Wireless Sensor Networks with an Intelligent Sleeping Mechanism

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Abstract

In this article, we present LEACH-CS, a centralized low-power sleep protocol for use in wireless sensing networks. By suggesting a method that makes a clever selection of func tioning nodes based on the data detected at the moment, LEACH-CS helps wireless sensor networks last longer. Some groups may be put to slumber until the next data round if their output appears to be negligible over a given time span. It has been suggested that a program called the Intelligent Sleeping Mechanism (ISM) be used to select the operational states of individual nodes. In models, LEACH-CS outperforms the well-known LEACH-C protocol by a wide margin, reducing end-to-end latency in data transmission by an average of 50 percent and prolonging the lifespan of the network by 35 percent. LEACH-CS has been suggested for use in agriculture, where environmental factors often stay constant and are not time-sensitive.

KEYWORDS

Lifetime; LEACH-C; Hierarchical algorithms; Sleeping nodes; Wireless sensing networks.

Introduction

In order to gather environmental context data, wireless sensor networks (WSNs) use tiny sensor units to create an ad hoc dispersed detection [1] and data transmission network. WSN is used in many fields, including national defense, military expos, industrial control, environmental monitoring, traffic management, medical care, and smart homes [2-4] to gather reliable and accurate data from remote and potentially dangerous locations. For both military and domestic uses like target tracking, monitoring, and security management, it is crucial that the chosen routing protocol make effective use of the sensor's power given its low cost and reliance on batteries for energy. The sensor node is made up of four main parts (sensor, processor, wireless, and electricity) [5]. Each component in a sensor network constantly monitors its surroundings and relays that information to a central location called the base station (BS), which is typically quite some distance from the area being monitored. The finite energy supply source of the distributed sensor nodes is the most limiting element in the lifespan of a wireless sensor network. Wireless sensor network protocols must address the problem of energy economy because sensor nodes have finite and often irreversible power supplies. Other concerns [5] like self-configuration, failure tolerance, and latency should also be handled by the network protocol. Since data transmission speed is crucial in many uses, such as combat and medical/security tracking systems, it is an essential factor in the architecture of a sensor network. Such uses necessitate prompt delivery of data collected by sensing networks. The efficiency of wireless sensing networks is significantly influenced by the methods used for exchanging information among nodes in the network. Therefore, it is critical to extend the lifespan of wireless sensing networks by developing energy effective protocols. Routing algorithms in wireless sensing networks have been the subject of extensive study, evaluation, and improvement [6, 7].

Connected Tasks

Clustering methods in routing have been suggested as a means to improve the network's energy economy [7–12]. Low-Energy Adaptive Clustering Hierar chy was suggested by Heinzelman et al. [7] as a clustering-based single-le vel method. (LEACH). It presumes that all sensing nodes have straight line-of-sight to the main station. To reduce power consumption, LEACH selects only cluster leaders from among a subset (p) of the available sensing nodes. According to the signal intensity from the cluster leaders, the remaining sensing nodes will join the appropriate groups.

Each round of cluster heads' operations includes a cluster set-up phase during which new clusters are formed, and a steady-state phase during which cluster heads aggregate the data received from their cluster members and send the aggregated data to the base station via single-hop communication. Each round results in the appointment of new directors. The selection criterion is to pick a node at random from among those that have never been a coordinator before, or from among those that have been coordinators the fewest number of times. There are benefits to using LEACH's distributed cluster creation method, but the location and/or quantity of cluster leader nodes are not guaranteed. Due to the flexible nature of the groups, a bad round of clustering will not have a huge impact on the results. It's possible that stronger clusters would result from using a centralized management method to create the clusters and then spreading the cluster heads out across the network. The LEACH-centralized (LEACH-C) [8] protocol is based on this principle; it employs a centralized grouping method but otherwise provides the same features as LEACH. The base station determines the cluster leaders, organizes the clusters, and broadcasts the transmission plan after collecting data from the sensing nodes about their present position and energy level. Since LEACH-C's base station has access to the full architecture for cluster head selection, it improves upon LEACH's performance while simultaneously reducing the load on the sensing nodes. Although LEACH and LEACH-C are still in use today, there is room for improvement in terms of longevity and other factors. The modes examined in this study, in which nodes transition from active to resting modes based on a cognitive analysis of data, are not taken into account by LEACH or LEACH-C. It was suggested in [9] that 5% of the network's active nodes serve as cluster leaders, using the LEACH-CE protocol. As a result of the base station, 10% of the network's components enter a low-power state. This is done before any candidates for cluster leaders are chosen. While in slumber mode, the nodes neither collect nor transmit any data to the base station, nor do they receive any cluster head information. The modules are controlled by the base station. Cluster chiefs are selected by the base station, with the prior round's cluster leaders being ineligible to join until all nodes in the network have become cluster heads. This model arbitrarily selects the nodes put into slumber mode, so while it maintains lifespan, it does not ensure data integrity.

Energy-Efficient Centralized Adaptive Clustering Hierarchy Protocol (LEACH-C)

Despite its usefulness, LEACH's decentralized approach to cluster creation does not ensure the correct location or quantity of cluster heads. Getting a bad clustering arrangement in a given round won't have much of an effect on the total results because the clus ters are flexible. However, by spreading the cluster leaders across the network, clusters formed using a centralized management method may yield improved results. The LEACH-centralized (LEACH-C) [8] protocol is based on this fundamental concept; it employs a centralized grouping method but otherwise provides the same capabilities as LEACH.

Clustering of Base Stations

During LEACH-C's initialization period, each node communicates its present position (potentially via GPS sensor) and battery status to the home base. The base station must not only identify desirable groups, but also guarantee uniform power consumption across all nodes. The average energy of all nodes is calculated by the base station, and any node with an energy less than this threshold is disqualified from being the cluster leader for the current round. The base station uses the simulated annealing method to tackle the NP-hard issue of identifying optimum clusters, with the remaining stations serving as potential cluster leaders. This method seeks to limit the total sum of squared distances between all non-cluster head nodes and the closest cluster head in order to reduce the amount of energy expended by the nodes transmitting their data to the cluster head. Once the cluster leaders and their groups have been located, the base station will send out a transmission with the cluster leader ID included. If a node's ID matches that of a cluster head, it acts as a cluster head; otherwise, it sleeps until it is its turn to send data, at which point it awakens and prepares its TDMA spot for transmission.

The Low-Power Centralized Sleeping Protocol for Adaptive Clustering Hierarchies (LEACH-CS)

This part provides a comprehensive overview of the LEACH CS procedure, a refinement of the LEACH-C method. The suggested network architecture used to create the protocol is described in Section A. In Part B, we go over the specifics of the wireless model used by the protocol. LEACH-CS operation is ultimately defined in Section C.

Modelling Networks.

The following are some of the presumptions made during the planning phase of the protocol network:

- the distance between the main station and the sensors is always predetermined.
- The electricity of the sensing units is standard across the board.
- sensing nodes are immobile.
- communication between nodes and the hub is guaranteed.
- Channel of symmetrical transmission.
- Six, all the nodes constantly have data to transmit back to the hub because they are constantly sensing the surroundings.

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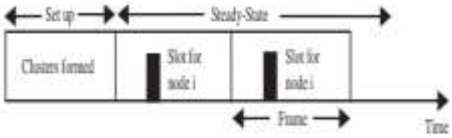

Figure 1 LEACH-C Operation.

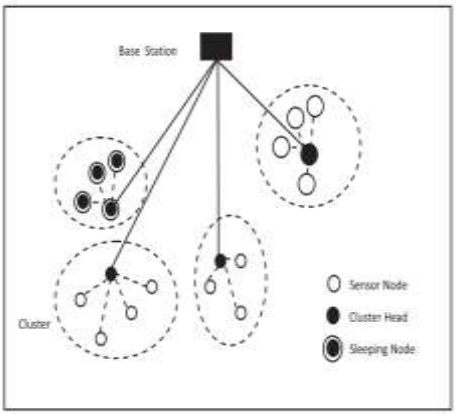

Figure 2 A typical LEACH-CS network.

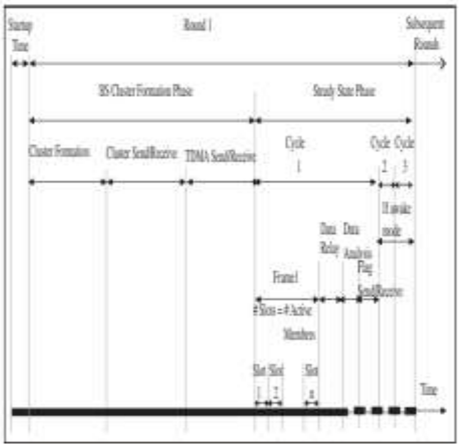

Figure 3 LEACH-CS Timeline.

LEACH-CS protocol evaluation

The LEACH-CS protocol has been implemented using the OMNet++ discrete event emulator [14]. From one hundred to one thousand components make up the network. We evaluate the LEACH-CS protocol against the LEACH-C protocol in terms of speed, latency, and network lifetime. When there are fewer than ten nodes left in the network, we say that the network has lived its full existence. Table 1 displays the test settings.

Permanent

In Fig. 5 we can see how many iterations the network goes through before dying out completely. According to the graph, the lifespan is increased by about 20% for networks with 50-500 nodes, and by as much as 45% for networks with 1000 nodes when using the proposed LEACH-CS algorithm. Since the number of resting nodes rises as the groups grow in size, LEACH-CS is found to perform vastly better than LEACH-C at bigger networks. Figure 6 also demonstrates that the LEACH-CS change affects the first node to perish in most situations.

Table 1 Summary of the parameters used in the simulation.

Parameter	Value
Field size ($M \times M$)	1000×1000
Initial energy of sensor node	0.5 J
Transmitter/receiver Electronics E_{Tx} and E_{Rx} (E_{elec})	50 nJ/bit
Transmitter amplifier where $d < d_o$	$\varepsilon_{fs} = 0.0013$ pJ/bit/m^2
Transmitter amplifier where $d \geqslant d_o$	$\varepsilon_{amp} = 10$ pJ/bit/m^2
The energy for aggregation	5 nJ/bit/signal
The data packet size	4000 bits

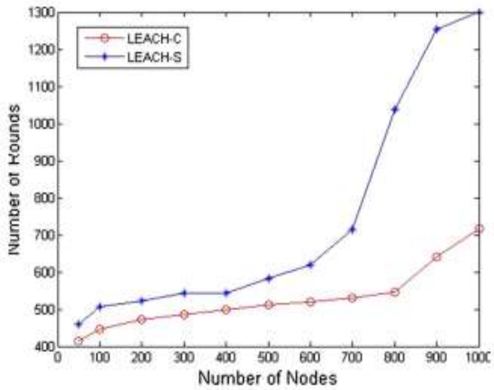

Figure 4 Number of rounds before the network is dead.

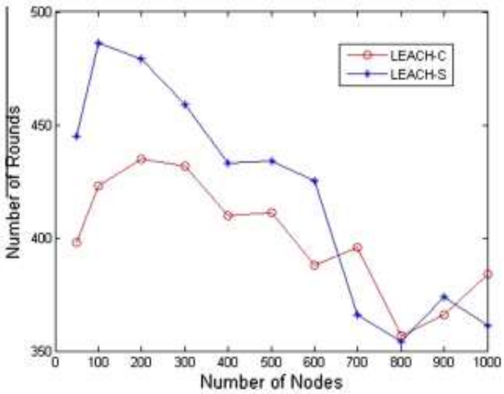

Figure 5 Number of rounds before the first node is dead.

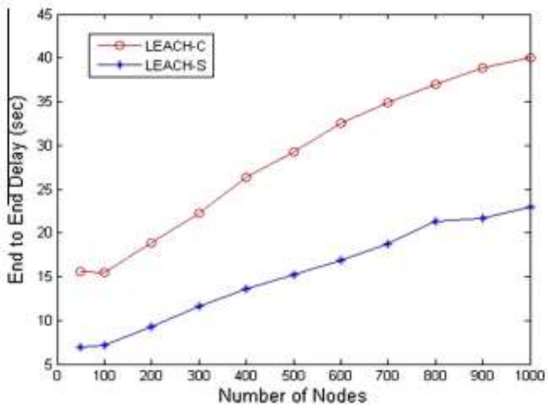

figure 6 End-to-end delay.

As discussed above, when running simulations with the default management approach of DFIG, sub-synchronous oscillations are observed under grid disruption. Due to the powerful interplay between DFIG and SVG, the efficacy of a conventional DFIG dampening control approach is limited in its ability to suppress the sub-synchronous vibration. The suggested combined dampening optimization control strategy of DFIG and SVG can effectively mitigate the sub-synchronous fluctuation under the varying active power of wind farms, thereby enhancing the stability of the power grid.

CONCLUSION

Sub-synchronous oscillation's underlying physical process is thoroughly investigated. Later, we dive into the specifics of the self-optimization parameter tuning strategy and the synchronized dampening optimization control strategy. The following inferences can be emphasized for clarity: 1) Due to the high density of energy storage resources in DFIG and SVG, energy can be frequently traded between resources during system disturbances. This is the primary cause of the non-synchronous oscillations observed in a DFIG and SVG-connected electricity infrastructure. 2) The suggested synchronized dampening optimization control of DFIG and SVG can be used to reduce the sub-synchronous oscillatory current by adding reaction current. Through these measures, the reliability of the electricity infrastructure serving DFIG and SVG is enhanced. Thirdly, the best DFIG and SVG control parameters can be obtained through synchronized dampening optimization thanks to the self-optimization parameter tweaking approach suggested here.

Under non-synchronous frequencies, the synchronized damper control exhibits a superior dampening feature. Both the self-optimization parameter tuning strategy and the synchronized dampening optimization control strategy that were suggested are practical and efficient. Future work will also implement two elements of the present research: DFIG and SVG, with the goal of resolving the sub-synchronous instability issue in a real-world electricity system. Since proportional and differential control technologies are commonly used in engineering, we will first attempt to tackle real sub-synchronous issues using the suggested coordinated damper optimization control technique. Second, a wide variety of cutting-edge control methods for DFIG and SVG will be investigated for reducing sub synchronous oscillations.

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