An Improved Time Synchronization Protocol for Wireless Sensor Networks

Group No-10 (CSE)

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Major Project
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PROBLEM STATEMENT

To design a protocol for time synchronization in wireless sensor networks that focus on energy conservation..

What is WSN?

Wireless sensor networks (WSNs) are distributed networks of low-cost sensors, which are capable of wireless communication and data processing, dedicated to closely observing real-world phenomena.

In wireless sensor networks, the basic operation is data fusion, whereby data from each sensor is agglomerated to form a single meaningful result.

Network Topology

The Network under consideration consists of a base station and several sensor nodes. Further , every node is reachable to another node in the network.

TPSN Protocol

TPSN stands for Time-Sync Protocol for Sensor Network which relies on tradional approach of sender-reciever synchronization. This Protocol works in two phases:

1. Level Discovery Phase:
   - One node is selected as root node with level-0 and this node initiates this phase by broadcasting a level-discovery packet that contains the identity and the level of the sender.
   - The immediate neighbors that receive this packet assign themselves a level that is one greater than the level in the packet received.
   - After this step, these neighbors broadcast a new level-discovery packet with their own level. This process is continued until each node has a level.

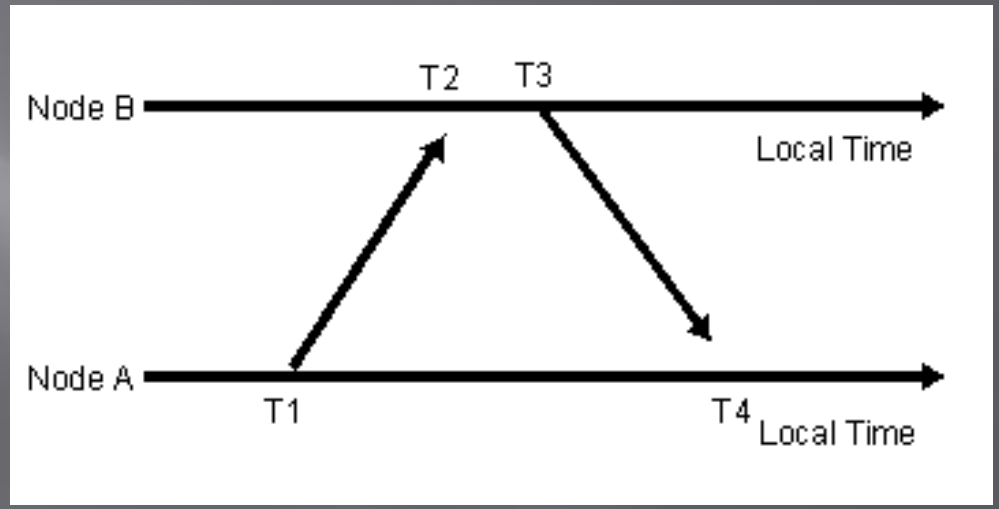
2. Synchronization Phase:
   Step-I: At time T1, A sends a sync-pulse message to B. This message contains the level number of A and the value of T1 . Node B receives this packet at T2, where $T2 = T1 + \delta + d$; δ = clock offset b/w two nodes and d = propagation delay.

TPSN Protocol

Step-II: At time T3 , B sends an acknowledgement packet to A. This packet contains the level number of B and the values of T1 , T2 , and T3 . With this information, node A calculates the clock offset and delay as follows.

$$\Delta = ((T2 - T1) - (T4 - T3)) / 2;$$

$$d = ((T2 - T1) + (T4 - T3)) / 2;$$



Step-III: Node A corrects its clock to synchronize with node B according to the computed offset.

LEACH Protocol

- It stands for Low Energy Adaptive Clustering Hierarchy Protocol which is a pioneer clustering routing protocol for WSN.

- Its main objective is to increase the energy efficiency by rotation-based Cluster Head (CH) selection using a random number.

- The operation of LEACH consists of several rounds where each round is divided into two phases: i) set-up phase and ii) steady state phase.

- During the set-up phase, CH selection, cluster formation and assignment of a TDMA (Time Division Multiple Access) schedule by the CH for member nodes are performed. In CH selection,each node participates in a CH selection process by generating a random priority value between 0 and 1. If the generated random number of a sensor node is less than a threshold value T(n) then that node becomes Cluster Head.

LEACH Protocol

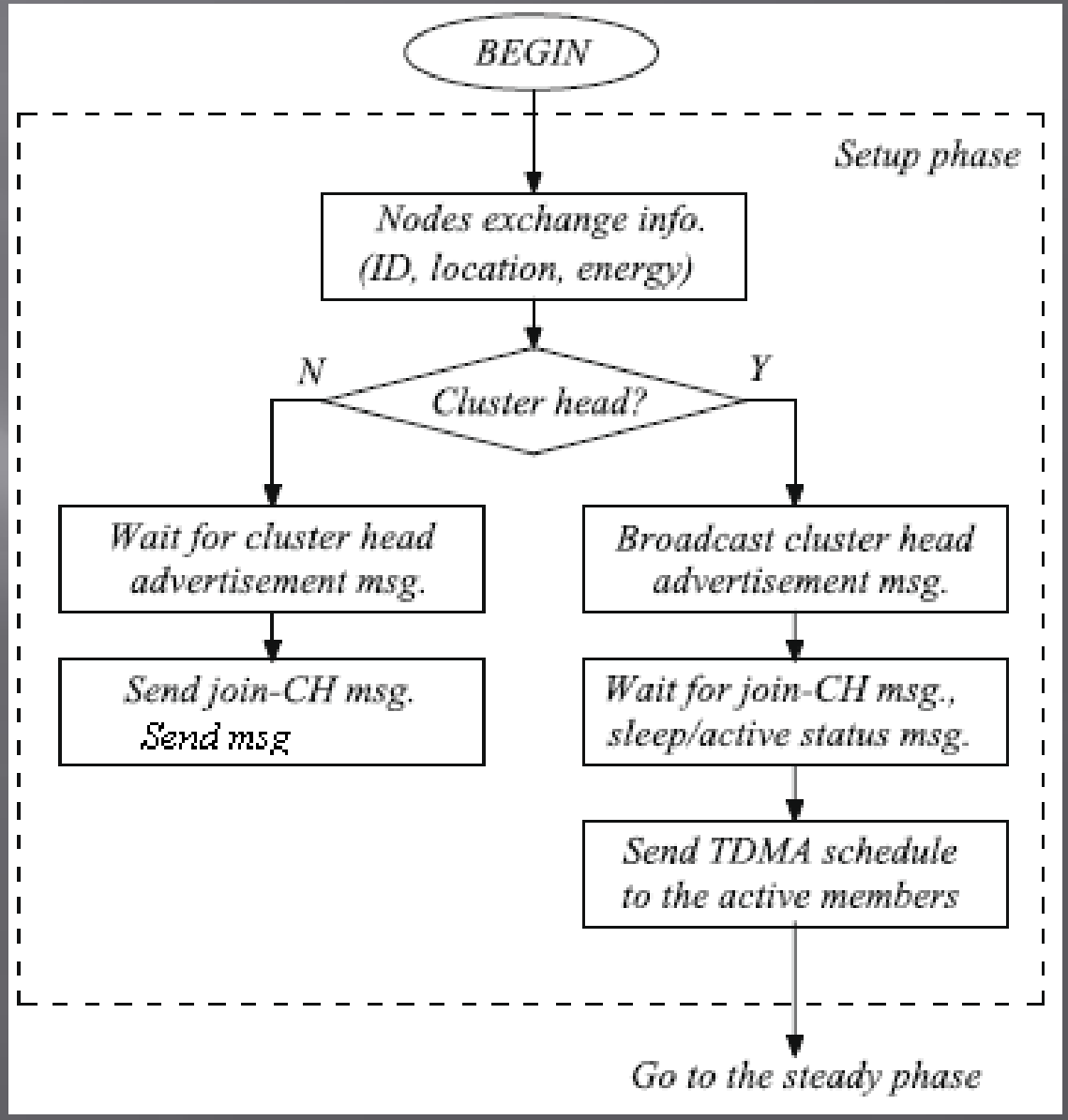
1. Set-up Phase:

- If generated random number of a sensor node is less than the Theshold value, then it becomes a CH.

- Threshold value can be calculated as

$$t = \begin{cases} \dfrac{P}{1 - P \times [r \bmod 1/P]} & \text{if } n \in G \\ 0 & \text{otherwise} \end{cases}$$

Where, P = desired percentage of nodes to become CHs, r = current round and G is the set of sensor nodes that have not participated in CH election in previous 1/P rounds.



LEACH Protocol

The stage after the cluster head selection is the cluster member node adding stage.

When the cluster head node is selected, all the cluster heads broadcast advertising message to all other nodes with the maximum power.

The node selects a signal with the strongest signal and replies to a message, which means that the cluster head is added to cluster node closest to the node.

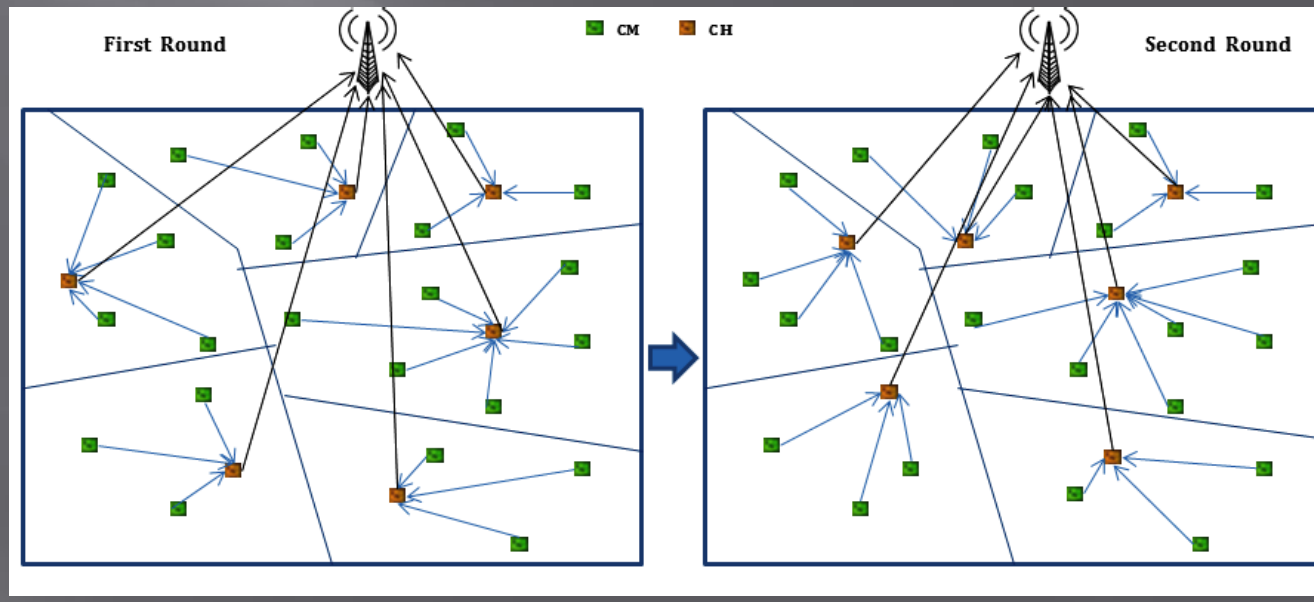
LEACH Protocol

2. Steady State Phase:-

In the steady state phase, transmission of sensed data from member nodes to the CH and CH to the BS are performed using the TDMA schedule.

Member nodes send data to the CH only during their allocated time slot and other nodes of that cluster remains in the sleep state. This property of LEACH reduces intra cluster collision and energy dissipation which increases the battery life of all member nodes.

CHs aggregate data received from their cluster members and send it directly to the BS using TDMA scheduling.



CLECTS(Model to be compared)

The algorithm requirements that wireless sensor network first of all generates the cluster topology, and then makes the base station and cluster to achieve time synchronization, and then realizes the cluster node time synchronization, so as to achieve the ultimate goal of the whole network synchronization.
The election of cluster head uses LEACH protocol.

The first step of the algorithm is to select the cluster heads and the selected cluster heads can select the cluster head nodes of the next cluster. For example, in the zeroth layer, the root node selects the first I node in its next layer node group as the cluster head node of the next layer of cluster and continues to broadcast the message. The energy consumed by the sending message is determined by the distance between the root node and the node for its communication.

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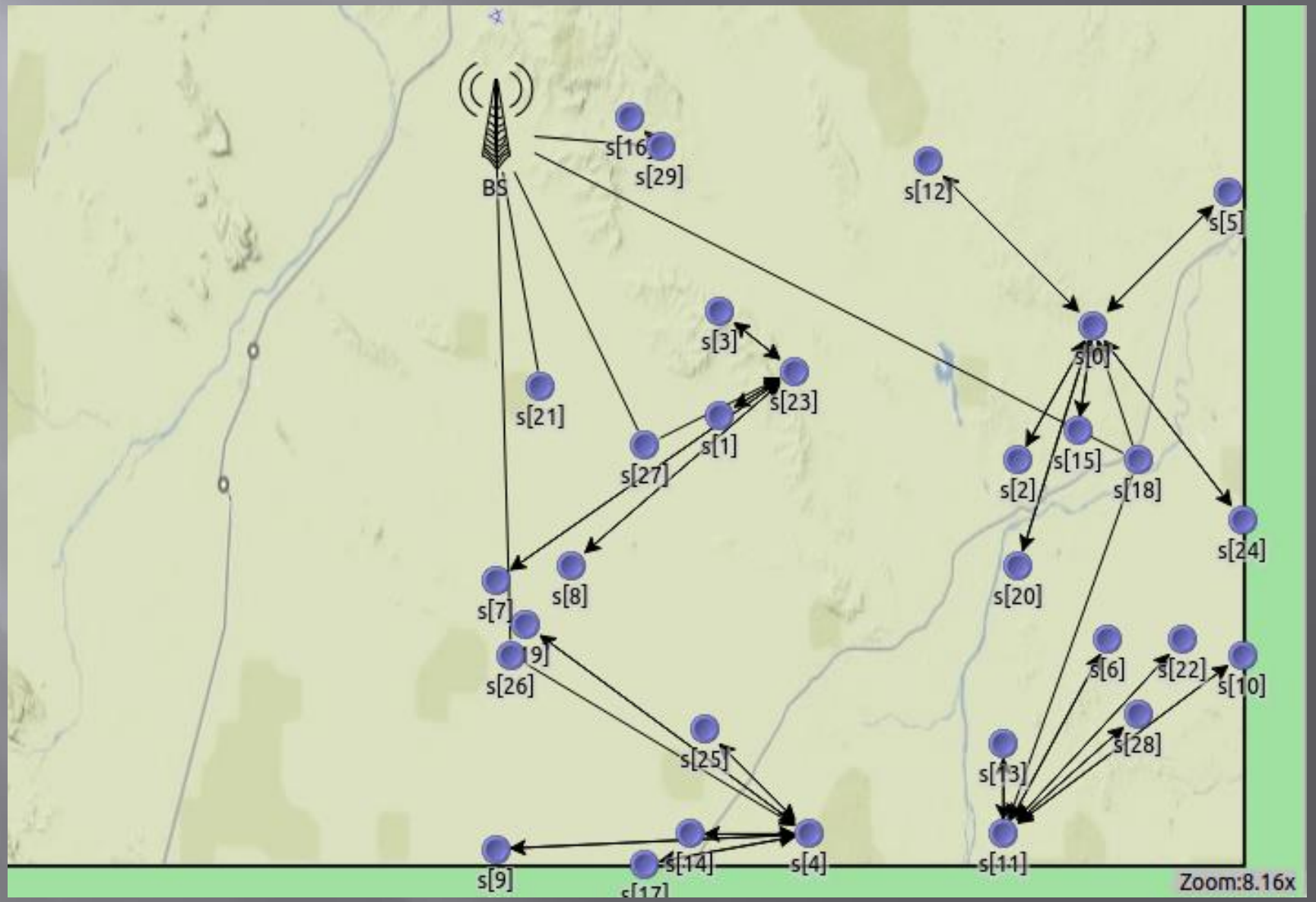
CLECTS(Model to be compared)



OUR MODEL

The algorithm used to synchronize two nodes is TPSN which requires timestamps T1, T2, T3 and T4. Let there be two nodes p and q. T1 is the local time of p when p sends a synchronization message to q containing T1; T2 is the local time of q when it receives that synchronization message; T3 is the local time of q when it replies back to p with T1, T2 and T3; and, T4 is the local time of p when it receives this message. The synchronization details using T1, T2, T3 and T4 is already explained in section 4.2. The initial energy of each node is 1 joule.

First of all, selection of cluster head is done using LEACH protocol as explained in section 4.3. After that all the cluster heads sends a message to base station, telling it the state of its cluster head formation along with time T1, and gets a message replied by base station with T1, T2 and T3, which synchronizes all cluster head with base station.

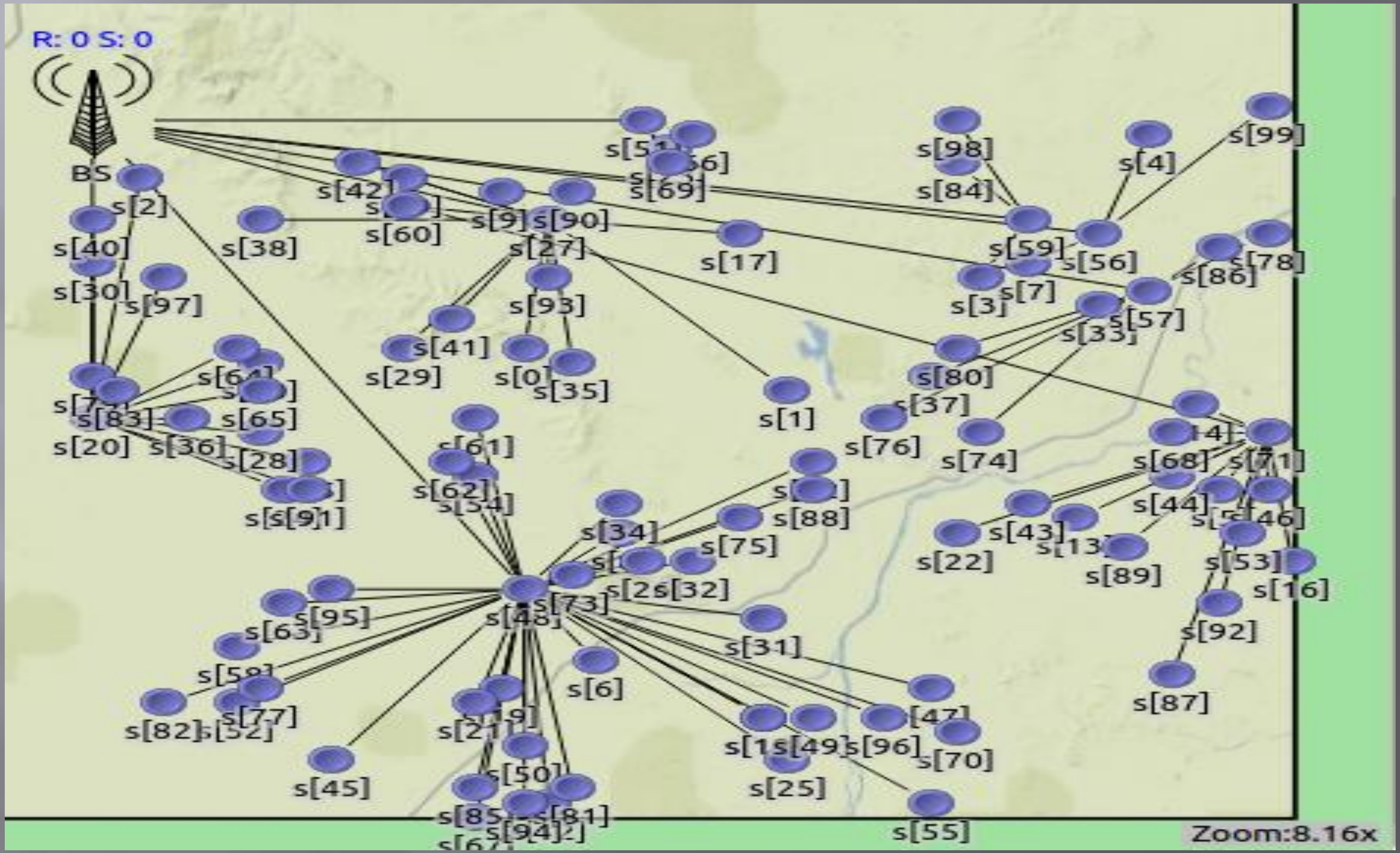
OUR MODEL

Now , each cluster head sends an advertisement packet in order to decide the members under it. All the normal nodes, i.e which are not cluster head chooses its cluster head with strongest signal.

Now in order to tell it’s cluster head that it is its member, the normal nodes sends joining request to their respective chosen cluster head along with T1 timestamp. In answer to which, the cluster head broadcast TDMA schedule to the nodes seeking it’s membership, along with timestamp T1, T2 and T3, thus leading to synchronization between cluster head and its members.

The same process is repeated after a particular period of time as it happens in LEACH.

OUR MODEL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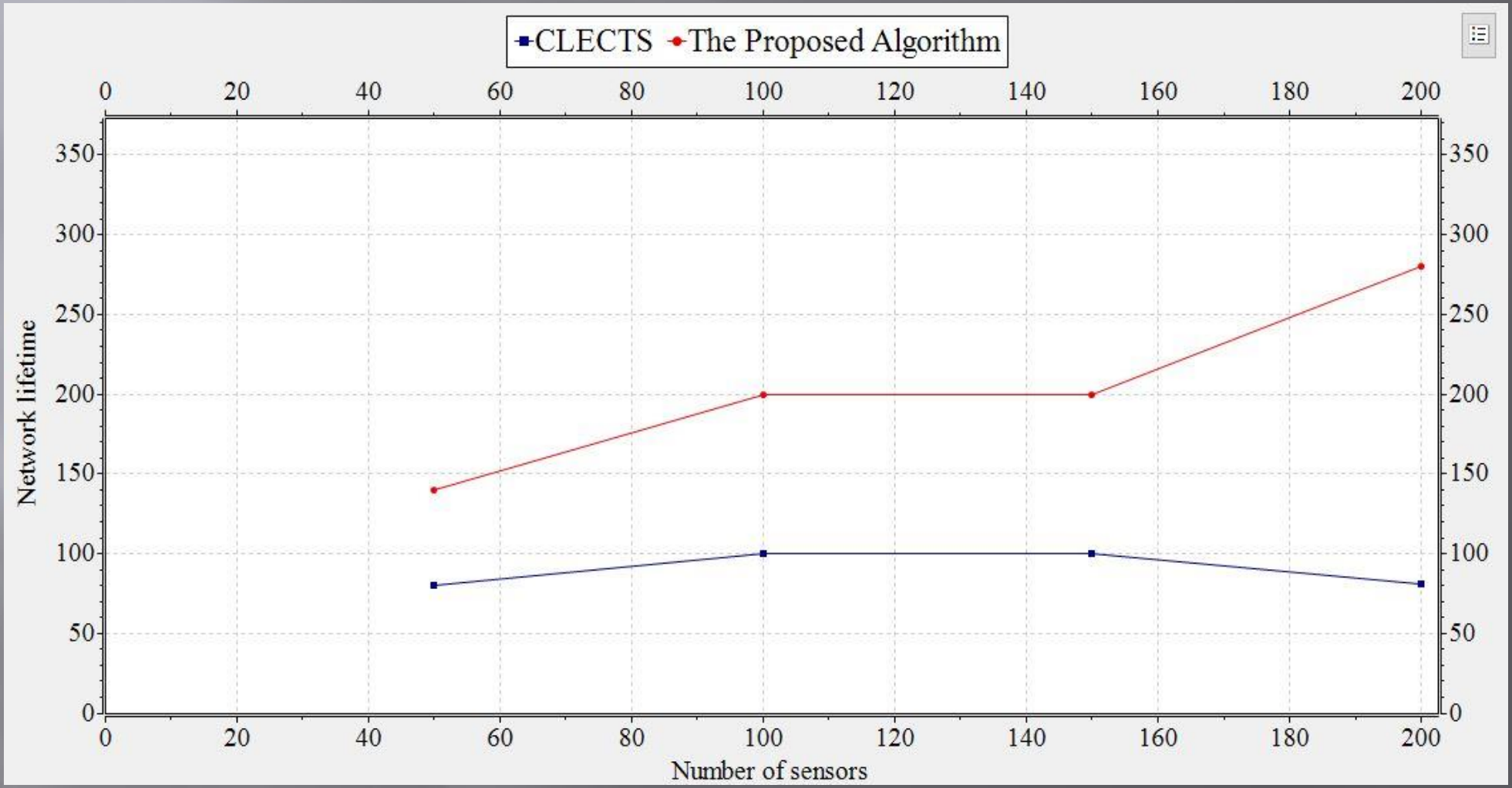
Result Analysis



Result Analysis

The x-axis denotes number of sensor nodes , whereas y-axis denotes the lifetime of network in seconds. In our proposed algorithm, we can see that lifetime of network increases monotonically with number of sensor nodes. In CLECTS, lifetime of network first increases and then decreases with number of sensor nodes. But overall, our model has more lifetime than CLECTS every time even when number of nodes vary.

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Thank You