards next node on the basis of the location information. y is closest to D, so x transmit packet to y. But here, one thing important is the location information of the nodes. This information is obtained from GPS (Global Positioning System) [29].Sometimes, this method does not work due to distance problem or the obstacles or opaque objects between their paths. So, GPS free services [30] are also available to provide the location information of the nodes.

3.2 Pitfalls of Topology Based Routing

This paper gives a brief review of the routing protocols related to static and mobile ad hoc networks. Since, VANETs are mobile ad hoc networks with decentralized structure and nodes are placed in the ad hoc manner. So, it requires routing with lesser mobility and suffers from stringent energy requirements. The pitfalls of the topology based routing are reviewed in the coming subsections with the brief description of the few traditional routing approaches. Topology based routing protocols needs the information about the links between nodes forming the complete network in order to make routing decisions. The common topology based routing protocols are shown here.

1) Proactive Routing Protocols

These are the routing protocols that need the maintenance of the routing information regarding all the paths formed during network design. This information is necessary to maintain even if we do not need it. These types of routing protocols bears quite high routing overhead and more energy is required to kept extra information.

3.3 Limitations of Proactive Routing Protocols

1) Proactive routing protocols like Distance vector routing and link state routing protocols suffers from maintenance of the unused paths.
2) Wastage of the valuable bandwidth.
3) Coping with frequent topology changes.
4) Significant energy requirement get increased.

3.4 Reactive Routing Protocols

Common reactive routing protocols like DSR[] seems to be better than the proactive routing protocols which we have studied in the previous sub sections. These routing protocols kept the information about paths that we have to use in forwarding the packets. So, the subsets of the available paths are maintained instead of caching information about available sets of paths. This reduces the overhead of unnecessary information maintenance in these routing protocols.

3.5 Limitations of Reactive routing protocols

1. Reactive routing protocols requires the route discovery for finding out the efficient paths that needs to be followed to forward the packet to right path and information about which routes are needs to be maintained.
2. Delay get increased due to time spend in the discovery of the efficient routes.

3. Route information is necessary to be kept up to date and if route becomes outdated, there is problem of maintaining routing information according to changing topology. This problem becomes more worst if the nodes are changing their positions due to mobile networks.
4. Sometimes, packet gets lost due to sudden path changes.

3.6 Hybrid routing protocols

Hybrid routing protocols combines the properties of the previous topology based routing protocols. Hybrid routing protocols includes ZRP in which we have to maintain the routing information regarding all the paths that we have to use in packet forwarding. The main *limitation of the hybrid routing protocols* is that we have to keep the information regarding topological changes in the ad hoc and sensor net environment. Here, we have shown the limitations of the traditional routing protocols that are based on the topological changes in the network. This paper completely gives the brief review on the famous topology based routing protocols. In the coming section, we have shown the geographical routing protocols that removes some of these limitations and provides an enhancement to the present topology based routing protocols in VANETs.

Location based routing is based on distinct forwarding strategies like DREAM and Greedy Forwarding as well as different location services (GPS based and GPS less)[29][30].Some of geographical or location based routing protocols along their characteristics are discussed below.

a) GPSR (Greedy Perimeter Stateless Routing) [27]: GPSR is position based routing protocol that utilizes the position of routing nodes to deliver the packets to destination. GPSR is considered as stateless routing algorithms as each node needs to know about its one hop neighbor's position only. In GPSR two methods are adapted for packet forwarding. First method is to forward the packet using greedy forwarding that means to send the packet to neighboring node which is nearest to destination and second method is to forward the packet to the neighbor using perimeter forwarding or the Right Hand Rule in counterclockwise direction. But planarization is also used to eliminate crossing links.

b) Greedy Perimeter Stateless Routing with Lifetime for VANETS [31]: It is modified form of GPSR routing protocol in which concept of lifetime is introduced. Lifetime represents time a node exist in the range of another node or the time for which a node exist as a neighbor of another node. The neighboring node can change its position or the node itself can move and the hello message can be lost. For this, a lifetime timer is used and for next hop selection, the node that is closest to destination with good link quality and nonzero lifetime tune is considered.

c) GPCR (Greedy Perimeter Coordinator Routing) [32]: It defines the geographic routing between intersections or junction nodes that is one of the improvement over GPSR used in VANETs. GPCR (Greedy Perimeter Coordinator Routing) [32] uses the concept of city streets which form natural planar graph & does not depend on static street maps. It uses two approach restricted greedy forward & recovery phase for routing efficiently. When the local maximum condition arises, GPCR includes a repair strategy in which right hand rule is followed to choose the street where the packet should be forwarded. After the local maximum condition is overcome, then it again switches to the greedy forwarding approach to forward the packet between two junctions. GPCR is considered as more reliable routing protocol of VANETs than GPSR.

d) GpsrJ+[33]: GpsrJ+ is an enhanced perimeter routing protocol of GPSR that outperforms the GPSR and GPCR in terms of packet delivery ratio. This protocol removes expensive planarization strategy of GPSR by considering the natural planes feature of urban maps. Furthest neighboring node is considered as next appropriate next hop destination for forwarding node than that of junction nodes. This protocol uses the concept of enhanced beacon format & modified neighbor list to overcome the limitation of GPSR and GPCR which considers node's position in the beacon.

e) GyTAR (Greedy Traffic Aware Routing protocol)[34]: GyTAR is an intersection based routing protocol for finding robust and efficient routes in urban vehicular networks. The protocol proposed a method for junction selection that depends on vehicular traffic density & road topology parameters. An improved greedy strategy is used to forward packets between two junctions where periodic hello messages are exchanged between two vehicles. It utilizes the delay tolerant network approach during recovery strategy when the local optimum condition is reached or greedy forwarding approach is achieved.

f)E-GyTAR (Enhanced Greedy Traffic Aware Routing protocol)[35]: This paper gives the difference between GyTAR & improved GyTAR in terms of Junction selection where packets are forwarded between junction by considering vehicle speed & direction for routing. This junction selection mechanism enhances the packet delivery ratio as compared to other position based routing protocols and decreases end to end delay between routing nodes improve junction mechanism in which a junction is selected with high traffic density so that end to end delays get reduced and connectivity between routing nodes is higher as compared to lower density areas. This protocol has been proposed to illustrate the Packet forwarding approach that uses a neighbor table, to maintain information about speed, velocity & direction of each vehicle.

g) GeoCross [36]: This protocol is an event driven geographic routing protocol to detect cross links leading to loops in urban vehicular networks. GeoCross algorithm use natural planer feature of urban maps and avoid the use of complex planarized algorithm. GeoCross is suitable for highly dynamic topology where vehicles are mobile and their speed variation is high that is further an improvement over GPSR. GeoCross utilizes probing to detect loops created due to cross links. GeoCross algorithm is used where cross links are removed only when loops are detected. GeoCross follows simple right hand rule in recovery procedure when local loops are detected without cross links. GeoCross increases time and space optimizations by using caching and by recording cross links respectively.

h) VADD [37]: Vehicle Assisted data Delivery in Vehicular Adhoc networks [37] illustrated a vehicle assisted data delivery model to route the packets in highly mobile and disconnected network due to sparser network. VADD follows carry and forward approach in case of disconnected network. This protocol emphasizes on use of delay tolerant network for routing packets in intermittent network.

i) Connectivity aware Minimum delay Geographic routing protocol (CMGR)[38]: This protocol represents route selection logic by considering the connectivity and maximum available bandwidth for the route. It also represents vehicle tracking mechanism to handle the moving destinations in case of sparser and denser networks. CMGR protocol deals with sparse network where network partitions are more by prioritizing the

roads according to vehicular densities and the denser network to deal with less congested route where end to end delay between vehicular nodes is less.

j) GeoSpray: A Geographic routing protocol for vehicular Delay Tolerant Networks [39] gave an extension to existing Delay Tolerant Network routing protocols, that is, VDTN routing protocol called GeoSpray to deal with dynamic topology leading to disconnected network. This protocol uses store-carry-forward and bundle oriented approaches. It utilizes single copy and multi copy concept to create multi copy path. Multi copy concept is used to find alternate path and clears the delivered bundles from cache after delivery to enhance resource utilization and it utilizes single copy or Simple forwarding scheme to improve delivery success and reduces delivery delay.

k) GeoDTN+Nav[40] : This Protocol includes three phases like Greedy forwarding, perimeter model or recovery phase and DTN mode. It overcomes the limitation of existing Geographic routing protocol that utilizes VNI (Virtual Navigation interface System) system which involves two kinds of primitive information route information of vehicle and confidence or the probability that vehicle will follow same route. In this protocol, restricted greedy forwarding is followed or the packets are forwarded between junction nodes and the perimeter forwarding approach is followed if local maximum condition is reach. But the packet forwarding is made non DTN to DTN mode when the network is sparser or disconnected. In DTN mode, two factors are considered n/w disconnection and delivery quality of nodes storing a packet. So, a "Score function" S is calculated on basis of three factors, Probability that network is disconnected, delivery quality of neighboring node and direction of the movement of the neighbor node.

l) DTFR (Delay Tolerant Firework Routing): A geographic routing protocol for wireless delay tolerant network [41] is another protocol designed for the networks where mobility of node is high called Delay Tolerant Firework Routing Protocol. This protocol delivers the packet to destination node by following four phases: Homing phase, explosion phase, spread phase & locking phase. In homing phase, the packet is forwarded to Firework Center (FC) where destination is estimated to be at time of packet arrival, when packet arrives at FC, it enters into explosion phase where number of replicas are created, then spread phase is followed where replicas are propagated into different directions to maximize chances of finding destination once replica reaches to destination, it enters to locking phase. It contain greedy phase & DTN phase but not perimeter phase as in GeoDTN+ Nav.

m) GeOpps[42]: GeOpps is a new a trajectory based protocol that uses opportunistic nature of mobility pattern of vehicles and geographic information by using navigation systems. It used delay tolerant networks representing concept of store-carry-forward to route packet in case of intermittently connected network & it depends on trajectory information about various routes between vehicles than the geographical information of various routing nodes. This protocol takes advantage of vehicle navigation system which suggests route to select the vehicles likely to move closer to the destination.

n) GSR (Geographic Source Routing) [42]: This protocol uses greedy forwarding and perimeter mode for packet forwarding in VANET scenarios if there are no node in direction of destination, than it switches to perimeter mode otherwise it uses greedy forwarding.GSR utilizes the location of source and destination node with city

map to compute the path having sequence of junction to be followed. It utilizes Dijkstra shortest path algorithm on street map to calculate the appropriate path made up of junctions. Then greedy approach is applied to forward packet between junction nodes.

o) TO GO (Topology Assist Geo Opportunistic Routing) [43]:It is hybrid routing protocol which uses 2 hop beacon information & opportunistic forwarding to send packet to target node instead of destination node.

p) VCLCR [44]: A practical geographic routing protocol is designed to remove the cross links for avoiding loops in urban vehicular Ad hoc networks. This protocol is proposed to consider natural planer feature of urban maps without considering planarization strategy as represented in geographic routing approach. It is an event driven protocol that can route packet to destination in the presence of cross links. As cross links do not affect the delivery of packets, so only loop inducing cross links are considered and a dynamic loop detection method is used. VCLCR do not consider the probing packets as used in CLDP & LCR to reduce resource overhead. The silent features of dynamic loop detection and statelessness feature of VCLCR makes it suitable for mobile VANETS. This protocol also provides space and time optimization by recording cross links only and by using caches for recording unroutable links respectively.

q) CBF (Contention-Based Forwarding)[45]: Contention-Based Forwarding is a geographic routing protocol that does not make use of beacon messages which saves bandwidth. In CBF data packet is send by broadcasting the packet to all direct neighbours& these neighbours will find out among themselves the one that will forward the packet. It reduces the probability of packet collision & inefficient routing by ignoring inaccurate neighbour tables. It Provides low packet delay when mobility is higher.

r) A-STAR-Anchor-based Street-and Traffic- Aware Routing[46]:This routing protocol considers the list of junctions or anchors with street awareness and traffic density information to forward the packet. It uses Dijkstra's algorithm is employed to compute the shortest route between source and destination. In this, data packets are expected to be routed through those streets with more vehicles to provide higher connectivity among nodes.

IV. COMPARISON OF GEOGRAPHICAL ROUTING PROTOCOLS

In this section, a qualitative comparison of few geographical routing protocols is reviewed in form of table 2. The various geographical routing protocols are compared on basis of some parameters like packet delivery ratio, end to end delay, scalability, mobility pattern, hop count and many quality parameters. Some parameters are still needs to be considered like optimization, connectivity problem, density pattern, collision ratio, highly mobile environment, frequent topology changes are needs to be considered.

Table 2: Comparison of Geographical Routing Protocols

	Delay Tolerant Network	Use Carry and forward approach	Packet Delivery ratio >80%	End to End Delay		Hop Count		Enhance Scalability	Road Map Required	Mobility Pattern considered	Planarization required	Loop free
				More	Less	More	Less					
GPSR			√	√			√				√	
GPSR-L			√	√			√				√	
GPCR					√	√		√	√			
GpsrJ+					√	√		√			√	
GyTAR		√			√		√	√	√			
E-GyTAR		√	√		√		√	√	√			
GeoCross					√	√		√				√
VADD	√	√	√	√		√		√			√	
CMGR			√		√	√		√				
Geospray					√	√		√			√	
GeoDTN +nav	√	√	√	√		√					√	
DTFR	√	√	√		√	√		√		√	√	
GeOpps	√		√	√			√	√	√	√		
GSR			√		√	√		√	√			
TOGO		√	√	√		√						
CBF		√	√	√		√		√	√	√		
VCLCR		√	√		√	√		√			√	√

A-STAR			√	√		√			√			

V. CONCLUSION AND FUTURE WORK

VANETs will play an important role for future automobile developments as they enable a large range of applications. In VANETs, geographical routing is quite challenging task but it seems to be better than other routing strategies due to some properties as we have described in previous sections. In this paper, we have reviewed the basic method of geographical routing along with the advancement incorporated by describing the research involved in this field. At last, we have compared various geographical routing protocols on basis of some parameters. In future, we will try to focus on the problems faced by these geographical routing protocols like change in network topology, high mobility, disconnected network and scalable network and will enhance these existing protocols to meet the requirement of change in environmental factors. In the near future, automobiles may have factory installed wireless ad-hoc network capabilities to improve traffic flow and safety, in part, because it is more cost effective than continually undertaking massive construction projects, which are proving to have limited success. Consequently, future developments in automobile manufacturing will include new communication technologies to help provide more effective spacing and collision avoidance systems. In order to avoid communication costs and guarantee the low delays required for the exchange of safety-related data between cars, inter-vehicle communication (IVC) systems based on wireless ad hoc networks represent a promising solution for future road communication scenarios, as it permits vehicles to organize themselves locally in ad-hoc networks without any preinstalled infrastructure.

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