A simulation model for hierarchical routing protocols in Wireless Sensor Networks

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Abstract

One of the critical issues in wireless sensor network is power saving scheme as network should be considered to operate more efficiently. The sensor nodes are usually operated by a finite number of batteries and it should have a certain lifetime for gathering, processing, and transmitting information. Since some sensor nodes may fail due to lack of power, this consideration has led to give more interest about routing protocols.
Depending on the network structure, a sensor network can be hierarchical or cluster-based hierarchical model, where the nodes will play different roles in the networks.
We present three different types of routing protocols: LEACH, PEGASIS, and VGA, several simulations are conducted to analyze the performance of these protocols including the power consumption and overall network performance.
On the average, VGA has the worst power consumption when the sensing range is limited, while VGA is the best when the sensing range is increased.

Related Work

Hierarchical routing is the procedure of arranging routers in a hierarchical manner. Specifically, hierarchical routing protocols have proved to have considerable savings in total energy consumption of the WSN. The less the energy consumption, the more the network life time.
In a hierarchical architecture or Cluster Based Routing Protocol (CBRP) the cluster members just send the data to the cluster head (CH), the CH routes the data to the base station (BS). This data aggregation in the head nodes greatly reduces energy consumption in the network by minimizing the total data messages to be sent to BS.
We analyze three cluster based scheduling mechanisms: LEACH, PEGASIS, and VGA.
- In LEACH (Low Energy Adaptive Cluster Hierarchy) the Cluster-head creates a Time Division Multiple Access (TDMA) schedule notifying each node when it can transmit, then each node send data during their allotted time.
-In PEGASIS (Power Efficient Gathering in Sensor Information Systems) Construct chain start at a node far from sink and gather everyone neighbor by neighbor, nodes passes token thru the chain to leader from both sides , then the leader transmit to the base station.
- In VGA (Virtual Grid Architecture) square clusters were used to obtain a fixed rectilinear virtual topology. Inside each zone, a node is optimally selected to act as CH. Data aggregation is performed at two levels: local and then global. The set of CHs, also called Local Aggregators (LAs), perform local aggregation, while a subset of these LAs are used to perform global aggregation.

Simulation Environment

Sensoria simulator for simulating different routing protocols is used as experiment platform. Sensoria is a fully fledged simulator for WSNs. It is a very powerful in simulating a range of small to large scale WSNs based on a simple and complete Graphical User Interface (GUI).
To evaluate the performance of the hierarchal routing protocols, the simulation consists of 80 homogeneous nodes with initial energy of 0.5 Joule, scattered randomly within a 40x40 m sensor field . The Base Station is (BS) located at (25,150) m, so it is at least 110 m far from the closest packets and 248 bit control packets. The energy consumption due to communication will be calculated using the first order energy model. We assume that each sensor node generates one data packet per time unit to be transmitted to the BS. For simplicity, we refer to each time unit as a round. During the simulation process, only a set of sources will be selected randomly at each round to send their data to the BS. The sensing range is 8 m.

Results

Two scenarios are used to measure the performance, as follows:

- In the first scenario we ran the simulations to determine the number of rounds of communication when the network loss its connectivity using LEACH, PEGASIS, and VGA with each node having the same initial energy level and transmission range which are 0.5 Joule and **15 m** respectively. Our simulations show the following results:

1. The lifetimes of the network are 2174, 1017, and 28 rounds for PEGASIS, LEACH, and VGA respectively, Figure 1 shows the network life time.

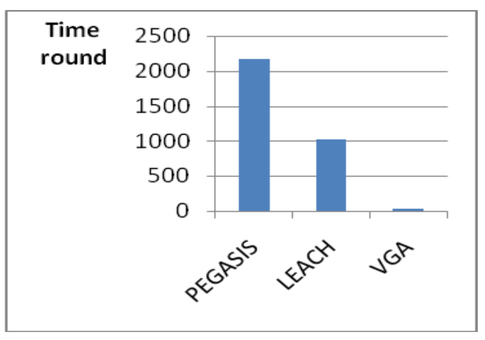

Figure 1. Network life time

2. The latest total network energy is 0.1170, 4.4354 and 13.2178 for PEGASIS, LEACH and VGA. The minimum value is achieved by PEGASIS, since it has loss connectivity after the round time for LEACH and PEGASIS.
3. The number of failed nodes became 99 at the last period in PEGASIS, 53 in LEACH and 49 in VGA .

We conclude that PEGASIS achieves approximately 2x the number of rounds compared to LEACH. It approximately achieves 77x the number of rounds compared to VGA. LEACH approximately performs 36x the number of rounds compared to VGA.

- We run the simulations to determine the number of rounds of communication when the network loss its connectivity, where this time the transmission range is **70 m**. Figure 2, 3 respectively shows the clustering in VGA when the transmission range is 15 m and when the transmission range is 70 m.

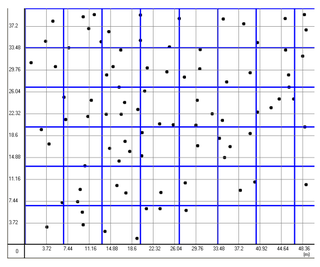

Figure 2. VGA with transmission range 15 m

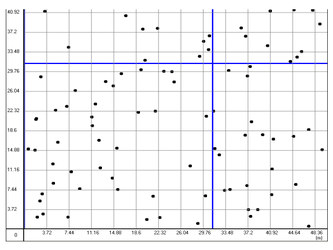

Figure 3. VGA with transmission range 70 m

Our simulations show that VGA approximately achieves 3x the number of rounds compared to PEGASIS. It approximately achieves 11x the number of rounds compared to LEACH. While PEGASIS approximately performs 3x the number of rounds compared to LEACH. The lifetimes of the network are 8124, 2285, and 741 rounds for VGA, PEGASIS, and LEACH respectively. Figure 4 shows the network lifetime.

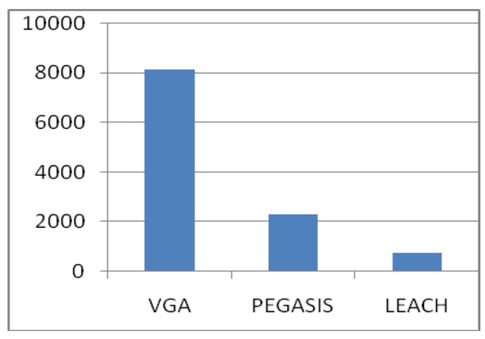

Figure 4. Network life time

Conclusion

In this work we presented a simulation model for LEACH, PEGASIS, and VGA hierarchical routing protocols. Sensoria simulator is used to compare the performance of the three routing protocols. The simulation results show that PEGASIS can greatly prolong sensor network's lifetime when the transmission range is limited. VGA saves more energy than other protocols when the transmission range is farther, since the early death of the nodes reduces the network's coverage badly.