QOS BASED ROUTING USING ADMISSION CONTROL AND LOAD BALANCING IN MANET

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Abstract—**In the design of routing protocols and algorithms, the knowledge of Quality of Service parameters such as residual energy and bandwidth availability is required. In order to support reliable routing, link stability of the nodes should also be considered in the mobile environment. In this proposed system a Multi-objective optimization based admission control in routing is proposed to choose the desired path with sufficient energy, bandwidth and link stability for real time data transmissions in the Mobile Ad Hoc Network. Quality of service based admission control leads to load balancing in the network because the bandwidth is reserved before the data transmission. Hence there is no chance of overloading in the network. Thus the proposed system increases the throughput of the routing protocol.**

***Index Terms*— Admission control, AODV Routing Protocol, Mobile Ad-Hoc Networks, Quality of service.**

I. INTRODUCTION

In recent years Mobile Ad hoc networks (MANETs) have become very popular due to the rapid growth of wireless and mobile communication. MANET is a collection of mobile nodes that dynamically form a temporary network and are capable of communicating with each other without the use of a network infrastructure or any other centralized administration. Each device in a MANET is free to move independently in any direction, and will therefore change its links to other devices frequently. In MANET the individual nodes are responsible for dynamically discovering other nodes to directly communicate with each other. . In order to enable communication between nodes that are not directly within each other's send range, intermediate nodes act as routers that relay packets generated by other nodes to their destination. The MANET structure is shown in figure1.

The important characteristics of MANET are i) Dynamic topologies: The nodes on the network keep on moving with different speeds, which results in the variations in the structure of the network. ii) Energy constrained Operation: The devices in the modern electronic world completely rely on batteries. The design of the network is to be optimized to conserve the energy consumed by the mobile nodes. iii) Limited Bandwidth: The bandwidth of the wireless network is very much limited and the networks are to be optimized to perform with the maximum efficiency with in the limited bandwidth.

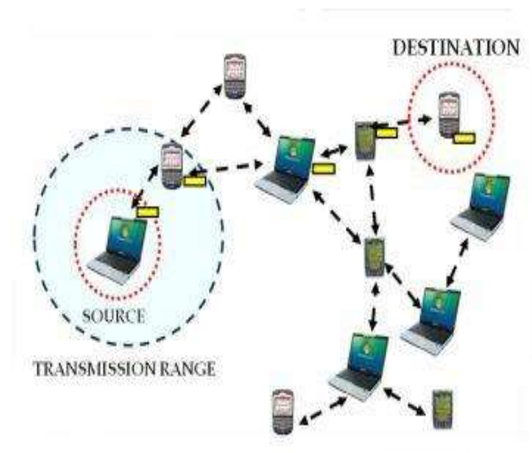

Fig 1: MANET Structure

A. *ROUTING IN MANET:*

Routing is the biggest challenge in the MANET infrastructure. Routing is the process of selecting paths in a network along which the packets are transmitted. An ad hoc routing protocol is a standard, which controls how nodes decide the path to route packets between computing devices in a mobile ad hoc network. In ad hoc networks, nodes do not start out familiar with the topology of their networks instead; they have to discover the topology. Here, a new node announce its presence and should listen for announcements broadcast by its neighbors. Each node learns about its nearby nodes and how to reach them and announce that it can reach them. The forwarding in routing process is done on the basis of routing table which maintains the record of the routes to network destinations.

The three major categories of routing protocols are Proactive, Reactive and Hybrid. In Proactive protocols (table driven) the nodes should keep track of all possible destinations so that it can be used immediately while forwarding a packet. In Reactive protocols (on demand) the routes are established on when needed. The hybrid protocol is the combination of both the proactive and reactive protocols.

B. QUALITY OF SERVICE IN MANET:

QoS can be defined as a collection of constraints or characteristics that a connection must guarantee to meet the requirements of an application. The characteristics can be a set of measurable requirements such as minimum energy, minimum bandwidth, link and path stability, maximum delay, maximum delay variance and maximum packet loss rate. Among those energy, bandwidth and stability are the major requirements.

Energy represents an important resource that needs to be preserved in order to extend the lifetime of the network. The mobility and bandwidth of the nodes impact on the protocol's performance over ad hoc networks. In particular, mobility changes network connectivity and it can reduce the stability of the link, degrading the performance of the routing protocols. The link and path stability among nodes allows the reduction of control overhead and can offer some benefits in terms of energy saving over ad hoc networks. Bandwidth must be satisfied in a given route for an application so that data is transferred smoothly and available for presentation at the destination even under the conditions of mobility and limited resources. For long duration connections, nodes/links on the path must be stable so that connection failures are overcome; this facilitates data transfer without interruption. Thus, it is evident that the aforementioned parameters should be considered in designing the protocols.

On the basis of the previous considerations, the main aim of this work is to propose an optimization model for routing within a mobile ad hoc network. The model attempts to simultaneously minimize the energy consumption of the mobile nodes and the bandwidth, and maximize the link stability of the transmission when choosing paths for individual transmissions. The admission control mechanism has to be implemented that controls the access to the nodes based on the above parameters. In order to take into account the energy consumption, bandwidth and link stability of mobile nodes, a multi-objective integer programming model has been developed.

II. RELATED WORKS

This section briefly describes some of the works related to energy, link stability and bandwidth and their respective routing protocols. In addition to the descriptions of contributions that separately account for energy, link stability and bandwidth, a few papers on joint energy- stability and energy-bandwidth metrics are also described.

The paper [1] proposed a new mechanism to establish stable and sustainable paths between all pairs of nodes in a Mobile Ad hoc Network. In this mechanism, we use a stability function as the main path selection criterion based on the calculation of the mobility degree of a node relative to its neighbor. This mechanism is applied on the OLSR protocol to elect stable and sustainable MPR nodes and topology. It significantly minimizes the recalculation of MPR and the routing table recalculation process. Moreover, it guarantees other QOS metrics such as the packet loss and the response time. Paper [2] aimed at identifying the issues and challenges involved in proving QoS in MANETS. It improves the peer to peer communication in wireless mobile ad hoc networks by identifying the location of mobile node using Predictive Location Based Routing Protocol (PLBRP) and admission control mechanism .Authors of paper [3] have implemented a new protocol called the Link stability and Energy Aware routing protocol that takes into account the link stability and residual energy of the node. They have formulated the multi objective optimization formula for the joint energy and link stability metric. Paper [4] proposes a new solution for QoS aware routing and admission control that deals with the practical phenomena such as shadow fading and the link quality dependent fluctuation of link transmission rates. It maintains the backup routes for active sessions, adapting transmission rates, and routing around temporarily low-SINR links that improves the reliability of assured throughput services. The paper [5] proposed a new protocol called Greedy-based Backup Routing protocol In GBR, the primary path is constructed primarily based on a greedy forwarding mechanism, whereas the local-backup path for each link is established according to the link lifetime. GBR has excellent performance in terms of route lifetime, packet delivery ratio and control overhead. But it does not consider other issues QoS, security and load balance.

In paper [8], the problem of finding optimal paths in mobile ad hoc networks is addressed. In order to evaluate the validity of the proposed model, a greedy approach is devised. Some preliminary computational experiments have been carried out, in a simulation environment. The selection of a shorter route leads to a more stable route, but to a greater energy consumption. On the other hand, if longer routes are selected the route fragility is increased, but the average energy consumption is reduced. In paper [11] a new energy efficient bandwidth allocation scheme is proposed. The authors proposed two schemes for connection admission control: the Victim Selection Algorithm (VSA) and the Beneficiary Selection Algorithm (BSA) to reduce energy consumption at each terminal. VSA is designed to minimize energy consumption. BSA is used to achieve maximum energy conservation. The Connection Admission Control technique admits new protocol requests and handoff connections to avoid network congestion and reduce packet dropping. CAC allocates bandwidth to determine the transmission rate of nodes while not degrading QoS parameters. The paper [13] presents a novel analytical framework that jointly accounts the energy consumption and the link stability of mobile nodes. Two indexes for energy and link-lifetime are defined and a multi objective integer linear programming problem has been defined. The proposed target function separates the energy and the link-stability contributions in order to differently change the weights of two opposite characteristics of mobile ad hoc networks.

III. PROPOSED WORK

In the proposed work the admission control mechanism has been introduced for providing access to the nodes. The admission control is deployed in all the nodes. The selection of the node to transmit the packet is done based on the calculated residual energy, available bandwidth and stability of the link. A multi-objective formulation has been defined based on admission control that minimizes energy consumption and bandwidth and utilizes the link stability.

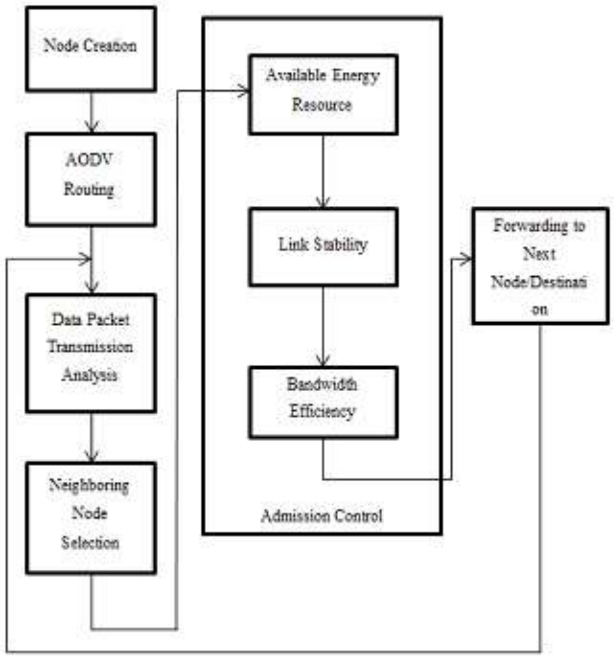

Fig 2: Block diagram of the proposed system

In this proposed work the aodv protocol is used for transmitting the packet. That is it builds routes between nodes only as desired by source node. Here the admission control is deployed in all the nodes. The decision in selecting the node for transmitting the data is done by the admission control. If a packet is received to a node's admission control checks for the residual energy, available bandwidth and link stability. If all the three resources are enough to transmit the data then the bandwidth needed for the transmission can be reserved. And data will be received and transmitted to the next node. Otherwise the access will be denied. The process goes on till the destination is reached.

A. CALCULATION OF LINK STABILITY

In this paper the link stability metric of the node is considered to provide the scalable protocol as in [3]. The node that has the best tradeoff between the energy link stability and bandwidth is chosen for transmission.

Definition:*A link between two nodes i and j with transmission range R is established at time instant tin when the distance between both nodes is such that d(i,j) < R.*

A statistical-based approach is adopted to discriminate among several links which are more stable, in that they are the most likely of all to stay available for some periods of time, without exactly predicting the residual link lifetime of each link. A practical method based on the observations of the link in the previous time instants is used to make decisions on stability. Since the stability of a link is given by its probability of persisting for a time span, the *link residual lifetime* of the link is considered. The link residual life time determines the remaining lifetime of a wireless link on arrival of a new packet.

The expected residual lifetime $R_{i,j}(a_{i,j})$ of a link (i,j) of age a_{ij} is determined from the collected statistical data as follows:

$$\mathbf{R_{i,j}(a_{i,j})} = \frac{\sum_{a=a_{ij}}^{Amax} a{,}d[a]}{\sum_{a=a_{ij}}^{Amax} d[a]} - ai,j \;\forall (i,j) \in A$$

where$a_{max}$is the maximum observed age of the links and d is an array of length $a_{max}+1$ used to store the observed data.

In particular, d is determined through a sampling of the link ages every fixed time interval and its generic component d[a] represents the number of links with age equal to a.

The coefficient $R_{i,j}(a_{i,j})$ can be defined as the ratio between the sum, on all links with age equal or greater than $a_{i,j}$, of the products of the age a and the number of links with age equal to a, over the total number of links with age greater or equal to a_{ij}. The main disadvantage of using the coefficient $R_{i,j}(a_{i,j})$ for path selection is related to the fact that it does not allow discrimination among links of the same age. In order to overcome this drawback, the average traveled distance d_{ij}^{avg} should be taken into account. If two links have the same residual lifetime, a shorter average distance is preferable to a longer distance in terms of link stability.

The stability of the link (i,j) ∀(i,j) ϵ A, at time *t*, has been represented by the coefficient $s_{i,j}(t)$, defined as follows:

$$\mathbf{S_{i,j}} = \frac{d_{i,j}^{avg}}{R_{i,j}(a_{i,j}).k} \qquad \forall\,(i,j) \in A$$

where*k* is a scaling factor, defined in such a way that the link stability can be compared to the energy consumption.

B. CALCULATION OF AVAILABLE BANDWIDTH

The available bandwidth of a node can be calculated by using the formula,

$$\mathbf{B_a = B_t} - \sum_{i=1}^{n} B_i$$

If B_a value is less than the minimum bandwidth needed to transmit the data packet then the node cannot be selected to transmit it.

If B_a value is greater than the minimum bandwidth required totransmit the data packet then it can be selected.

C. CALCULATION OF RESIDUAL ENERGY

The energy coefficient $e_{i,j}(t)$ can be calculated by taking into the factors such as propensity $PR_j(t)$ of the node, the transmission power $P_{i,j}(t)$, the drain rate DR_j of the node and the initial energy E_j^0 of the node [3].

It can be represented as,

$$\mathbf{e_{i,j}(t)} = \frac{P_{i,j}(t)}{PR_j(t)} \cdot \frac{DR_j(t)}{E_j^0} \cdot T_{i,j}$$

Therefore the energy coefficient $e_{i,j}(t)$ can be defined as the ratio between the power utilized to send data from node i to node j and the propensity of the node j.

It is to be noted that if the value of$PR_j(t)$ is high, then there is a higher propensity of node *j* to receive information, whereas if the value of $P_{i,j}(t)$ is high, then it is the lower the advantage of selecting node *j*. Moreover, if the energy drain rate DR_i associated with node *i* is high, then the consumption in the time of energy is high and so the link cost $e_{i,j}$will also be high.

D. MULTIOBJECTIVE PROBLEM FORMULATION:

The selection of the path connecting node s to d according to the energy and bandwidth consumption and link stability can be mathematically stated as,

$$\min f_1 = \sum_{(i,j)\in A} e_{i,j}(t) \cdot x_{i,j},$$
$$\min f_2 = \sum_{(i,j)\in A} s_{i,j}(t) \cdot x_{i,j},$$

$$\min f3 = \sum_{(i,j)\in A} b_a(t) \cdot x_{i,j}.$$

The following condition represents the flow conservation constraints that are used to ensure that each feasible solution of the proposed model is a path from S to D.

$$\sum_{(i,j)\in A} x_{i,j} - \sum_{(i,j)\in A} x_{j,i} = \begin{cases} 1 & if\ i = S, \\ 0 & if\ i \in N\{S,D\}, \\ -1 & if\ i = D, \end{cases}$$

$$x_{i,j} \in \{o, i\}\ \forall\ (i,j) \in A$$

Where,

$$e_{i,j}(t) = \frac{P_{i,j}(t)}{PR_j(t)} \cdot \frac{DR_j(t)}{E_j^0} \cdot T_{i,j} \forall\ (i,j) \in A,$$

$$d_{i,j}^{avg} = \frac{\sum_{k=1}^{|O_{i,j}|} |O_{i,j}|}{d_{i,j}^{(k)}} \forall\ (i,j) \in A,$$

$$s_{i,j} = \frac{d_{i,j}^{avg}}{R_{i,j}(a_{i,j}).k},\ a_{i,j} \in \{0, \ldots, A_{max}\} \quad \forall\ (i,j) \in A$$

$$b_a = b_t - \sum_{i=1}^{n} b_i$$

The above model can be transformed into a single objective one using the arbitrary importance factors for each criterion (i.e. p1, p2 and p3) and combining the objectives into a single function to be minimized.

The resulting single-objective problem, in which a positively weighted convex sum of the objectives has to be minimized, can be represented as follows:

$$f_{tot} = p_1 f_1 + p_2 f_2 + p_3 f_3$$

$$= p_1 \sum_{(i,j)\in A} e_{i,j}(t) \cdot x_{i,j} + p_2 \sum_{(i,j)\in A} s_{i,j}(t) \cdot x_{i,j} + p_3 \sum_{(i,j)\in A} b_a(t) \cdot x_{i,j}$$

The single objective optimization model assumes the form as follows:

$$\min f_{tot} = \sum_{(i,j)\in A} (p_1 . \ e_{i,j}(t) + p_2 . s_{i,j}(t) + p_3 . b_a(t)) \cdot x_{i,j}$$

Parameters p_1, p_2 and p_3 are chosen such that the condition $p_1+p_2+p_3=1$ is satisfied. It is easy to prove that the optimal solution of the model introduced above is Pareto optimal [13]. The user should choose appropriate values for the parameters p1 and p2. Indeed, by minimizing the convex sum of the objectives for various settings of the convex weights, it is possible to determine various points in the Pareto set.

E. FORWARDING STRATERGY:

The data forwarding strategy of LAER [3] is used here. This strategy is based on a greedy technique such as GPSR. However, differently by GPSR, the next hop selection tries to minimize the joint energy stability metric. BELS packet forwarding presents high scalability property because only the neighborhood and destination knowledge are necessary for the greedy technique. The flexibility of energy-stability-based greedy forwarding is offered through the capability to weight the stability, bandwidth and the energy consumption on the basis of the interest of the application layer. This means that if an application is more sensitive to the path stability and, consequently, the link stability, it is possible to give more importance to the s(i,j) index. On the other hand, an application that needs to prolong the network lifetime and to reduce the energy consumption also selecting longer route with higher data packet end-to-end delay, the e(i,j)terms is more considered.

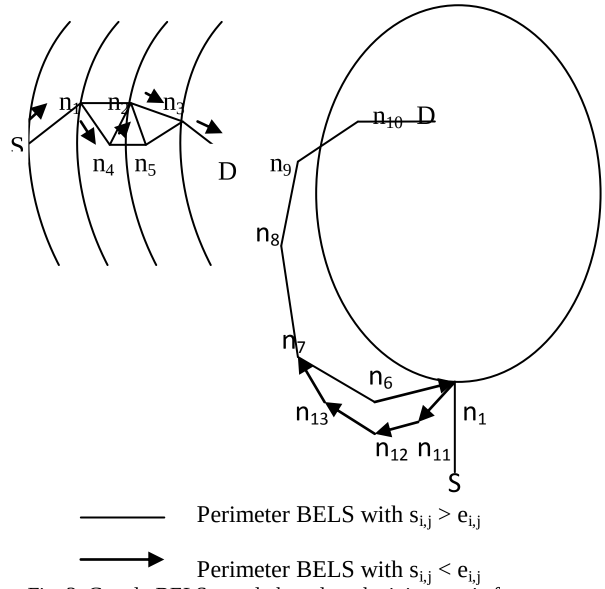

Fig. 3. Greedy BELS greedy based on the joint metric ftot.
Fig. 4.Perimeter forwarding in BELS protocol.

In Fig. 3, it is shown the packet forwarding under the greedy technique based on the euclidean distance and the forwarding scheme with the joint stability and energy aware metric. In particular, in the figure the following situation is depicted: S falls in the transmission range of node n1 (and vice versa), n1 in the transmission range of nodes n2 and n4, n2 in that of n3 and n5, and n3 in that of node D. It is possible to observe as the selected path can be different depending on the metric considered and on the weights used when the joint metric is applied. The BELS forwarding scheme selects S _ n1 _ n4 _ n2 _ n3 _ D path. This means that BELS selects a longer path but with higher residual energy. In order to avoid either routing loop or long packet detour and to offer always a progress direction, a combined euclidean distance-based forwarding and a joint stability-energy metric for the next hop selection are adopted. In particular, it is selected as next hop the neighbor node j of current node i with the highest f_{tot}, and a distance from destination equal or lower than the current node i.

This approach guarantees a progress direction in the application of greedy technique and also permits to select the best candidate for the joint metric rather than the node with only the highest euclidean progress direction.

PSEUDOCODE:

The following is the pseudo code of modified BELS Greedy-Forward from node i at the arrival of packet p.

Modified BELS greedy forward(packet,i)

$j_{best} = n_{current}$;
S_{min}= max(s_{ij}); for all j € N_i
d_{best} = Dist(j_{best},p,d);
For each j€N_i
  Calculate f_{tot}(i,j);
  distance = Dist(j,p.d);
  if distance <d_{best} then
  { for each j' € N_i
    ifs_{ij}<s_{min} then
    { s_{min} = s_{ij};
     }
    if$b_{allocate}$<b_{ij} then
        { b_{ij} = b_{ij} – $b_{allocate}$;
    j_{best} = j';}
  }
  ifj_{best} = $n_{current}$ then return modified BELS Greedy Failure;
      else {
    forward p to j_{best};
    returnmodified BELS Greedy success;
}

IV. Experimental results

This section deals with the experimental performance evaluation of our algorithm through simulations. In order to test our technique, the NS2 simulator [version 2.29] is used.

F. Simulation Setup

In the simulation, the number of nodes is kept as 50. The nodes are arranged in a 500 meter x 500 meter square region for 60 seconds of simulation time. All nodes in the network have the same transmission range of 200 meters. The simulated traffic is TCP and Constant Bit Rate (CBR). It operates on network layer.

G. Performance Metrics

In our experiments, we measure the following metrics such as the Residual Energy, Link Stability and Bandwidth.
The simulation results are described in the next section.

H. Results

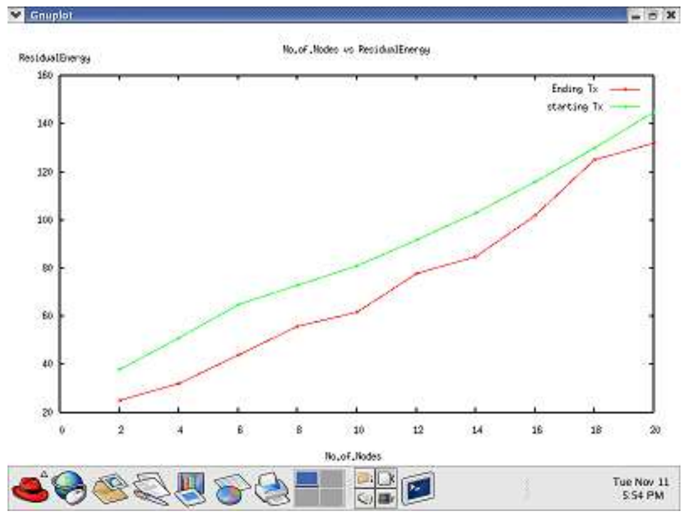

Fig 5: No. on .nodes Vs Residual Energy

Fig 5 shows the residual energy of the nodes at the starting of the data transmission and the ending of the transmission. The figure indicates that there is considerable residual energy of the nodes even at the end of the data transmission. Hence there is no chance of the link to break because of lack of energy of the nodes.

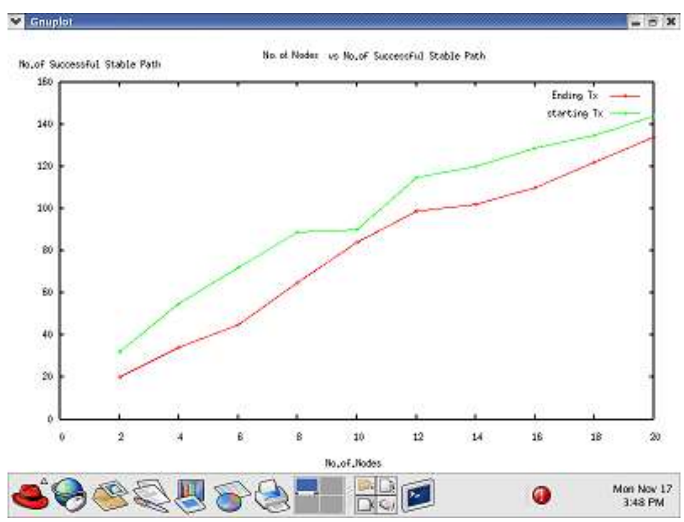

Fig 6: No. of. nodesVs Successful Stable paths

Fig 6 shows the number of paths selected for data transmission before starting the transmission and the number of successful path that lasted till the end of the transmission. The figure indicates that there are stable routes till the end of the transmission. Hence the link breakages due to the lack of link stability would be less.

V. Conclusion

In this paper the AODV routing protocol has been modified based on the joint metric of energy, link stability and bandwidth. It makes use of greedy technique based on a joint metric. It has a high capability to balance traffic load due to the minimum drain rate metric included in the joint metric. The link stability and residual energy are considered to avoid alternate route discovery. This scheme also avoid the overloading in the network since the bandwidth needed for the transmission is already reserved. The selected route provides less delay for data transmission and increases throughput.

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