Super Cluster based Routing Protocol in Sensor Network

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Abstract:

In variety of environments for applications, wireless sensor networks have received increasing attention in the recent few years. But, sensor nodes have many limitations including battery power and communication range. These networks require robust wireless communicant protocols that are energy efficient and provide low latency. In this paper, we propose new protocol as is defined SCP. The key idea of SCP is that only one node which is defined as a Super-Cluster Header sends the combined data to the BS. We evaluated the effectiveness of SCP through experiments which have several parameter violations. Simulation results shows that performance of SCP is much better than other legacy protocol within the framework of energy cost, life time of the sensor network and fair distribution of the energy consumption.

Keywords: Wireless sensor network, data aggregation, energy efficient operation, LEACH

1. INTRODUCTION

Wireless micro-sensor networks are expected to have significant impact on the efficiency a variety of environments for applications that include surveillance, machine failure diagnosis, and chemical, biological detection, since advanced in sensor technology, low power electronics, and low-power radio frequency (RF) design have led to the development of micro-sensors[1-5]. For example, in health, sensor nodes can also be deployed to monitor patients and assist disabled patients. Some other commercial applications include managing inventory, monitoring product quality, and monitoring disaster areas. In security system, acoustic, seismic, and video sensors can also be used to detection intrusions.

These sensor networks are very challenging due to several characteristics that distinguish them from contemporary communication and wireless ad hoc networks [1].

First of all, it is not possible to build a global addressing scheme for the deployment of sheer number of sensor nodes. Therefore, classical IP-based protocols cannot be applied to sensor networks. Second, in contrary to typical communication networks almost all applications of sensor networks require the flow of sensed data from multiple regions (sources) to a particular sink. Third, generated data traffic has significant redundancy in it since multiple sensors may generate same data within the vicinity of a phenomenon. Such redundancy needs to be exploited by the routing protocols to improve energy and bandwidth utilization. Fourth, sensor nodes are tightly constrained in terms of transmission power, on-board energy, processing capacity and storage and thus require careful resource management. However, the most important difference in the design of between sensor network and traditional wireless ad hoc network is that node's power, computational capacities, memory, and communication bandwidth are significantly more limited than traditional wireless ad hoc networks.

At the routing in sensor networks which having these constraints, the main aim is to find ways for energy-efficient route setup and reliable relaying of data from the sensor nodes to the sink, to use the available bandwidth and energy efficiently so that the lifetime of the network is maximized.

In this paper, we proposed new protocol SCP (Super-Cluster header based routing Protocol) to achieve the same goal. The key idea of our proposed scheme is that only one designated cluster header node, which is defined as a Super-Cluster Header, sends the combined data to the BS in order to gather data in regional. Therefore, the SCP can reduce energy cost significantly and increase the life of the sensor network.

We assume the flowing to achieve SCP :

Every sensor node has power control and the ability to transmit data to any other sensor node or directly to the BS [6, 7].

Each sensor node always has data to send to the end user.

Every node has location information.

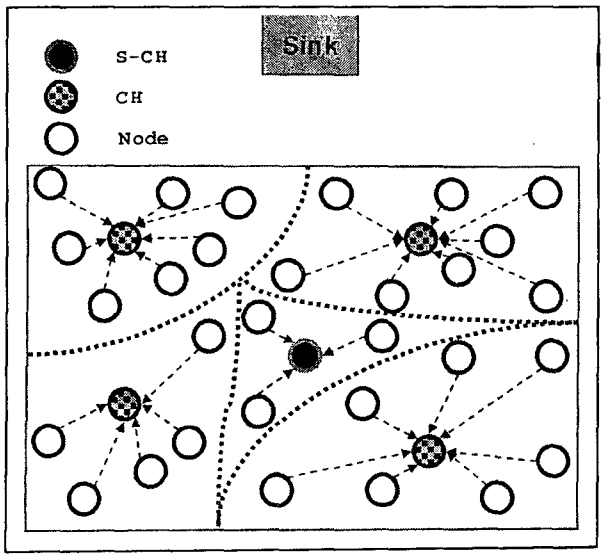
These assumptions are reasonable due to technological advances in radio hardware and low-power computing.

This paper is organized as follow: In this paper's section 2, we introduce legacy routing protocol and problems of the legacy routing protocol in sensor network. In section 3, we present a Radio Model for Energy in Sensor Network. We represent proposed mean in section 4. In section 5, we compare proposed method with legacy method through simulation and analysis them and then finally, we conclude in section 5.

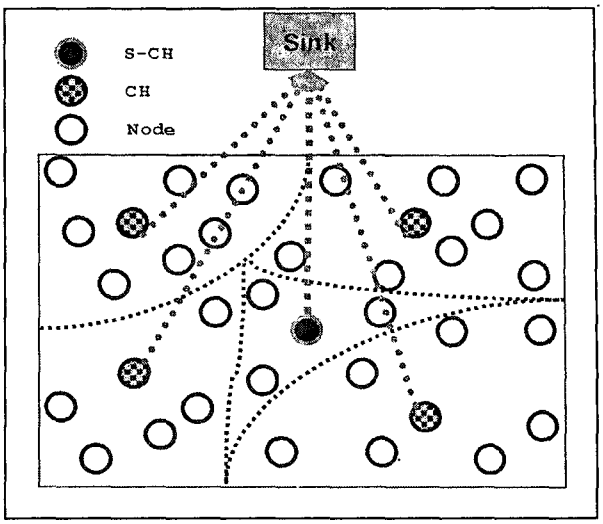
2. LEGACY ROUTING PROTOCOL IN SENSOR NETOWRK

In sensor network, all data sensed from all nodes have to be collected and be sent to a distant BS (Base Station), where the end-user can access the data. A simple approach to accomplishing this task is for each node to transmit its data directly to the BS. Since the BS is typically located far away and the energy cost is proportional the distance in transmission, the cost to transmit to the BS from any node is high so nodes will die very quickly. In addition, Since the BS is received redundant data which can be done very well; node's unnecessary data and energy is being used. Therefore, an improved approach is data fusion that helps to reduce the amount of data transmitted between sensor nodes and the BS [9-11]. It uses as few transmissions as possible to the BS and reduces the amount of data that must be transmitted to the BS in order to reduce energy and redundant data. Further, if all nodes in the network deplete their energy levels uniformly, then the network can operate without losing any nodes for a long time.

LEACH is one of the most popular hierarchical routing algorithms for these approaches in sensor networks. Fig. 1. shows operation of LEACH.



(a). Data gathering in cluster



(b). Data transmission from each CH to BS

Fig. 1. shows operation of LEACH

LEACH is a self-organizing, adaptive clustering protocol that uses randomization to distribute the energy load evenly among the sensors in the network. In LEACH [1, 12-13], the nodes organize themselves into local clusters, with one node acting as the local base station or cluster heads. If the cluster heads were chosen a priori and fixed throughout the system lifetime, as in conventional clustering algorithms, it is easy to see that the unlucky sensors chosen to be cluster-heads would die quickly, ending the useful lifetime of all nodes belonging to those clusters. Thus LEACH includes randomized rotation of the high-energy cluster-head position such that it rotates among the various sensors in order to not drain the battery of a single sensor. In addition, LEACH performs local data fusion to "compress" the amount of data being sent from the clusters to the base station, further reducing energy dissipation and enhancing system lifetime. The idea is to form clusters of the sensor nodes based on the received signal strength and use local cluster heads as routers to the sink. This will save energy since the transmissions will only be done by such cluster heads rather than all sensor nodes. Optimal number of cluster heads is estimated to be 5% of the total number of nodes [1, 12-13]. All the data processing such as data fusion and aggregation are local to the cluster. Cluster heads change randomly over time in order to balance the energy dissipation of nodes. This decision is made by the node choosing a random number between 0 and 1. The node becomes a cluster head for the current round if the number is less than the following threshold:

$$T(n)=\begin{cases}\dfrac{p}{1-p*(r \bmod 1/p)} & if\ n \subset G \\ 0 & Otherwise\end{cases} \quad (1)$$

Where p is the desired percentage of cluster heads (e.g. 0.05), r is the current round, and G is the set of nodes that have not been cluster heads in the last 1/p rounds.

In LEACH, a designated node in each cluster collects and fuses data from nodes in its cluster and transmits the result to the BS. LEACH uses randomization to rotate the cluster heads.

In LEACH, since a small number of clusters are formed in a self-organized manner, it is an elegant solution to energy efficiency in sensor network. The nice property of the LEACH protocol is that it is completely distributed and sensor nodes organize in a cluster hierarchy to fuse their data to eventually transfer to the BS without requirement in global knowledge of network. Therefore, the nodes die randomly and dynamic clustering increases lifetime of the system. Actually, LEACH achieves over a factor of 7 reduction in energy dissipation compared to direct communication and a factor of 4-8 compared to the minimum transmission energy routing protocol

2.1. The problem of LEACH protocol

Although, The LEACH is an elegant solution to data fusion, but, LEACH have several following problems.

Cluster head of average five percent in a network of nodes transmit the fused data from the cluster to the distant BS. Further improvement in energy cost for data gathering can be achieved if only one node transmits to the BS per round.

3. RADIO MDDEL FOR ENERGY CALCULATIONS

In this section, we present a Radio Model for Energy in Sensor Network which is same radio model as discussed in LEACH which is the first order radio model [12-13]. In this model, a radio dissipates E_{elec} = 50 nJ/bit to run the transmitter or receiver circuitry and E_{amp} = 100 pJ/bit/m^2 for the transmitter amplifier. The radios have power control and can expend the minimum required energy to reach the intended recipients. The radios can be turned off to avoid receiving unintended transmissions. An r^2 energy loss is used due to channel transmission [14-15]. The following equations show radio transmission costs and radio receiving costs for a k-bit message and a distance d.

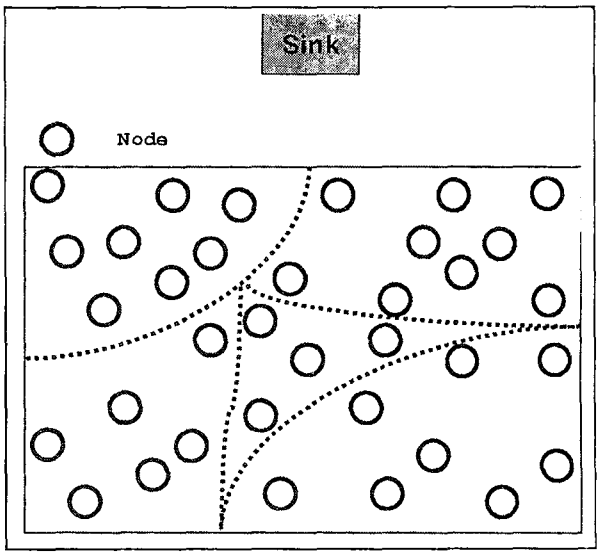
$$E_{Tx}(k,d) = E_{elec} * k + E_{amp} * k * d^2 \quad \text{(2)Transmission cost}$$
$$E_{Tx}(k,d) = E_{elec} * k \quad \text{(3) Receiving cost}$$

The best solution in sensor network is that the number of receives and transmissions is minimal. In our simulations, we used a packet length k of 2000 bits. With these radio parameters, when d^2 is 500m^2, the energy spent in the amplifier part equals the energy spent in the electronics part, and therefore, the cost to transmit a packet will be twice the cost to receive.

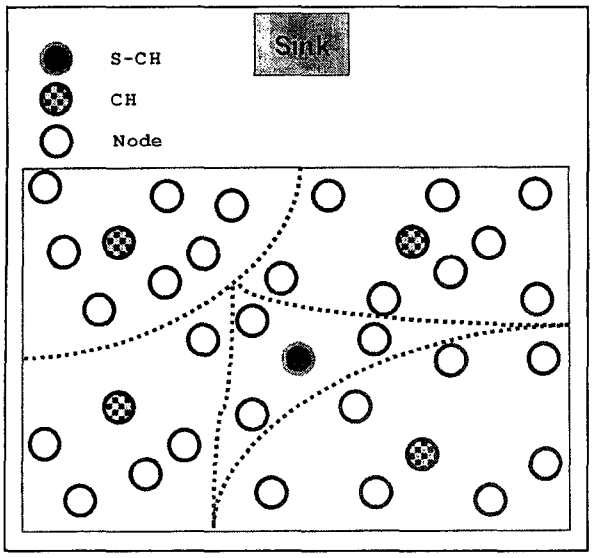
We make the assumption that the radio channel is symmetric such that the energy required to transmit a message from node X to node Y is the same as the energy required to transmit a message from node Y to node X for a given signal-to-noise ratio(SNR), typically 10 dB. For our experiments, we also assume that all sensors are sensing the environment at a fixed rate and thus always have data to send to the end-user.

4. SCP : SUPER CLUSTER HEADER BASED PROTOCOL

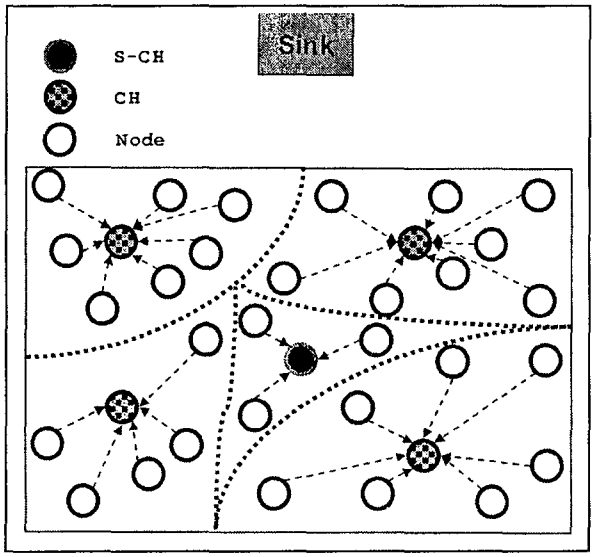
The most important problem of LEACH is that cluster head of average five percent in a network of nodes transmit the fused data from the cluster to the distant BS. Therefore, we present a new protocol called SCP in order to meet the unique requirements of wireless micro-sensor network. The SCP is near optimal to energy cost for data gathering. In addition, it fairly distributes the energy consumption. The key idea of our proposed scheme is that only one node which is defined as a Super-Cluster Header, sends the combined data to the BS in order to gather data in regional. Therefore, the SCP can significantly reduce energy cost and increase the life of the sensor network. SCP is similar to operate on LEACH. When Cluster header sends advertisement message, we compare to their signal strength in order to select only one node which is defined as a Super-Cluster Header. Super-Cluster Header is selected as having the maximum signal strength among cluster headers. Selected Super-Cluster header broadcasts ADV message. Non-Super Cluster headers send all of the information in each cluster o Super-Cluster header, and then Super-Cluster header combines all of the information in sensor network, and then combined information directly send to BS. These operations are more efferent than LEACH n framework of energy cost, life time of the sensor network and fair distribution of the energy consumption. Fig. 2. shows operations of SCP.



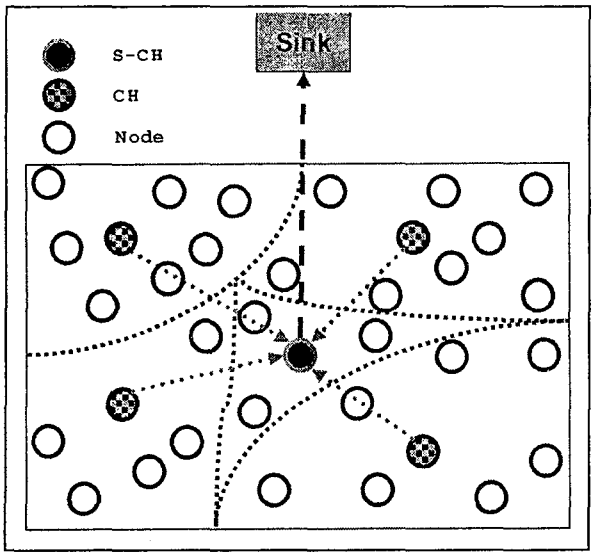
(a). randomly placed the nodes in the playing field



(b). selecting cluster header, Super-Cluster header



(c). regional data gathering.



(d). data transmission of the Super-Cluster header after data gathering from cluster header to Super-Cluster header.

Fig. 2. operations of SCP

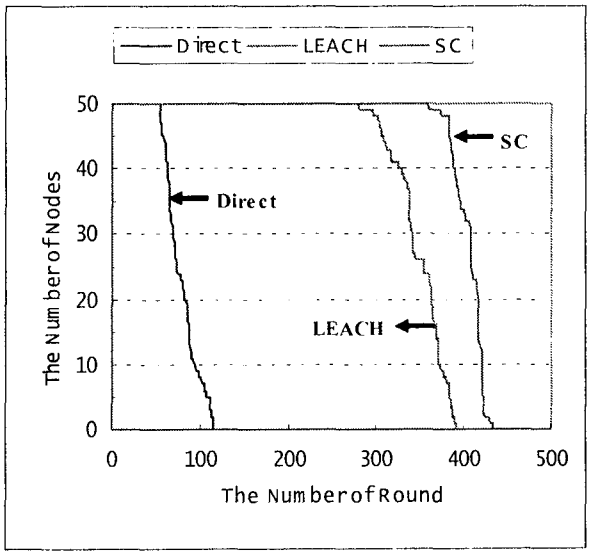
5. SIMULATION

In this section, we evaluate the effectiveness of the proposed scheme through experiments. We choose several parameter violations to investigate the performance of our scheme and compare it to other schemes. Experiments are carried out in each different network topologies. In each network topology, N nodes are randomly scattered in a fixed deployed area. The sink is located at least 100m from the nearest node. The packet size is fixed. We assume that all of the nodes have the same initial energy level of 0.25J. Table 1 shows simulation parameter.

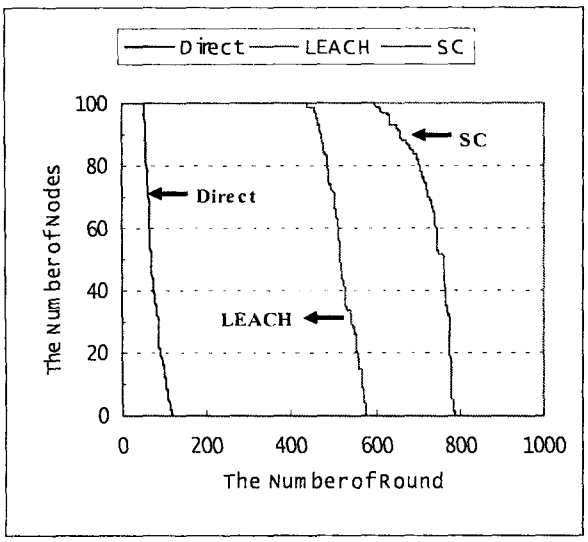
Table 1. simulation parameter

The number of nodes	50, 100, 200
Map size	50 x 50m, 100 x 100m
Packet size	2000bit,5000bit,10000bit
The location of sink	(25,150), (50,200)

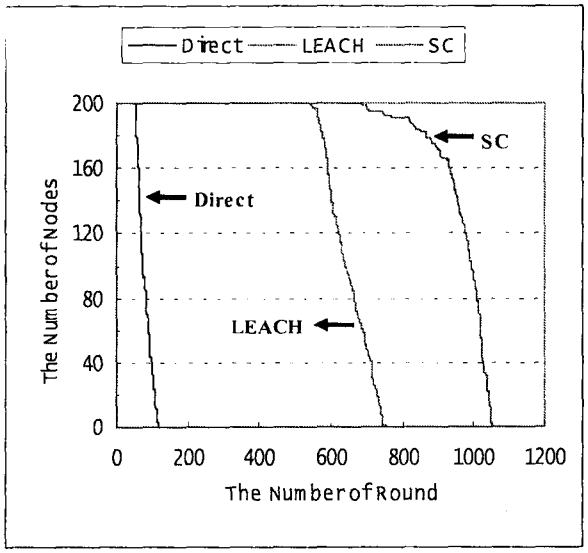
Main objectives of our simulation is to show SMP is better than legacy protocol within the framework of energy cost , life time of the sensor network and fairly distributes the energy consumption. Fig. 7. ~ 8. show the number of rounds of communication achieved until all nodes die to use direct transmission, LEACH, SC in order to compare performance within the framework of our main objectives. Parameter of Fig 7 is that size of network is 50m x 50 m, location of BS is (25,150), packet size is 2000bit, and then the number of nodes is 50, 100 and 200. Parameter of Fig 8 is that network is 100m x 100 m, location of BS is (50,200), packet size is 2000bit, and then the number of nodes is 50, 100 and 200. The results of simulation show that SCP is much better than other legacy protocol within the framework of energy cost, life time of the sensor network and fairly distributes the energy consumption, since only one node which is defined as a Super-Cluster Header, sends the combined data to the BS in order to gather data in regional. Also, the results of simulation indicate that SCP is suited to dense sensor network, since the number of rounds decrease when the map size and the number of nodes increase.



(a). 50 x 50m, 2000bit, BS(25,150), N(50)

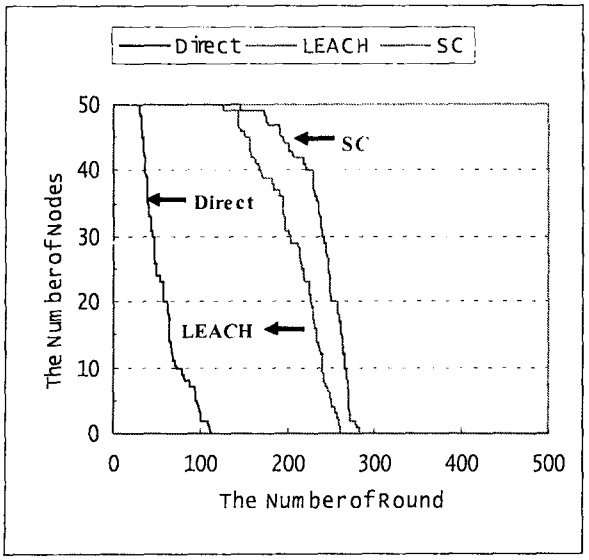


(b). 50 x 50m, 2000bit, BS(25,150), N(100)

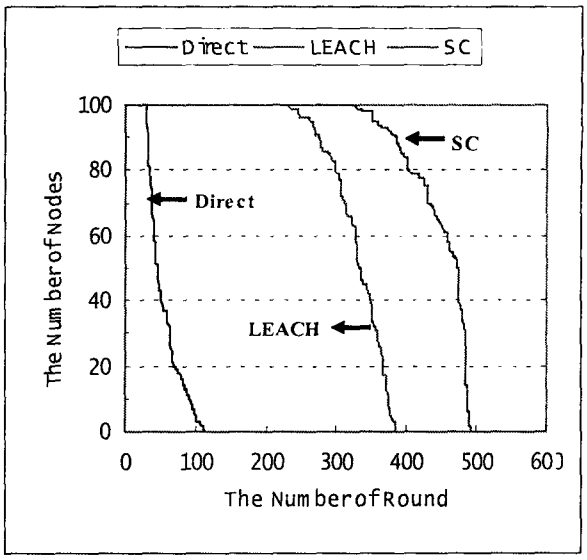


(c). 50 x 50m, 2000bit, BS(25,150), N(200)

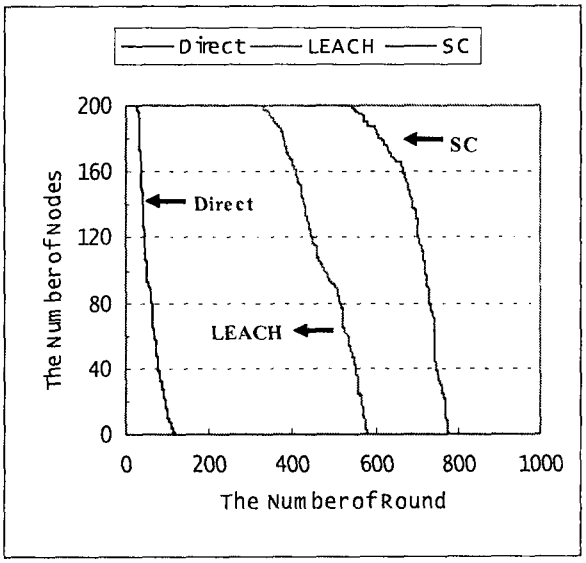
Fig .7. Performance results for a 50m x 50m network.



(a). 100 x 100m, 2000bit, BS(50,200), N(50)



(b). 100 x 100m, 2000bit, BS(50,200), N(100)



(c). 100 x 100m, 2000bit, BS(50,200), N(200)

Fig .8. Performance results for a 50m x 50m network

6. CONCLUSION

In this paper, we investigated the performance of SCP using new clustering algorithm for sensor network. Our proposed scheme overcomes problems of LEACH that cluster heads of average five percent in a network transmit the fused data to the distant BS. In our scheme, only one node sends the combined data to the BS. Therefore, performance of SCP is much better than other legacy protocol within the framework of energy cost, life time of the sensor network and fair distribution of the energy consumption.

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