A Novel Energy Efficient Spherical Routing Model for Dynamic Route Discovery in Wireless Sensor Networks

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***Abstract:-* Deployment of Wireless Sensor Networks (WSN) has achieved tremendous growth in recent years causing it to become one of the top developing areas of the low data capacity communications system. The significant issue in WSN is the constraint on energy and processing resources ability in mote which reduces down potential functionality of sensor node. Also continuous use of a single shortest route between source and sink results in a shorter life span of a sensor node which in turn degrades the network performance. The important consideration for the wide scale WSN is the progress on power utilization efficiency. Therefore clustering is important energy efficient routing techniques for WSN. The proposed Spherical Routing protocol (S_PRP) are designed and its performance metrics are evaluated as i.e. number of packet transmitted, number of packet received, percentage in packet delivery, throughput and average residual energy and compared with the performance metrics calculations of Modified LEACH (M-LEACH) clustering Protocol. The conclusion from the analysis of results is that S_PRP protocol achieves better optimized performance contrast to popular M-LEACH protocol. The projected work outcomes from the performance metrics can adds extra life time in a WSN to provide superior Quality of Service (QoS).**

Keywords — Energy; Data Capacity; Spherical Routing; M-LEACH; Life span; Quality of Service.

I. INTRODUCTION

In Wireless Sensor Network (WSN) several wireless sensors nodes are deployed over the wide geographical area where each node function is to sense input attributes surrounding to its environment. For transmitting the useful message to the base station sensor nodes construct an optimized shortest path using intermediate sensor nodes. Each Sensor Nodes coordinated to its neighbor sensor nodes for successful routing of information. There are wide verities of existing routing scheme which optimizes best bath between source nodes to destination node. Most of the routing methods adopt the approach which uses best routing metrics for efficient energy and resource utilization of motes. Sensor nodes are limited in its power and computational power which limits the operation on resource constrained wireless sensor nodes.

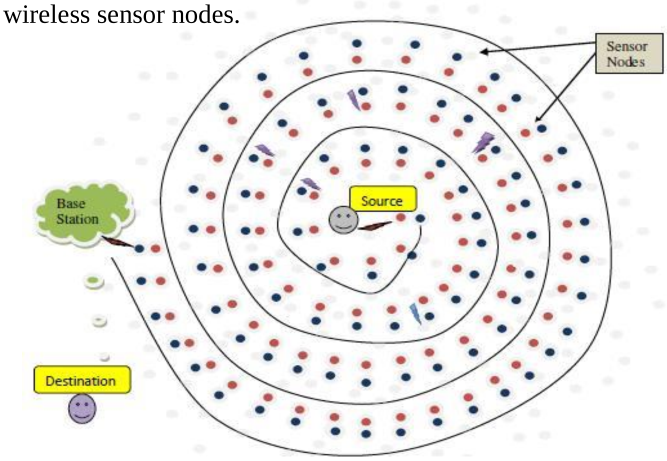

Fig.1. A general WSN Structure

The blueprint of sensor node includes sensor, processor, memory and radio trans-receiver as its main components to execute a task along with neighboring nodes. The figure 2 shows the main component as block diagram of a WSN"s node.

The various subcomponents of sensor nodes are sensors, power supply, ROM & RAM, memory, microcontroller and trans-receiver. The sensor components are defined in table I.

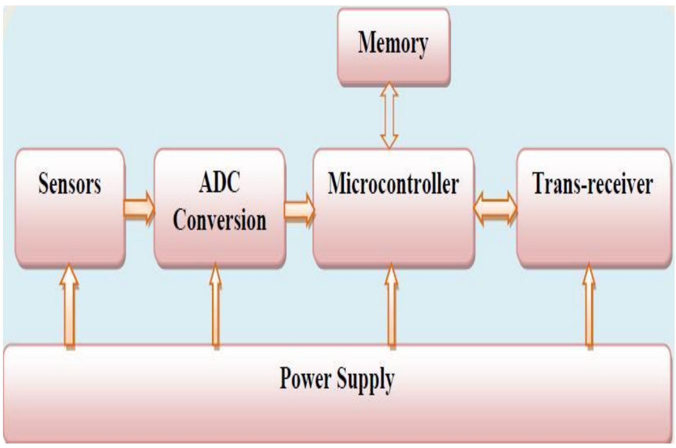

Fig. 2. WSN node functional block diagram

Table I. Components of Sensor Node

Component	Definition
Microcontroller	It fetches data from the storage element & performs the computational task.
ROM & RAM	It is used for storing information.
Trans-receiver	Transmission & Reception of information.
Sensor(s)	To sense input attributes.
Battery	WSN node components draw energy from it.

Sensor nodes are used in several applications with optimum uses of WSN node energy. The application of WSN are usually ideal in monitoring of environmental, distributed control system, radioactive sources detection, agricultural & farm, internet, defense and surveillance.

WSN is capable of being used for large scale area tele-communication linkage across different geographical regions. The design and deployment of WSN across various separate parts of wide region and their interconnectivity can be done and extended for the covering the area of complete earth by formation of group of networks which is approximated into spherical form as shown in figure 3.

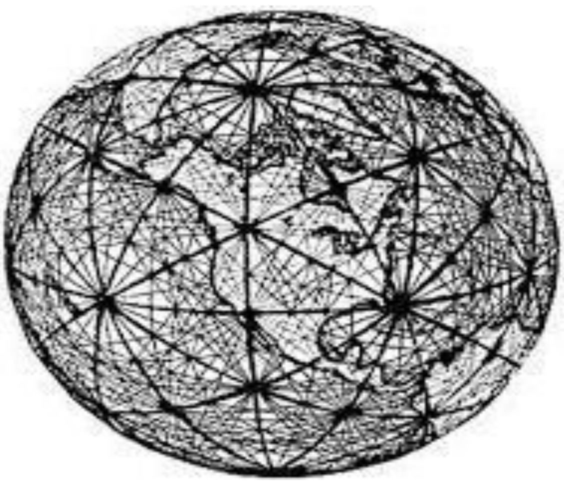

Fig.3. Globe coverage structure using WSN"s

II. WSN ROUTING: A REVIEW

The popular Grid based Routing Techniques are reviewed to understand the existing routing techniques in WSN and these surveys papers details have shown optimized results to improve the network lifetimes compare to other types WSN routing schemes.

LEACH (Low Energy Adaptive Clustering Hierarchy) is the widely accepted hierarchical routing method for wireless sensor networks [1]. LEACH arbitrarily opts for sensor nodes as cluster heads, with the intention that the power dissipation during communication considering the base station is extend to all sensor nodes. LEACH uses one hop routing with each node able to pass on message directly to the cluster head and the base station. Therefore, this method is not suitable to networks in the application of large coverage area. In addition, the design of active clustering includes more overhead such as changes in head, advertisements etc., which might weaken the gain in power consumption.

GBDD (Grid Based Data Dissemination) [6] grid cell area is formed by twin radio range of a mote. In GBDD grid building process starts depending on sink which was first involved in communication. Route metric are followed as when if valid grid is present, sink finds out nearest spot node. The benefit of this protocol is that it guarantees uninterrupted data release from source nodes to base station. But it consumes more power when the rate is very high.

ARA (Adaptive Routing Algorithm) [8] the network existence is improved by considering the sensor node outstanding energy and it creates an adaptive route path which is based adaptive routing algorithm useful for grid structure of WSN. The simulation result indicates the square sensor network offers key benefits contrast to the hexagonal sensor network, even though it has more coverage surface. ARA scheme is also favorite for arbitrarily deployed sensor nodes. The nodes are formed in clusters and the clusters are arranged in grid topologies. This way the cluster-head can be considered as a node from the grid.

GBDAS (Grid-Based Data Aggregation Scheme) [9] protocol partitioned the sensors ground into a grid of cells to optimize data transmission to the Base Station. In message collecting round, member nodes take turns to be cell head. Likewise, cell heads in the chain also take turns to be the chain leader. Therefore, the power consumption of sensor nodes is evenly distributed so as to exploit their lifetimes. As a result, the life span of the whole WSN extends.

CBDAS (Cycle-Based Data Aggregation Scheme) [10] node find-out which cell it related to by a simple arithmetic process. Grid-based WSN build the grid infrastructure by dividing the complete geographical section into a grid of cells. Better lifetime is achieved with this scheme of the sensor nodes to improve the lifespan of the complete sensor network. This method outperforms the other grid based approach in terms of optimizing power level, dimension of the network, and compactness of the node.

TTDD (Two-Tier Data Dissemination) [11] provides various mobile base stations data delivery. Assuming that sensor nodes are motionless and position aware, each data source proactively constructs a grid topology for disseminating data to the mobile sinks. Also, sensor nodes are location aware and stationary, whereas base station may move their locations energetically depending on situation. The simulation result shows that TTDD perform release of data from many sources to many mobile sinks with optimized performance.

III. METHODOLOGY

The abstract representation of projected Wireless Sensor Network framework is represented by figure 4.

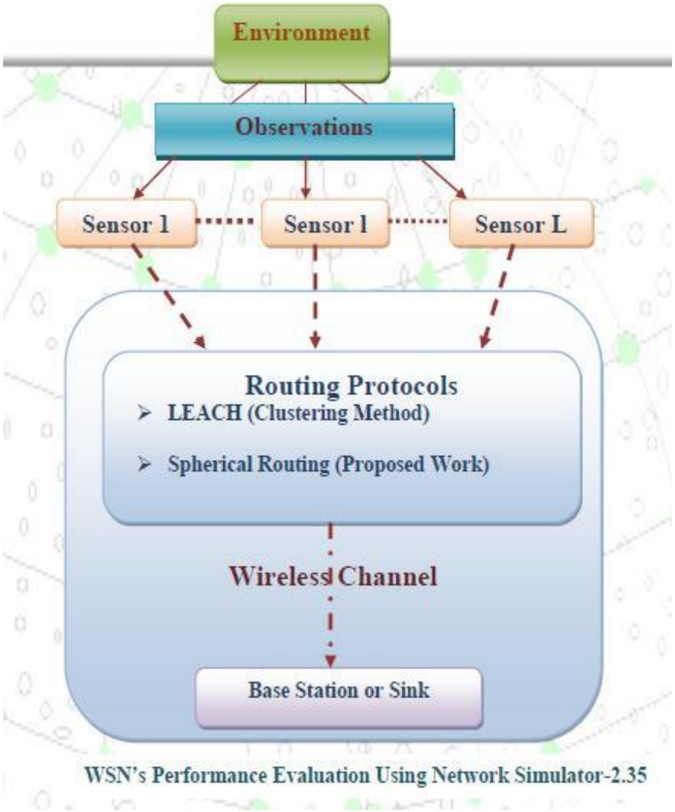

Fig.4. Abstract Representation of Proposed WSN Model

IV. MODIFIED LEACH PROTOCOL

LEACH (Low Energy Adaptive Clustering Hierarchy) protocol is an efficient energy resourceful clustering algorithm for wireless sensor network as shown in figure 5, in which entire network is separated into several numbers of clusters of networks. Each cluster nominates a node which acts as a cluster heads based on its threshold value, which establishes communication link with one or more different cluster heads for the routing of the data to the sink or base station. In LEACH method a cluster head is elected based on the threshold value from number of nodes „n" as Th (m) of the latest stage if the number is small contrast to the threshold as follows:

Th(m) = 1− (1)' if m ∈ G

0, otherwise

Where, P indicates the fraction of desired cluster heads, and „r" indicates the in progress round, and G represent the nodes set that is so far not chosen as CHs in the last 1/P rounds.

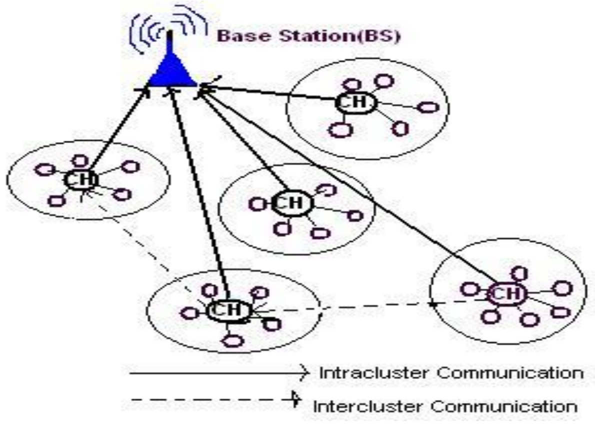

Fig.5. Modified LEACH Protocol

The LEACH protocol which is designed, modeled and implemented using Network Simulator-2.35 as shown in Fig 6. The performance metric obtained and calculated from the simulator trace file is shown in result section.

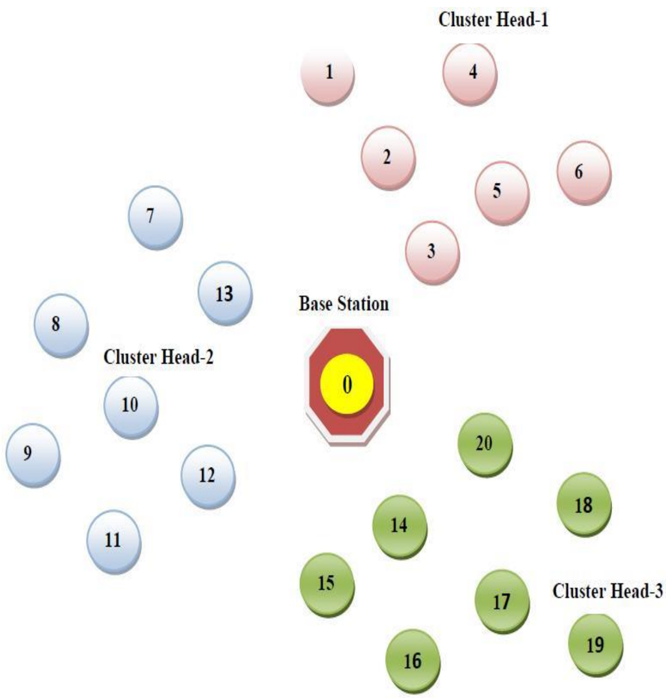

Fig..6. LEACH Simulation Model

Considered wireless sensor network model of 20 nodes. Assuming node 0 is base station. Remaining 19 nodes are separated in to three different groups of clusters. In each cluster based on utmost energy value of node a cluster head is elected. The function of cluster head is to gather & aggregate data from node of local set member and forwarding of data towards base station or other cluster leader. Figure 6 represents three different clusters which are indicated by three different colors. Dynamically number of clusters construction takes place and cluster heads are selected in conditions of highest energy value of the sensor node.

V. SPHERICAL ROUTING PROTOCOL (S_PRP): A PROPOSED METHOD

In this section a novel concept of Spherical Routing Protocol (S_PRP) is proposed. The S_PRP architecture is shown in Fig 7 to Fig 9. Here sensor nodes are randomly dispersed over a geographical region to monitor its environment. Sensor node coordinates each other to help in constructing a spherical routing link between source nodes to base station via intermediate nodes to transmit observed data. In S_PRP, sensor nodes promote their request such as messages for advertisement with the path which is equivalent to a logarithmic spherical curve; where as a sink node transmits its query message with the path which is equivalent to a logarithmic spherical curve opposite way to the advertisement path.

For the resource constrained wireless sensor nodes logarithmic spherical curve is chosen which is ideal for S_PRP. It is assumed that in advance the spherical curve related required parameters are in prior installed to every sensor node. When sensor nodes observe some events and ready to get disseminated, it initiates the spherical dissemination. The picking of the next hop neighbor node depends on the use of Spherical Path Search Protocol (SPSP) which fits the planned best spherical path and then to the chosen sensor node it sends an advertisement which includes the position and ID of the preceding hop node, the spherical direction of the preceding hop node, and some more parameters like advertisement TTL (Time-To- Live), the utmost hop number of the distribution path, etc.

After receiving an advertisement packet by a sensor node, it stores a local copy of the advertisement message, then make use of the same SPSP to decide a neighbor as the subsequent hop, and then transfer the advertisement message. By this approach, forwarding of the advertisement message takes place hop by hop in the sensor network which follows a spherical like track. When the spherical link reaches the edge, or the when limitation on hop is reached routing will stop when it meets some preset condition. In opposite direction query procedure is similar to the dissemination procedure. When a query is initiated by a sink node, the query follows the opposite way spherical path till it satisfy the spherical dissemination, or the end condition is fulfilled. The source node can once in a while bring up to date the information along the spherical path, or work in an unexpected form that starts the spherical distribution every time the concerned event is observed.

At i_{th} hop SPSP uses path search algorithm which is shown by the following equation:

Max ------- (A)

Subject to,

Where, w denotes a node, k_C denote the spherical angle weight and k_e denote the distance weight. In the above equation, the sum of weight of the period spherical angle and the distance to the ideal spherical is represented as the cost function.

The spherical routing formation takes place in the sensor fields with predetermined angular position between two or more nodes. One or more layers of spherical routing paths may be formed depending on applications as shown in Fig 9.

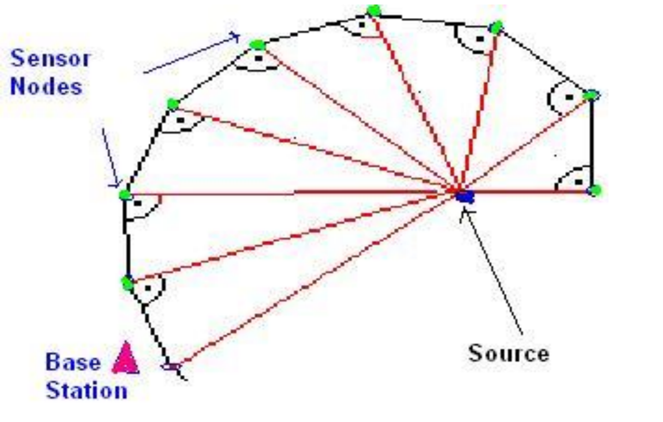

Fig.7. A Spherical Path Formation

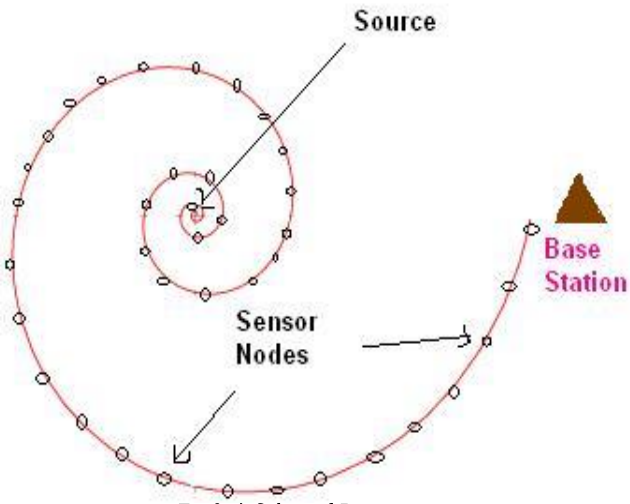

Fig.8. A Spherical Routing

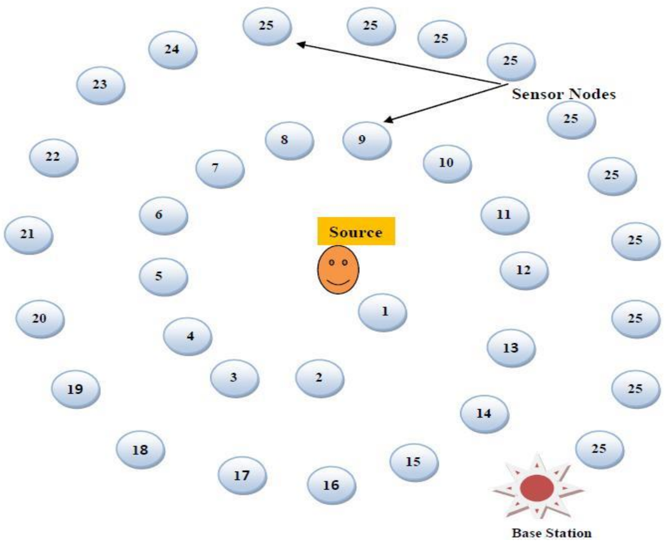

Fig.9. S_PRP Model using NS-2.35

VI. RESULTS & DISCUSSIONS

The analyzed and evaluation of proposed S_pRP method are done using network simulator (NS-2.35). Table II shows the detail of the parameters used in the simulation. The M-LEACH is compared with the proposed research work and the results are shown in Table III. The NS-2.35 simulated Result of S_pRP outperforms existing M-LEACH protocol.

Table II: WSN Model Simulation parameters

NS-2 Parameters	Value
Types of Channel	Wireless Channel
Max Packet in IFQ	59
Type of Network interface	Phy /WirelessPhy
Type of MAC	Mac/802_11
Interface Queue Type	Queue/DropTail /PriQueue
Types of Link Layer	Link Layer
Model of Radio-propagation	Propagation usingTwo Ray Ground
Routing Protocol	S_pRP and M-LEACH
Model of Antenna	Antenna/Omni Antenna
Number of Mobile Nodes	76
Topography X dimension	2800
Topography Y dimension	2800
Time of Simulation End	50
Initial Energy (Joules)	100
Type of Network	Movable
Connection Pattern	Random
Size of Packet	Standard(512 bytes)
Types of Connection	CBR

Table III: M-LEACH versus S_pRP

Performance Metrics	M-LEACH	S_pRP
No. of Packet Transmitted	823	1276
No. of Received Packet	743	1219
Ratio of Packet Delivery	90.28	95.53
Average Throughput	44.66	62.29
Average Residual Energy	85.42	97.33

The result generated for LEACH and S_pRP protocol from the simulator trace file is shown in Table III. The overall number of packets sent by source node and total number of packets received by end (destination) node and is obtained from NS-2.35 trace file. Packet Delivery Ratio (PDR) is performed with the ratio of reception of packets to packet sent. The PDR calculated for S_pRP is better than LEACH protocol with simulation parameters as shown in Table III. The average throughput which is defined as average transform rate that is improved for S_pRP over M-LEACH. Average Residual Energy metric is concerned with the network lifetime and result shows the average dissipation of energy per node over time in the network. As shown in fig.10 different performance metrics computed for analysis indicate that S_pRP outperforms the M-LEACH protocol.

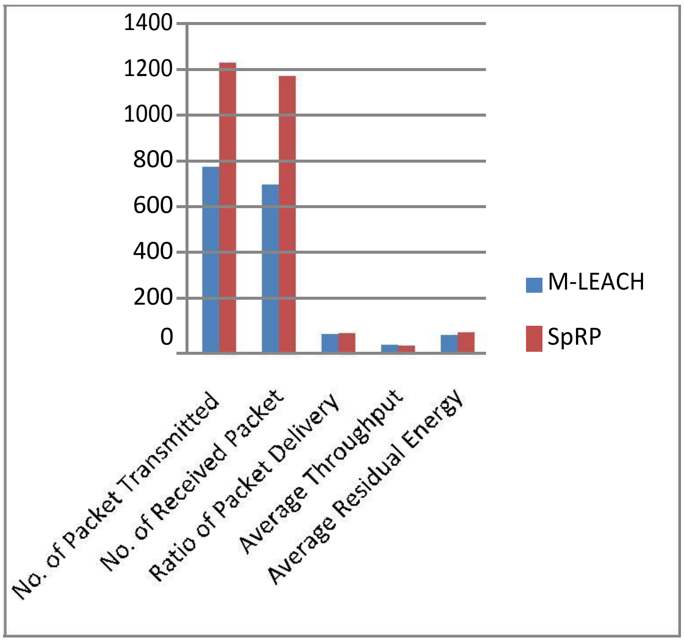

Fig.10: M-LEACH versus S_pRP

CONCLUSION

There is necessity to design and develop energy efficient routing algorithms which self configures power-saving scheme to improve energy efficiency and to maintain high geographical area coverage in WSNs. S_pRP architecture mainly specifically focuses on network topology formation, selection of spherical routing path and optimal routing. WSNs are divided into multi levels of angular spherical curve: 1-tier and n number of tiers. Each tier forms a spherical cluster up to n number of spherical route for scalable WSN network, which combined together, is called N-tier S_pRP. Simulation reveals that the protocol S_pRP achieves better energy balance and network coverage than M-LEACH. The conclusion from the analysis of results is that S_pRP protocol achieves better optimized performance compare to popular wireless sensor network M-LEACH protocol. The proposed work result outcomes from the performance metrics can adds extra life time in a WSN to provide better Quality of Service (QoS) along with security for routing applications.

The research future work will focus on extending scalability and security of S_pRP protocol. Using proposed work and performances metric analysis the researchers can investigate further scope for improvement in proposed routing protocol by overcoming the limitations such as complete network failure due to a node energy exhaust of S_pRP, and also packet delivery ratio, Throughput, low packet drops & optimized power consumption can be further enhanced in highly scalable random mobility network.

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