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Modified Leach in Wireless Sensor Network

Nabeela Ansari[1], Raj Kumar Paul[2]
[1](Department of CSE, Vedica Institute of Technology, Bhopal, MP, India)
[2](Department of CSE, Vedica Institute of Technology, Bhopal, MP, India)

Abstract: *Wireless sensor network consists of large number of sensor nodes which is used to capture environmental conditions, process and transfer it to base station. These sensor nodes are sensitive to energy consumption and gets exhausted on working. So we need to emphasize on reducing energy dissipation of sensor nodes in order to improve network lifetime. Various routing protocols are developed to enhance network scalability and stability. The cluster based routing is an efficient way of reducing energy dissipation by limiting data transmission from nodes to base station. For this purpose we proposed a new routing method which improves the life span of network, its data transmitting capability with low energy consumption. It is an improvised version of LEACH protocol which conserves energy by load balancing .Multi hop routing is proposed for the transmission of data. Reduction of energy consumption is achieved with the help of TDMA scheduling. Time division multiple access (TDMA)-based MAC can potentially reduce the delay and provide real-time guarantees as well as save power by eliminating collisions. To keep network alive we had added a random node on replacement of dyeing node. The performance evaluation of protocol is based on simulation test performed in network simulator 2 (NS2) to prove the effectiveness of this proposed method in terms of network lifetime and energy efficiency.*

Keywords: *Base station (BS), Clustering, Energy efficiency, Routing protocol, Wireless sensor network (WS*

I. Introduction

WSN is composed of nodes capable of sensing ambient conditions in its surrounding, transmitters to transfer data from nodes to sink and a base station to receive sensed data from nodes placed in distant locations. There are thousands of battery operated sensor nodes deployed in distant location which are unattended, mostly self-configuring and self-organizing[2].These sensor nodes communicate in peer-peer network, transferring data from one node to other in order to reduce energy consumption. As these nodes have limited life span, low processing capability and limited bandwidth which requires more energy to sense and transmit a data from a faraway region to base station. The real need of a WSN is to provide an optimal path between sensor node and a base station with low energy consumption. An energy efficient routing protocol is required in transmission of data to improve network reliability and stability. The purpose of routing protocol is to maximize sensor nodes capacity, to increase network lifetime by providing an optimal path [3].

Clustering is the technique used in routing protocols to minimize the energy dissipation by balancing the energy consumption of sensor nodes present in network. It provides an energy efficient routing protocol which enhances the life span of network [3]. This technique divides the entire network into various disjoint sets known as cluster, every cluster is managed by a cluster head which is the highest energy sensor node present in the network. All the sensor nodes in a cluster transmits data to their cluster head which compresses and delivers it to base station .In this paper we are introducing a technique which uses a TDMA scheduling for transmission of data to reduce delays and provide real time data with no collisions which reduces the energy consumption of network. WSN has an immense potential in future research and development. Usage of Wireless sensor network will revolutionize our economy and life in the field of medicine, forecasting environmental conditions, military monitoring, security, smart city, factory monitoring etc.[1]

II. Related Work

Over the years development in wireless sensor network technology has enabled reliable monitoring and analysis of unknown and untested environments, still it has some untouched fields which has an immense scope of research and development. One of them is the energy conservation which plays an important role in sensing technology. To improve network capabilities various routing protocols are developed depending upon the type of network structure designed for the application or the network operations carried out using these protocols for a specific application model [15]

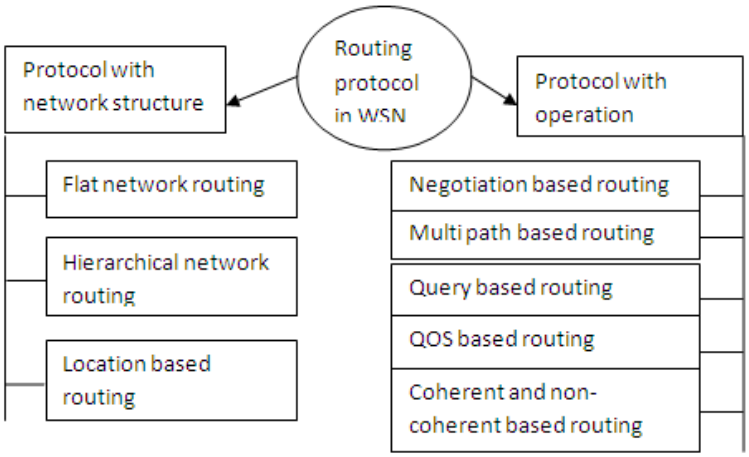

Figure: 1 Types of routing protocol in wireless sensor network

1. Flat Routing Protocol –

This protocol distributes information to any node that can be reached or receive information from any node. All nodes in network are treated in same way and procure same function such as collecting data and communicating with the sink. No efforts are made for grouping of network. Example: SPIN, Directed diffusion.

1.1 Sensor Protocols for Information via Negotiation (SPIN) –

Flooding and gossiping are the techniques used to transmit data in previous years, but these protocols were not energy efficient. SPIN protocol was used to remove deficiencies due to these old technique. In flooding technique whenever a node receives a data it transmits it to all the nodes available on network and due to this whole network is flooded with the same data thus transmitting redundant data to BS. This is wastage of energy residue, storage capacity as well as time. Then in gossiping technique data is transmitted to randomly select nearby node which again selects a random node to forward data. This is how a path is selected to transmit data to destination which is not energy efficient and time efficient .It randomly selects path to its destination and not on the basis of optimality. So SPIN routing protocol was developed to overcome the drawback by using data negotiation and resource adaptive algorithm for distribution of data [10]. The technique used in SPIN names a data with high level descriptors or meta data. There are three messages in SPIN protocol to communicate among sensor nodes. ADV- This is used to advertise a particular message among nodes. REQ- this is used to request a data from a particular node. DATA- This is used to transmit the data. For transmission these meta data are advertised among the sensor nodes on receiving new data. Nodes who do not have data, receives it by sending a request message. The advantage of SPIN network is that topological changes are localized since each node needs to know only its single-hop neighbors. SPIN protocol removes many problem from flooding like passing of redundant data, resource blindness, overlapping [4, 5].

One of the drawback of SPIN is that if nodes in between the source and destination are not interested in receiving data, data will not be transferred to destination. If middle link disconnects, transmission of data will not be possible this will lead to packet dropout and delay in communication. Due to this real time data will be delayed.

2. Hierarchical Routing Protocol-

Hierarchical protocol organizes its network in a hierarchy, higher energy nodes are used to aggregate and send the information whereas low energy nodes are used to sense the data which is transmitted through an optimal path. Clustering is the technique in which sensors are gathered into a disjoint set known as cluster and one of the sensor node acts as the head of a cluster, which communicates compressed information to the base station. Nodes that are not cluster head only communicate with the cluster head in a TDMA fashion, according to the schedule created by the cluster head. [6][7].This technique plays an important role in scalability and stability of network .Example- LEACH, TEEN, APTEEN.

2.1 LEACH- Low energy adaptive clustering hierarchy -

It is one of the energy efficient hierarchical routing protocol. This routing protocol use a clustering method to transmit data in order to obtain advantage on reduction of energy consumption. [1]. In this method whole network is divided into several group known as cluster and each cluster is ruled by a cluster head which is randomly selected on the bases of energy level. All the other low energy node senses the data from surrounding and transmit it to the cluster head, where it aggregates and communicate it to Base Station. This reduces the energy consumption as transmission will only be done by cluster head rather than all sensor nodes. A TDMA

schedule is created for the transmission of data to base station, this reduces collision and saves energy. LEACH routing protocol operations are based on rounds. Each round goes through two phases [8, 9].

1.1.1 Setup Phase –

Cluster and Cluster head are created in this phase. Cluster head is selected randomly among the nodes whose energy exhaustion is less than all the other nodes. In this phase all the nodes select a random number between 0 and 1. Sensor node whose number is lesser than the pre-defined threshold T (n). That node becomes a cluster head and threshold value is obtained by a formula.

$$T(N) = \frac{P}{1 - P\left(r \bmod \frac{1}{P}\right)} \quad \forall n \in G$$

Where T (n) is threshold, P is probability of selection of node as cluster head, r is the present round, G is the node that is not selected as cluster head in 1/p round. [2][3] .In this way every node has an equal opportunity to serve as a cluster head.

2.1.2 Steady State Phase -

Selected cluster head will advertise a message to all the nodes and provide a time slot for a response from sensor nodes. Node capture data from surrounding and transmit it to CH in a given time duration and rest of the time they remain in a sleeping mode. This reduces the energy consumption and network lifetime is improved. The data received by cluster head is processed, compressed and sent to the base station. Leach protocol also uses CDMA so that each cluster uses a different set of CDMA codes, to minimize collision between clusters. This reduces delay and is efficient in sending real time data [1] [13] [14].

3. Location Based Routing Protocol –

In this routing protocol sensor nodes are addressed with the help of their location. Their location is obtained by GPS (Global Positioning System) and receiving radio signals. With the help of location, distance between two nodes is calculated to assume energy consumption required for the transmission of data. Example- GAF, GEAR

3.1 Geographic and Energy Aware Routing Protocol (GEAR) -

GEAR is an energy efficient routing protocol. It addresses sensor nodes with the help of their location . Every node must equip a GPS system or localization system in order to know their neighbours location and their own position. This information is used to calculate distance between two nodes and to assume energy consumption for transmission of data.Sensor nodes are aware of their residual energy and path which helps in routing a packet from energy efficient route to its destination. Then, GEAR uses a recursive geographic forwarding algorithm to disseminate the packet inside the target region. This algorithm is obtained to find an optimal path [11, 12, and 15]

4. Negotiation Routing Protocol

Flooding technique used for transmission of data causes implosion and overlapping of data. Due to the transmission of duplicate data over, overhead traffic load increases on nodes leading to high consumption of energy and wastage of time and resources. So this protocol is used to prevent transmission of redundant to other nodes through negotiation. [6, 7]

5. Multi Path Routing Protocol

These are the routing protocols that uses multi path for sending data rather than a single path. This acts as an alternate path for transmission of data if main path drop or fails. To maintain network connectivity this protocol is used and transmission of real time data is done with no delays .Periodically messages are sent through these path, to keep it alive. In this way network reliability is increased on the cost of energy efficiency. [7]

6. Query Based Routing Protocol

In this protocol a node broadcast a query in the network to obtain a data from other nodes. Node whose data matches with the query will reply back to the initiated node. Thus transmission of data takes place when query is generated.

7. Qos Routing Protocol

Along with the minimization of energy consumption, we need to provide a quality data to BS. Some of its quality of service requirements are to maintain delay, network reliability, bandwidth availability, fault tolerance etc[7,15]. Thus QOS protocol is used to maintain energy dissipation and data quality.

8. Coherent And Non Coherent Based Routing Protocol-

Data processing is an important task in transmission of data in wireless sensor network. There are two types of data processing technique-

Coherent data processing in which minimum processing of data is done on initial node and further processing is done on aggregators. Minimum processing tasks are time stamping, removal of redundancy etc.
Non coherent data processing – In this technique data goes through 3 phases.
1. Target detection, data collection, and preprocessing
2. Membership declaration
3. Central node election.
It has low data traffic loading [15].

One of the main challenge in development of routing protocol is energy constraint. As sensor are deployed in harsh and isolated environment, there is scarcity of energy resources. So the objective of developing new protocol should be as energy efficient as possible to prolong individual lifetime of sensor node and hence network lifetime

We have designed an improvised LEACH protocol by modifying some of its attributes. Its proposed methodology is explained along with a flow chart.

III. Proposed Methodology

Description of proposed routing protocol Myriad routing protocols are developed for energy efficient communication. Every day changes are made in these protocol for a better protocol. We have also improved LEACH routing protocol in order to increase its efficiency.

In our routing protocol we have assumed base station to be static and have unlimited energy residues and communication power. Sensor nodes are placed in isolated area either nearer or far away from base station.

The longer the distance between base station and sensor nodes, higher is the energy dissipation in transmission of data . All nodes present in network are grouped into disjoint sets known as cluster and one with the highest energy in a cluster becomes a cluster head. Thus number of cluster head are equal to number of clusters in network. Cluster head has a special responsibility of aggregating data from all the sensor nodes and communicating it to BS. [15]

In fig 2 most of the sensor nodes are nearer to BS in order to reduce energy consumption in communication whereas far away nodes communicate through multi hop route to maintain energy residue. In multi hop routing data is transmitted from one cluster head to other and obtain an optimal path to base station.

As we know nodes in farthest cluster require more energy for communication which leads to energy exhaustion and network failure. So to compete with this problem a random node is added continuously to replace a dyeing node. This enhances network lifetime.

To improve scalability and stability of network we have introduced CSMA/CA protocol for the transmission of data between sensor nodes and its cluster head, and TDMA scheduling between cluster head and base station. These protocols are used to prevent collision during transmission of data and to deliver real time data to user. Due to this routing protocol become more energy efficient as well as time efficient.

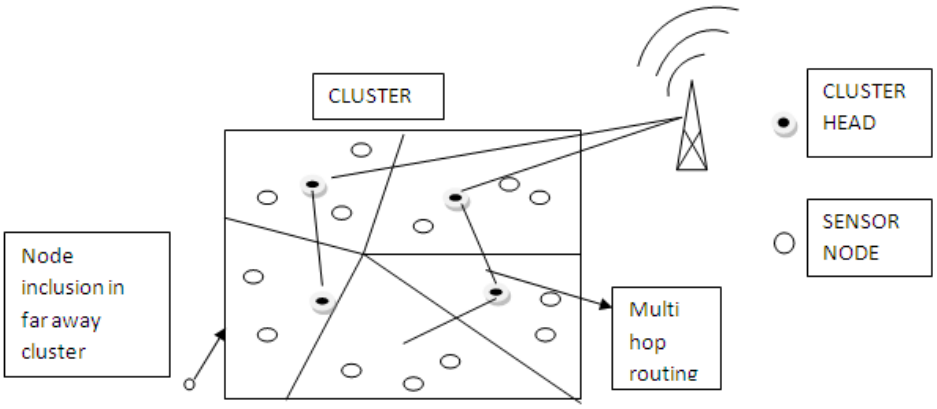

Figure 2. Proposed network model

With the help of this proposed methodology we had tried to make efficient utilization of energy residue of a sensor node and to obtain real time functionality. This ultimately improves network lifespan and provides regular update to base station.

This table 1 is used to initialize network. We had used these values to initialize node and to develop a network. Our network size is 100m*100m and square shaped. Number of nodes deployed in our network are 100 and their initial energy is 0.5j. These values are applied on our proposed methodology and results were obtained through simulation test.

S.No.	Table 1: Activation packet	
	Parameter	Value
1.	Network size	100m*100m
2.	Initial energy	.5j
3.	p	.1j
4.	Data aggregation energy cost	50pj/bit j
5.	Number of nodes	100
6.	Packet size	200 bit
7.	Transmitter electronics	50nj/bit
8.	Receiver electronics	50nj/bit
9.	Transmit amplifier	100pj/bit/m2

Table 1 – Show the Simulation Parameter

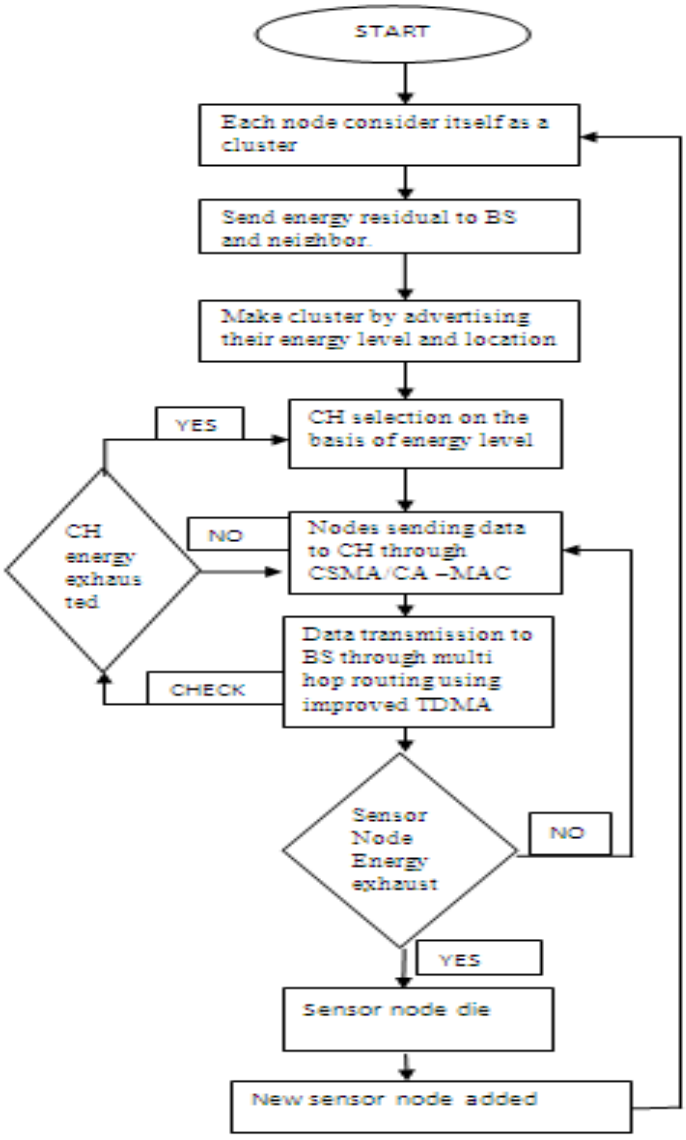

Figure 3. Flow chart for cluster formation and data transmission

Steps of Proposed Method –

1. Initialization of method-

Firstly network is initialized by using activation packet and each node is assumed as a cluster.

2. Startup phase-

In the startup phase first nodes broadcast their energy level and location to their neighboring nodes and sends this information to BS using a MAC protocol. At this time all nodes are claimant of cluster head. Cluster head selection is based on CEL (current energy level) and REL (residual energy level) of the remaining nodes.
Selection of cluster head is based on the formula.

$$T(N) = \frac{P}{1 - P\left(r \bmod \frac{1}{P}\right)} \qquad \forall n \in G$$

Where p- Desired cluster head percentage

R-current round

H-set of nodes which have not been CH in 1/p

3. Cluster formation –

Cluster formation is based on information received on signal strength of nodes through advertisement message. Each non cluster head node transmits a joint request message back to its closest cluster head using CSMA/MAC protocol. Now cluster head node will setup a transmission schedule with the help of TDMA method.

4. Data transmission is done in a specific proposed schedule that is through improved TDMA. Collection of data is done in a reserved time slot and it follows multi hop routing for data transmission.

5. Random node inclusion in cluster-

If energy residue is exhausted in sensor node, cluster dies. To keep it alive new sensor node replaces dead node.

II. Simulation and Result

Initially we had input values in NS 2 simulation software and then results were viewed with the help of Network Animator.

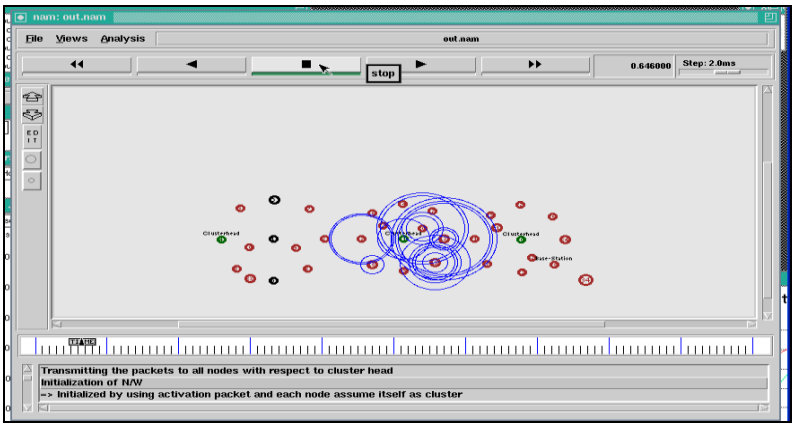

Figure 5: Result displayed on NAM

In this Fig 5 clusters are formed and their cluster heads are selected. Red one's are the sensor nodes and green one's are cluster head, blue circle denotes transmission of data. These graph shows the performance of proposed methodology. They compare our proposed method with the present methodology of Leach protocol.

1. Cost and Data packet

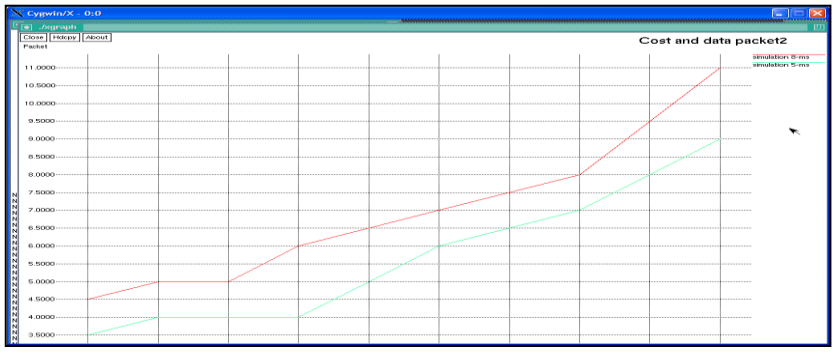

Figure 6: Graph for cost and data packet

In Fig 6 we have shown the Cost of data packet sending in different time slot. Here we generate a XY axis graph between Time and data packet. In the X-axis we will take a SIMULATION TIME and in the Y-axis we will take DATA PACKETS. Red line (modified leach) has higher rate of data transmission as compared to present leach. It sends lower data packets which is shown in green line. We clearly see that our proposed method sends 10000 more data packets from present Leach .

2. Network delay

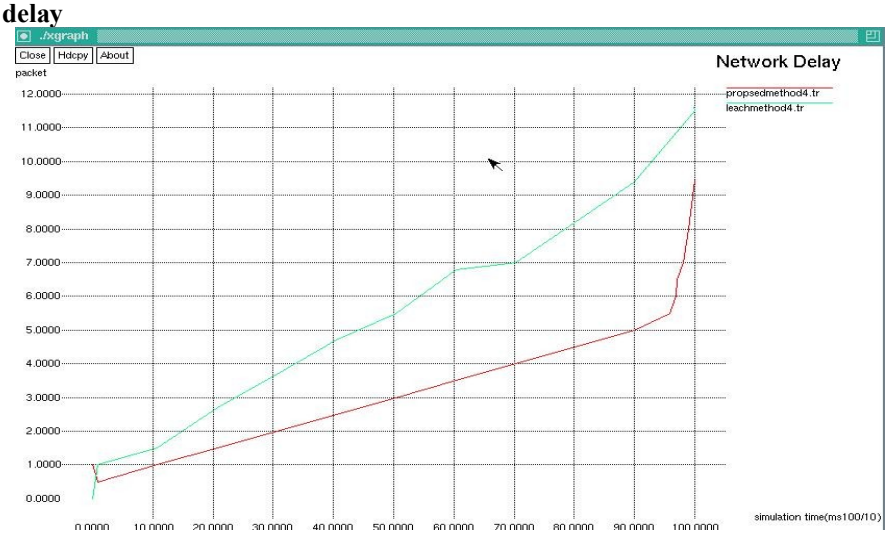

Figure 7: Graph for network delay

Here in Fig:7 we have shown the second result that is based on the Network delay. Network delay is an important design and performance character of a computer network like Wireless Sensor network or telecommunications network. The delay of a network specifies how long it takes for a bit of data to travel across the network from one node or endpoint to another. It is typically measured in multiples or fractions of seconds. Delay may differ slightly, depending on the location of the specific pair of communicating sensor nodes. Although users only care about the total delay of a network. Here green line specifies leach and red line denotes modified leach. we had compared Network delay of leach and our proposed method , so clearly see that the Network Delay of our proposed method is much lower as compared to the present leach. Reason behind them is that in our proposed method we have used multi hop leach in which packet are not send directly to the base station, instead from an optimal path through various cluster head. It works as a relay station and helps in reducing energy consumption of CH.

IV. Conclusion

In this paper we have discussed various routing protocols developed for wireless sensor network. The main concern of our survey is efficient usage of energy residue of sensor nodes in network and enhancing their lifetime. We had tried to maintain data quality along with energy efficiency. This method uses multi hop routing for transmission of data and CSMA/CA, TDMA for avoiding collision and delay of data. A random node is added to the far away cluster for improving network lifetime. Optimal routing path is found by considering the highest remaining power in battery with least number of hops and without overhead of traffic loads. We had compared our simulation result on the basis of network performance, network delay, packet delivery ratio, data packet and achieved satisfactory result for our proposed method. Wireless sensor network is an emerging technology with immense scope of research and development. In this field energy is the main constraint and has huge research possibility. Certainly further energy improvement is possible by improving routing protocol and cluster head selection technique.

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