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Mini Projet: Communication protocol Modeling & analzing

LEACH protocol Description :

LEACH is a hierarchical protocol that is based on data aggregation, dynamic allocation of CH and local control on data transmission. It operates round to round and each round comprises three phases: Advertisement phase, cluster set-up phase and steady-state phase.

Advertisement phase: Firstly, each node in the network decides if it will be a Cluster Head (CH) or not for the present round. This decision depends on the desired percentage of CHs in the network and the number of times the node has served as CH so far. In fact each node i choose a random number between 0 and 1. If this number is less than a threshold T(i), i becomes a CH.

$$T(i) = \begin{cases} \frac{P}{1-P*(r \bmod \frac{1}{P})} & \text{if } i \in G \\ 0 & \text{otherwise} \end{cases}$$

Where **P** is the desired percentage of cluster heads, **r** is the current round, and **G** is the set of nodes that have not been cluster-heads in the last **1/P** rounds. After CH election phase, each CH broadcasts advertising messages to the remaining nodes inviting it to choose which of the CHs they will join and finally, clusters are created for the current round. The choice of remaining sensor nodes will depend on the signal strength of the received broadcasting messages.

Cluster setup phase: Each remaining node communicates its decision to the chosen CH node that it will belong to the cluster. To receive this information, all CHs keep their receivers on during this phase. Based on the number of nodes in the cluster, the CH creates a time division multiple access (TDMA) schedule and informs other sensor nodes when it can transmit.

Steady-state phase: In this phase, transmission data starts. Sensor nodes send their data in their own time slot and their radio can be turned off. CH must keep their radio on to receive all data from nodes.

Optimization Steps:

Consider three fundamental criteria to calculate the threshold.: the remaining energy, the number of neighbours within cluster range and the distance between node and base station BS. Thus, nodes having at the same time high residual energy, short distance to the sink and

several neighbors are chosen as CHs. By incorporating above criteria, we can use a cost function which is expressed as:

$$cost(i) = \alpha \frac{E_{rem}(i)}{E_{init}} + \beta \frac{N_{nb}(i)}{N_{alive}} + \gamma \frac{D_{toBS}(i) - D_{toBSmin}}{D_{toBSmax} - D_{toBSmin}}$$

Where Erem(i) is the remaining energy of node i, Einit is the initial energy, Nnb(i) is the number of neighbors of node i, Nalive is the number of alive nodes, DtoBS(i) is the distance between the node i and the BS, DtoBSmin is the distance between the closest node to the BS and the BS and DtoBSmax is the maximum distance to the BS. Then the threshold can be written as follows:

$$T(i) = \begin{cases} \frac{P}{1 - P * (r \bmod \frac{1}{P})} * cost(i) & \text{if } i \in G \\ 0 & \text{otherwise} \end{cases}$$

After selecting CHs, the remaining nodes have to choose its cluster for each round. The choice of nodes is based on the distance between the node and the CH. Nodes opt to the closest one and bind to it to form clusters.

Project Outline:

1. Understanding LEACH Protocol:

- Dive deep into the LEACH protocol, its functionalities, and the rationale behind its design.
- Identify the key parameters and variables within LEACH that dictate the selection of cluster heads.

2. Translating LEACH into Maude Language:

- Express the LEACH protocol in Maude's formal language, capturing its rules and behaviors in the Maude framework.
- Implement the cluster head selection algorithm within Maude using rewriting logic.

3. Verification and Validation:

- Validate your Maude model to ensure it accurately represents the LEACH protocol.
- Simulate the behavior of the Maude model with different scenarios and parameters to analyze its performance.