

# Reliable Packet Transmission over Multi-Hop Wireless Network

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**Abstract:** In this paper we proposed A Fault node recovery algorithm to enhance the lifetime of a multi-hop wireless network when some of the sensor nodes shut down. The algorithm is based on the grade diffusion algorithm combined with the genetic algorithm. The algorithm can result in fewer replacements of sensor nodes and more reused routing paths. In networks, each sensor node has limited wireless computational power to process and transfer the live data to the base station or data collection center. Therefore, to increase the sensor area and the transmission area of the multi-hop wireless network usually contains many sensor nodes. Generally, each sensor node has a low level of battery power that cannot be replenished. Because of low battery power nodes are failure, the failed nodes will not relay data to the other nodes during transmission processing. Therefore using alternative path for reliable transmission of data to other node using trust value. A trust model is presented that allows the evaluation of the reliability of the routes.

**Keyword:** Genetic algorithm, grade diffusion (GD) algorithm, Fault node recovery algorithm, Trust value, Multi-Hop wireless networks (WN).

## I. INTRODUCTION

In wireless networks, every sensor node has limited wireless computational power for processing and transferring the data to the base station or data collection center. So that, to increase the sensor area or processing area and the transmission area in which data transfer from one node other node, the wireless network have to many sensor nodes. Generally, each sensor node has a low level of battery power so that it cannot be recovered. The failed nodes which have not anymore power to transfer data. The sensor node which failed to transfer data will not relay data to the other nodes during transmission processing. Thus, the other sensor nodes will be load with increased transmission processing. This paper proposes a fault node recovery (FNR) algorithm with trust value to increase the lifetime of a multi-hop wireless network (WN) and reliable transmission of data. At time when some of the sensor nodes shut down in transmission area & they do not have longer battery power (energy) or they have reached their operational threshold. Using the FNR algorithm we have result in some replacements of sensor nodes and more reused routing paths. This algorithm not only increases the wireless network (WN) lifetime but also reduces the cost of replacing the sensor nodes.

## II. RELATED WORK

### 2.1 Literature Servay

In [1], Author proposes a fault node recovery (FNR) algorithm to enhance the lifetime of a multi-hop wireless network (WN) when some of the sensor nodes shut down, either because they no longer have battery energy or they have reached their operational threshold. Using the FNR algorithm can result in fewer replacements of sensor nodes and more reused routing paths.

In [2], Author proposes process of finding the set of nodes whose battery power is less than threshold is called Fault

Node Determination. The nodes will be replaced with new nodes of same nodeid this process is called Fault Node Recovery. The FNR algorithm replaces the deactivated sensor nodes and uses more reused routing paths.

In [3], Author proposes a fault node recovery algorithm to enhance the lifetime of a wireless sensor network when some of the sensor nodes shut down. The algorithm is based on the grade diffusion algorithm combined with the genetic algorithm. The algorithm can result in fewer replacements of sensor nodes and more reused routing paths.

In [4], Author proposes the opportunistic routing paradigm is a new avenue for designing routing protocols in multi-hop wireless networks. In opportunistic routing protocols, all neighboring nodes that are closer to the destination may overhear a data packet, and may be a candidate to forwarding the packet for its destination. In [5], Author proposes a fault node recovery algorithm with trust value to increase lifetime of wireless network and reliable transmission. When in wireless network some of the sensor node shut down because of low battery power, using replacement of nodes it can find alternative routing path, and using trust value for reliable transmission of data.

In [6], Author proposes an algorithm based on ladder diffusion and ACO is proposed to solve the power consumption and transmission routing problems in wireless networks. The proposed ladder diffusion algorithm is employed to route paths for data relay and transmission in wireless sensor networks, reducing both power consumption and processing time to build the routing table and simultaneously avoiding the generation of circle routes. In [7], the proposed algorithm considers

recovery of each node based on the distance of each node from cluster heads, remained energy of cluster heads and member number of each cluster head and selects the best cluster head for recovery.

In [8], a trust model is presented that allows the evaluation of the reliability of the routes, using only first-hand information.

### III. PROPOSED WORK

#### 3.1 System Design:

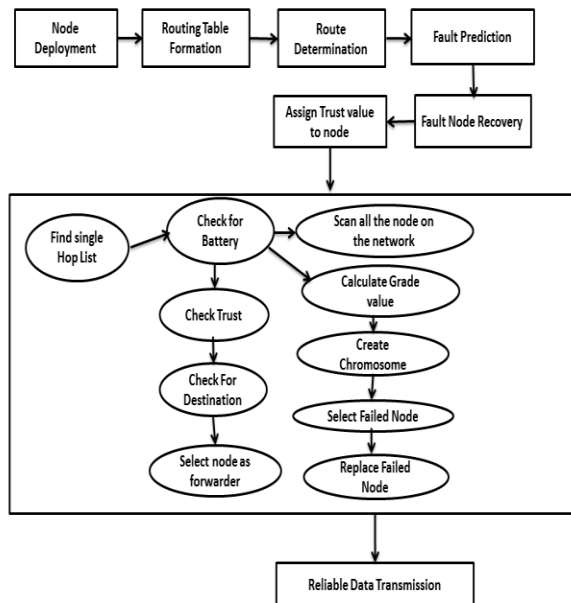


Fig.1. System Design Architecture

#### 1. Node Deployment Algorithm-

This algorithm is responsible for deployment of nodes in a particular area. This will position the nodes in the given area

#### 2. Routing Table Formation-

This is the algorithm which is used to form routing tables for each of the nodes. The routing table will contain information about other nodes in the network in terms of node id and distance of each node w.r.t other nodes in the network.

#### 3. Route Determination-

This is the process which involves determining the route from the source node to destination node with the aid of using the control packets and the route must be found in such a way that battery consumption is reduced and overall network lifetime is also increased.

#### 4. Fault node Prediction-

This is the process in which the node's whose battery power is below than certain threshold is determined

#### 5. Fault Node Recovery-

This is the process by which the nodes whose battery power is below threshold are determined and replaced with the new nodes but with same node id.

#### 3.2. Grade Diffusion Algorithm

The Grade Diffusion (GD) algorithm to improve the ladder diffusion algorithm using ant colony optimization (LD-ACO) for wireless sensor networks. The GD algorithm creates the routing path for each sensor node. It also identifies a set of neighbor nodes to reduce the transmission of data.

● Sensor Node  
● Sink Node

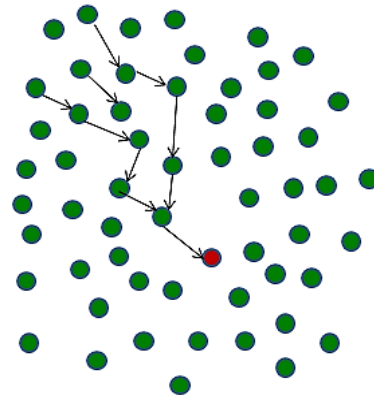


Fig. 2. Wireless sensor node routing

This algorithm provides a grade table for each sensor node. When its grade table detects a node unable to perform the relay. Each sensor node can select a sensor node from the set of neighbor nodes. The GD algorithm can also record some information regarding the data transmission. Then, a sensor node can select nodes which have lighter loading or more available energy or power than the other nodes to perform the extra transmission operation. That means, the GD algorithm can update the routing path in real time, and the data is sent to the sink node quickly and correctly. Whether the DD or the GD algorithm is applied, the grade-creating packages or interested query packets must first be broadcast to all sensor nodes. Then, the sensor nodes transfer the event data to the sink node, according to the algorithm, when suitable events occur. The sensor routing paths are shown in Fig. 3

● Sensor Node  
● Sink Node  
● Fault Node

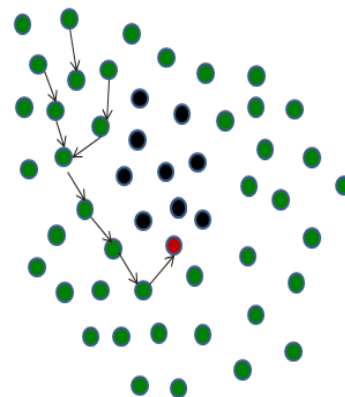


Fig.3. Wireless sensor node routing path when some nodes are not functioning.

The WSN may fail due to a variety of causes, including the following: the routing path might be broken; the WSN sensing area might be leaked; the batteries of some sensor nodes might be depleted, requiring more relay nodes; or the nodes damaged after the WSN has been in use a long period of time. In Fig. 2, the situation in which the outside nodes transfer event data to the sink node via the inside nodes (the sensor nodes near the sink node) in a WSN to provide the accommodation measures for non-working nodes. The inside nodes thus have the largest data transmission loading, consuming energy at a faster rate. If all the inside nodes reduce their energy or otherwise stop to function, the event data can no longer be sent to the sink node, and the WSN will no longer function. The power of the sensor nodes in WSNs is unavoidable. This paper, however, proposes an algorithm to search for and replace fewer sensor nodes and to reuse the most routing paths. Also using trustworthiness to transmit reliable data to sink node.

### 3.3 Route Discovery Process

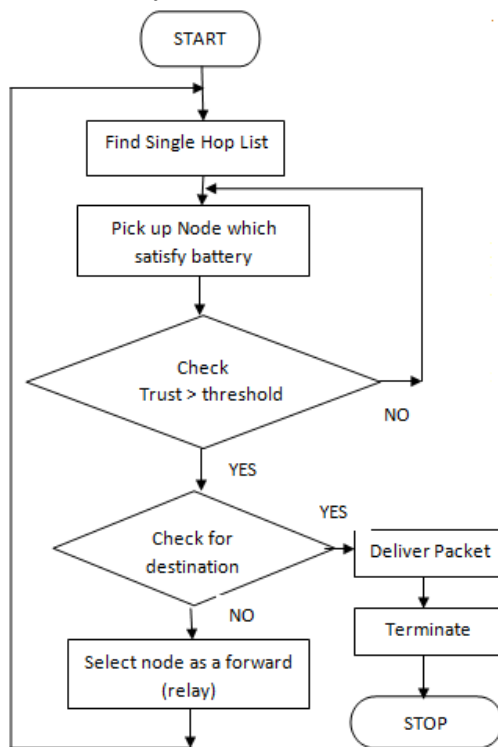


Fig. 4 shows the route discovery process using grade diffusion algorithm.

In the current approach, a route discovery approach is proposed which reduces amount of power consumption. The process of finding the set of nodes whose battery power is less than threshold is called Fault Node Determination. The nodes will be replaced with new nodes of same id this process is called Fault Node Recovery.

Fault Node Detection and Recovery Algorithm to send packets from source node to destination node. The algorithm has following steps:

- 1) The sensor node maintains a single hop list, which contains the ids of all nodes within its transmission range.
- 2) When a source node wants to send control packet to the sink, it includes a packet threshold with initial value N in each control packet.
- 3) The REQ packet is flooded to the single hop list.
- 4) Each neighbor will then send the REQ packet by picking the nodes which has highest battery power. This process is repeated until the link is established till the destination.
- 5) If packet threshold is zero then a process is followed by picking a node which helps us to reach the destination faster.

### 3.4. Genetic Algorithm

The Genetic algorithm is one of the best energy efficient algorithms in wireless sensor networks. It optimizes the signal strength of sensor nodes. This algorithm also helps in reducing the energy consumption and thus increases the lifetime of wireless sensor networks. This algorithm consists of five steps i.e., i) Initialization ii) Evaluation iii) Selection iv) Crossover v) Mutation.

#### i) Initialization

It is first step of the Genetic algorithm. In initialization step the genetic algorithm generate chromosomes. The total number of chromosomes will be the number of non-functioning nodes. The genes values will be 0 or 1.

#### ii. Evaluation

The second step in Genetic algorithm is Evaluation. Here in this stage fitness function is evaluated by providing fitness values. The fitness function is defined over the genetic representation and measures the quality of the represented solution. The fitness function is always problem dependent. The input parameters will be chromosomes itself.

$$f_n = \sum_{i=1}^{\max(\text{Grade})} \frac{P_i \times TP^{-1}}{N_i \times TN^{-1}} \times i^{-1}$$

Where,

$N_i$  = the number of replaced sensor nodes and their grade value at  $i$ .

$P_i$  = the number of re-usable routing paths from sensor nodes with their grade value at  $i$ .

$TN$  = total number of sensor nodes in the original WSN.

$TP$  = total number of routing paths in the original WSN.

#### iii. Selection

The third step in Genetic algorithm is Selection. The main aim of this step is to select the chromosomes. Chromosomes having the highest fitness value. First it selects the pair of chromosomes from the node. The selected chromosomes which is having highest fitness value will be send to the mating pool to produce new set of chromosomes which will happen in the crossover step.

#### iv. Crossover

The Crossover step in Genetic algorithm is used to create individual chromosomes. The two individual chromosomes will be selected from the mating pool to generate a new set of offspring. A one-point crossover is selected between the two parents and then the fraction of each of the individual according to the crossover will be swapped.

#### v. Mutation

The mutation step can introduce traits not found in the original individuals and prevents the GA from converging too fast. The sensor nodes will be replaced in the chromosomes with gene of 1 in order to get better network lifetime.

#### 3.5 Node failure detection:

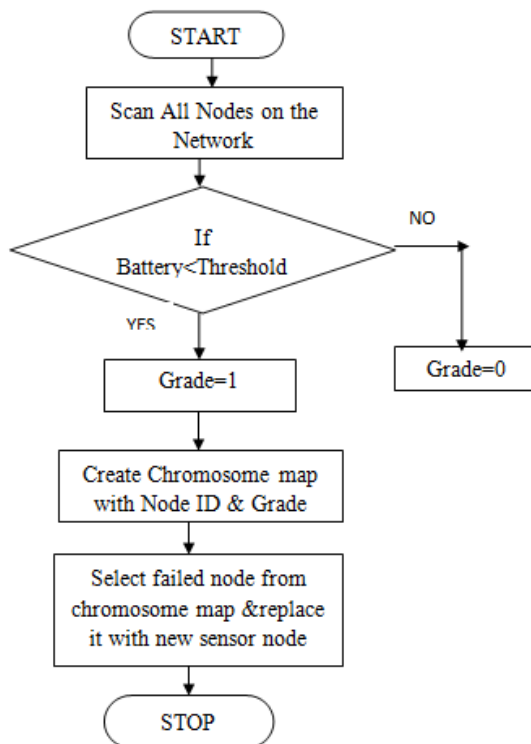


Fig 5: shows Node failure detection using Genetic Algorithm

The above flowchart shows the Node Failure detection process:

- 1) The Nodes are scanned from the first node onwards and link is established to collect data from each single hop list.
- 2) The mutation is computed by comparing the battery power with the threshold.
- 3) Each node is assigned a grade value of 0 or 1. A 1 is assigned if the battery power of node is less than threshold otherwise it will be assigned a value of 0.
- 4) A chromosome Map is created which will contain key as Node ID and value as the grade value.
- 5) Set of nodes is determined from the map which have a value as 1.

6) The process is repeated until all nodes have been scanned.

#### 3.6 FAULT NODE RECOVERY ALGORITHM

This paper proposes a fault node recovery (FNR) algorithm for wireless sensor network based on the grade diffusion algorithm combined with the genetic algorithm.

The FNR algorithm creates the grade value, routing table, neighbor nodes, and payload value for each sensor node using the grade diffusion algorithm. In the FNR algorithm, the number of non-functioning sensor nodes is calculated during the wireless sensor network operation, and the parameter  $B_{th}$  is calculated according to equation. The sensor nodes transfer the event data to the sink node according to the GD algorithm when events appear. Then,  $B_{th}$  is calculated according to equation in the FNR algorithm. If  $B_{th}$  is larger than zero, the algorithm will be invoked and replace nonfunctioning sensor nodes by functional nodes selected by the genetic algorithm. Then the wireless sensor network can continue to work as long as the operators are willing to replace sensors.

$$B_{th} = \sum_{i=1}^{\max(\text{grade})} T_i$$

$$T_i = \begin{cases} 1, & \frac{N_i^{now}}{N_i^{original}} < \beta \\ 0, & \text{otherwise} \end{cases}$$

Where,

$N_i^{original}$  = is the number of sensor nodes with the Grade value  $i$

$N_i^{now}$  = is number of sensor nodes still functioning at the current time with grade value  $i$

$\beta$  = value between 0 and 1.

#### 3.7 TRUST OPPORTUNISTIC ROUTING PROTOCOL:

A trust model is presented that allows the evaluation of the reliability of the routes, using only first-hand information. Trust value of each node should be assigned and computed in advance. If a node joins the network or the network is firstly working, its trust value is set as a initial value 0.5. When network topology changes, the trust value of each node can be updated by formula (1) and (2), and moreover.

If trust value of a node is less than  $T_{threshold}$ , this node will be elicited as a selfish or malicious node, so it will be omitted in next routing phrase from security of network point of view.

##### 3.7.1 Generate WSN Topology:-

Let  $G = (V, E)$  denote the topology of the network. Assume that node  $j$  is neighbor node  $i$ . It is denoted by  $T_j(i, n)$  trust on node  $j$  assigned by node  $i$ .  $T_j(i, n)$  is  $n^{th}$  topology computed by,

$$T_j(i, n) = \frac{F_{ij}(n)}{N_{ij}(n)} \dots\dots\dots (1)$$

Where,

$N_{ij}(n)$  = the number of packets that have been received by  $i$  at time  $n$ .

$F_{ij}(n)$  = the number of packets that have been received by  $i$  at time  $n$ .

**3.7.2 Implementation GDA with Trust value:-**

Calculate trust value of node by using a moving average model. Using  $(n + 1)^{th}$  topology

$$T_j(i, n + 1) = \alpha \cdot T_j(i, n) + (1 - \alpha) \cdot T_j(i, n + 1) \dots (2)$$

Where,

$T_j(i, n + 1)$  = is node  $j$ 's trust value measured by node  $i$  during the  $(n + 1)^{th}$  topology updating cycle.

$\alpha = 0 < \alpha < 1$  is a weighting factor used to tradeoff between current measurement and previous estimation.

**IV. SIMULATION AND RESULT**

The simulation of fault node recovery algorithm described in the above section has been performed to verify the methods and results.

The grid based topology is used to place the nodes. It will work for any topology. All the nodes will be given with same battery energy at the initial state. The graph for this is also shown. After some iterations there will be a loss of energy when packets has been sent from source node to sink node.

The fault node recovery algorithm is more useful as and when more number of iterations is considered. After some iteration there will be energy loss, and then FNR algorithm will check for the threshold count and trust value.

Using alternative routing path transfer the packet reliably from source node to destination. To compare the performance of the proposed protocol the following metrics were considered:

- 1) **Throughput** refers to how much data can be transferred from one location to another in given amount of time.
- 2) **Packet delivery ratio(pdr)** is the ratio between the number of successfully received packets and the number of generated packets.
- 3) **Packet loss ratio(plr)** is the ratio between the numbers of packets loss.
- 4) **Average end-to-end delay** per packet is the end-to-end delay (in seconds) for successfully received packets.
- 5) **Normalized routing overhead** is the number of routing packets per one data packet that is successfully receive at the destination.

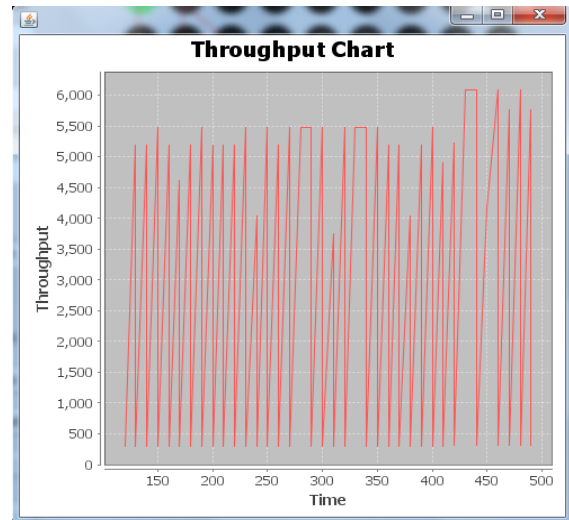


Fig.6 Time vs throughput

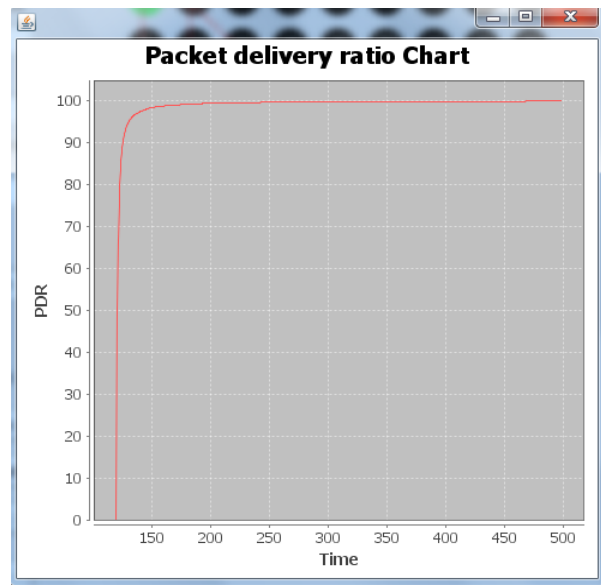


Fig.7 Time vs Packet delivery ratio

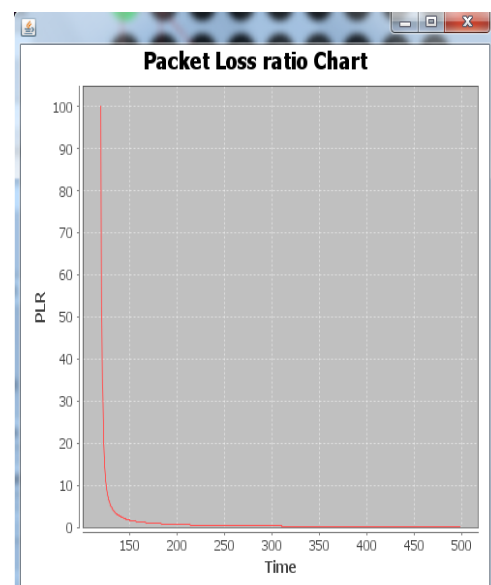


Fig.8 Time vs Packet loss ratio

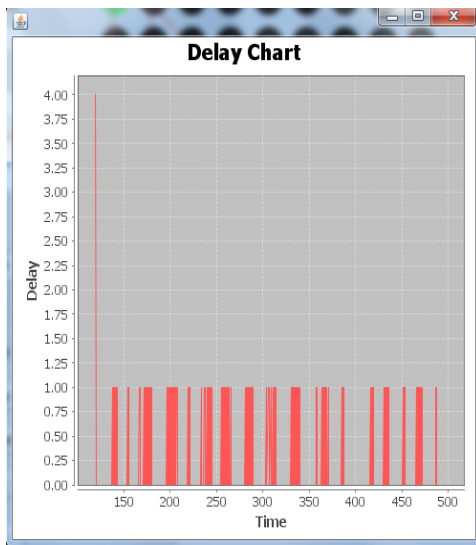


Fig.9 Time vs Delay

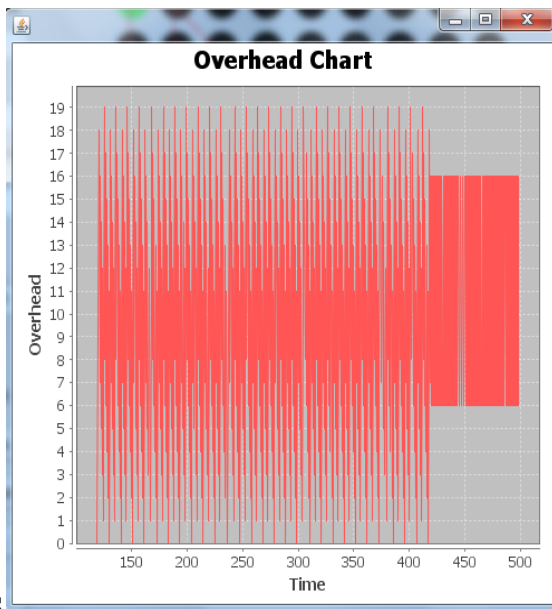


Fig.9 Time vs Overhead

## V. CONCLUSION

In multi-hop wireless networks, the sensor nodes use battery power supplies and thus have limited energy resources. In addition to the routing, it is important to research the optimization of sensor node replacement, reducing the replacement cost, and reusing the most routing paths when some sensor nodes are non-functional. The various simulations demonstrate that the round trip time, Number of Hops. The FNR algorithm using Trust value requires replacing fewer sensor nodes and reuses the most routing paths, increasing the WSN lifetime and reducing the replacement cost and transmission of data is reliable. A trust model is presented that allows the evaluation of the reliability of the routes.

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