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Reconstruction of internet of things based on compression sensing

Xianrui Deng[1], Yubin Liu[1*], Weiying Ding[1]

Abstract. In order to further reduce the energy consumption of wireless sensor networks (Sensor Networks Wireless, WSNs) and prolong the network lifetime, a distributed fuzzy logic based reasoning (WSNs) non uniform clustering routing (DUCF) is proposed. Wireless Sensor Networks (Sensor Networks Wireless, WSNs) are widely used in various fields. While the limited battery power is one of the biggest challenges in deploying WSNs applications, reducing the energy consumption of nodes has become the focus of research. The most common way to conserve energy is to use the node's sleep wake mechanism. For this purpose, the Improved New protocol time-based Relieved energy consumption (sleep) is proposed based on the optimal sleep time. The new protocol algorithm can improve the energy efficiency of the nodes by dynamically setting the time of the nodes. new protocol algorithm first establishes the sensing anomaly event model, and predicts the occurrence rate of the next abnormal event, and then establishes the cost function according to the residual energy factor and the data risk factor. The contradiction between the network energy consumption and the detection time delay of abnormal events by using the cost function. Finally, by solving the cost function of the optimal bisection method, the sleep time. The simulation results show that the proposed new protocol algorithm can effectively reduce the energy consumption and prolong the network lifetime without increasing the delay.

Key words. wireless sensor network; energy cost; delay; coverage; protocol.

1. Introduction

WSNs (Wireless Sensor Network) is applied in every walk of life, such as environmental monitoring of plant production, health care, target tracking and military reconnaissance [1-2]. Sensor node senses environmental data on a specified period and transmit it to information sink via multihop communication in monitoring area. For example, in plant cultivation base, sensor node senses environmental message such as temperature and humidity. By analyzing sensing data to determine if monitoring environment is in favor of vegetation or not [3-4]. These WSNs applications require that monitoring area can be fully covered by sensor node, namely all moni-

[1]Department of Computer Science, Tangshan Normal University, China

toring area is within sensing range of sensor node. SPMSC-Boc scheme mainly solve two problems: 1) how to forecast dump energy of sensor node, including energy consumption and obtained solar energy of current node; 2) how to dispatch node mobility. For one thing, estimate shadow area using growth model of the plant, at the same time, divide monitoring area into multiple grids that each node may cover one single grid, and dispatch node mobility to ensure that there's at least one node will across from each grid within work cycle. In the end, initial parameter of simulation is established and computer simulation is carried out through experiment reparation, the performance of SPMSC-Boc scheme is analyzed. Simulation results demonstrate that the node number of SPMSC scheme proposed reduced 4% and network lifetime improved 10% compared with similar schemes.

2. System model and problem description

2.1. Energy model

Each sensor mode may use solar panel to obtain energy E_{solar}, which is relevant to solar radiation intensity, as shown in formula (1)

$$E_{solar} = c \times E_{gen}\,, \tag{1}$$

where, E_{gen} is denoted as energy obtained by solar radiation intensity, c is c solar radiation intensity, unit is MJ/m^2.

The energy of sensor node mainly consumed in node movement, data transmission and data acceptance. Energy consumption of data transmission and data acceptance are $E_{Trans}\,(x, d)$ and $E_{Recep}\,(x)$, respectively, the definition of it is shown as in formula (2) and (3).

$$E_{Trans}\,(x, d) = E_{elec} \times x + \varepsilon_{amp} \times x \times d^2\,, \tag{2}$$

$$E_{Recep}\,(x, d) = E_{elec} \times x\,, \tag{3}$$

where, x is bit number, d is transmission distance. E_{elec} and ε_{amp} are denoted as energy consumption of signal and power amplifier, respectively, and they are the constant [8].

Energy consumption of node movement is denoted as E_{move}, as shown in formula (4).

$$E_{move} = d_m \times E_m\,, \tag{4}$$

where, d_m is denoted as moving distance and E_m is denoted as energy consumption of when moving 1m [1].

In addition, sensor node needs to sense environmental data. Suppose that to sense energy consumption of x bit number:

$$E_{sense} = E_{elec} \times x + E_s\,, \tag{5}$$

where, E_s is denoted as energy required when starting sensing data.

2.2. Solar energy model

Based on the analysis above, the intensity of solar radiation determines solar energy. Radiation intensity however changes along with weather situation. Toward this reason, four various kinds of radiation intensity $c_{night}(t)$, $c_{cloudy}(t)$, $c_{sunny}(t)$ and $c_{shadowy}(t)$, which are denoted as radiation intensity of night, daytime, sunny day andsunshine-covering, are defined. Intensity of solar radiation is determined by vegetation and solar position if it's sunny day, as shown in figure 1. The sun is covered by tomato. According to related literature, plant growth N_t:

$$N_t = \frac{K}{1 + \left(\frac{K}{N_{t-1}-1}\right) e^{-n}}\,, \tag{6}$$

where, N_t, K and n are denoted as height, weight and growth parameter of plant, respectively.

Fig. 1. Shadow diagram

3. SPMSC scheme of location

3.1. Computational energy

Initial t_j within every working cycle I, each node forecasts energy consumption and energy supply (solar energy) within I, then compute $t_j + I$ dump energy when work cycle I comes to an end. There are two situations: node remains static in work cycle I; node moves in work cycle I. The determination of movement for node is based on moving strategy.

Next, for one thing, forecast energy consumption and energy supply. According to energy model of previous section, the node is within time of t_j and t_j+I, consumed energy E^-_{total}:

$$E^-_{total} = E_{sense} + E_{Trans} + E_{Recep} + E_{move} \times flag\,, \tag{7}$$

where, $flag$ is denoted as if the node moves or not. If node doesn't move,

$flag = 0$, otherwise $flag = 1$.

In addition, each node forecasts obtained energy E^+_{total} through solar panel within time of t_j and $t_j + I$. Based on analysis of section 2.3. Weather situation has an impact on energy E^+_{total}. Suppose that the node determines weather condition by sensing weather, temperature and humidity etc data. Therefore, four marking variables $\alpha_{night}(t)$, $\alpha_{cloudy}(t)$, $\alpha_{sunny}(t)$ and $\alpha_{shadowy}(t)$ require to be defined, if their value are 1, then it indicates that it's night, cloudy day, sunny day and sun-covering, otherwise is 0. Obtained energy E^+_{total} of node:

$$\begin{aligned} E^+_{total} =& E_{gen} \times \int_{t_j}^{t_j+I} [c_{sunny}(t) \times \alpha_{sunny}(t) \\ &+ c_{shadowy}(t) \times \alpha_{shadowy}(t) \\ &+ c_{night}(t) \times \alpha_{night}(t) \\ &+ c_{cloudy}(t) \times \alpha_{cloudy}(t)]\, dt\,. \end{aligned} \tag{8}$$

3.2. Mobile scheduling of node

3.2.1. Selection of zone head

At the beginning of each work cycle I, one node is selected for each subdomain as the leader of it, it's called as head zone LN(Leader Node). Each head zone LN takes charge of mobile scheduling work of node mobility within domain in order to make the whole domain is covered with node.

At the initial time t_j within work cycle I, dump energy $E_{residual}$ for node is computed and set timer T_{imer} according to $E_{residual}$, once a timer is terminated, be prepared to broadcast campaign message M_{LN} of head zone. If no message M_{LN} received from other nodes before the completed timing of a timer, then immediately broadcast message M_{LN} when definite time is terminated, and it becomes LN of this subdomain. If message M_{LN} received from other nodes, then reset the times and close it.

$$T_{imer} = \left\lfloor \frac{T}{E_{residual}} \right\rfloor , \tag{9}$$

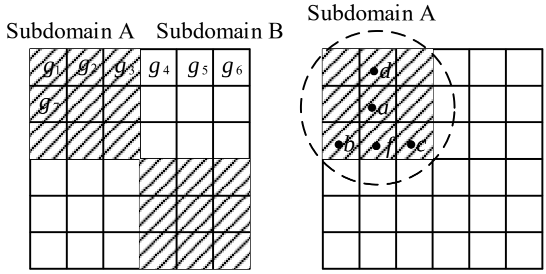
where, $\lfloor\cdot\rfloor$ is denoted as integer conversion of lifting step.

Based on formula (9), nodes with more dump energy come with great probability of becoming head zone LN.

3.2.2. scheduling node mobility

Head zone LN will collect beacon packet sent from sensor node within domain after head LN is determined. Beacon packet contains current dump energy of nodes and location information, which such location information is denoted as grid number of specified position. Grids of each subdomain are all numbered, the grid number is $g_1, g_2, \cdots, g_m$.

Head zone LN will judge nodes of uncovering network by detecting position information sent by the node within domain. Judgement principles: if nodes exist in grids, that means such grid is covered, the other way around.



(a) Grid number (b) Uncovering network

Fig. 2. The grid

After determining uncovering network, head zone LN takes charge of node movement within scheduling domain so as to ensure such uncovering networks will be covered within work cycle I. For one thing, head zone LN obtains dump energy information of each node in head zone in advance from beacon packet, then computes energy variation generated from all nodes to every uncovering network and selects a most suitable moving node aiming at each uncovering network.

Set an example of figure 3, 9 grids, of which g_1, g_3, g_7, g_9 are not covered, exist in domain A. As head zone LN, node a first compute change conditions of energy generated from each node to g_1, as shown in table 1. Table 1 lists out energy changes of all nodes to g_1, for example, if move node a to g_1, 5% energy will be consumed, node b, c and f consumed 5%, 15%, 5% and 5% energy, respectively, however, if move node d to g_1, its energy will be increased. This is because solar energy obtained is greater than consumed energy of movement in the process, its energy increased to 5%.

Table 1. Consumed energy of movement from node within subdomain A to g_1

Node	Current energy	Dump energy after moving to g_1
Node a	60%	55%
Node b	55%	50%
Node c	50%	35%
Node d	55%	60%
Node f	50%	45%

Through these data, node a selects node d to move to g_1, as shown in figure 3. Then select appropriate mobile node for g_3, g_7, g_9, respectively, in a similar way. Sensing data of new position will be sent to information sink after moving.

4. Numerical analysis

The performance of SPMSC-Bo scheme is analyzed based on experiments. For one thing, carry out experiment reparation to obtain experimental parameter, then

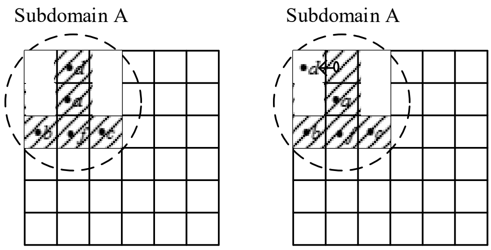


Fig. 3. Sample of Movement scheduling node

conduct computer simulation and analyze the performance of SPMSC-Bo scheme.

4.1. Experimental reparation

4.1.1. Solar power supply model

This section establishes a model of solar power supply, as shown in figure 4. MPPT (Maximum Power Point Tracking) circuit, solar panel and two batteries are used to constitute a solar charge, of which, the size of solar panel is $104mm \times 48mm$.

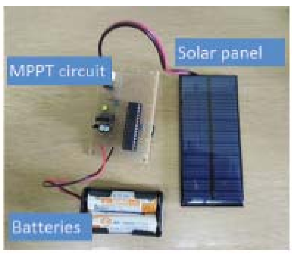


Fig. 4. Model of solar power supply

For one thing, measure solar energy of sunshine area and shadow area in a sunny day. 10 times of measurement for each area, of which shadow area refers to the sunshine area covered by plant etc obstacles. Measured date is shown as figure 2. Based on table 2, solar energy generated from sunshine area is more than from shadow area on an equal footing, the latter only accounts for 13% of the precedent. The data shows that intensity of sunshine radiation has an influence on solar energy. In a follow-up experimental simulation, sunshine area in table 2 is used as energy of unit time for sunny day and shadow area energy is used as solar energy of unit time of night, cloudy day and sunshine-covering.

Table 2. Area energy

Area	Energy
Sunshine	180mW
Shadow area	24 nW

4.1.2. Node mobility model

The node mobility model is shown as figure 7. Beauto detector is used as consumed energy of measuring mobile node [10]. The movement speed of node is 50cm/sec and measure its electric current and power consumption in the process of movement. By repeating experiment, power consumption is 1680mW when the speed is measured to be 50cm/sec.

4.2. Experimental simulation

In this experiment, tomato planting base is the main study subject, temperature and humidity data of the base are collected with sensor node. The goal of analysis is: dispatch node movement in a special period to have the entire base covered [11], experiment parameter is listed out in table 3.

Table 3. Experiment parameter

Parameter	Value
Target	$100m\times100m$ $200m\times200m$
Sensing radius	30 m
T	90 d
Cell voltage	2.4V
Battery capacity	1000mAh
E_{elec}	50nJ/bit
ε_{amp}	100pJ/bit/m^2
E_{sense}	0.018J/bit
Networking protocol	802.11a
Routing protocol	AODV
Propagation type	TwoRay Ground

Considering the growing period of tomato, it's required to monitor lifetime of wireless network of tomato planting base for 90 days. That is, all ranges of tomato planting base is to be monitored with sensor node within 90 days.

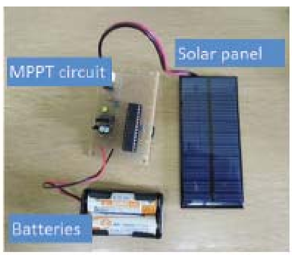


Fig. 5. Tomato and model

The code moves along with ridge in tomato planting base, as shown in figure 5. Simulate planting stent of tomato as plane figure of figure 6, of which the width and height of ridge are 120m and 20cm, respectively. Mobile node is able to move freely along with interspace between ridges and to move around if runs into ridge.

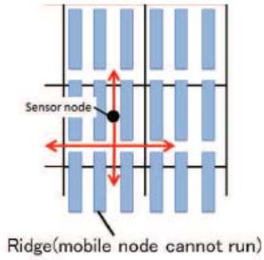


Fig. 6. Mobile node model

4.3. Simulation data and analysis

First of all, analyze the influence of mobile node number on lifetime of WSNs. In other words, Mobile node number is needed if to maintain an coverage of 90 days. Make a comparison of SPMSC-BoC proposed and SS (Simple Scheme). So-called SS scheme refers to node that lack of solar collection equipment, and only dump consumption of code is taken into consideration when decision node is moving. Repeat 10 times for each experiment and take an average value as final data. Figure 7 and 8 drew area data of two sizes $100m \times 100m$ and $200m \times 200m$, respectively. Of which, I=15mins. In figure 7, however, 23 mobile nodes are needed when SPMSC-BoC scheme maintains lifetime of 90 days, no less than 24 mobile nodes are needed for SS scheme. Similarly, in $200m \times 200m$ area, 96 nodes are needed for SPMSC-BoC scheme, however, 97 nodes are needed for SS scheme. The data shows, compared with SS scheme, that node number of SPMSC proposed has reduced 4% and 2%, respectively, in the area of $100m \times 100m$ and $200m \times 200m$, the lifetime of SPMSC scheme average improved 16% and 10% on average than SS scheme in $100m \times 100m$ and $200m \times 200m$ environment.

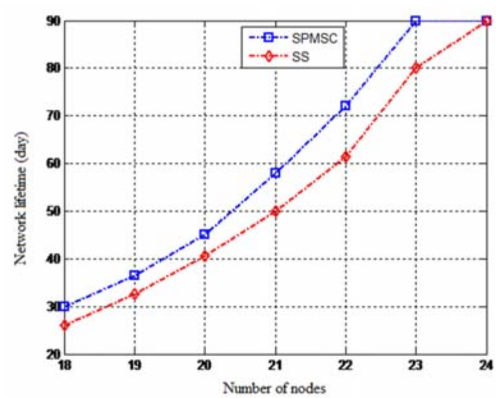


Fig. 7. network lifetime ($100m \times 100m$)

In addition, figure 9 describes dump energy of 23 nodes in $100m \times 100m$ environment. Figure 9 shows that dump energy of SPMSC-BoC scheme proposed are

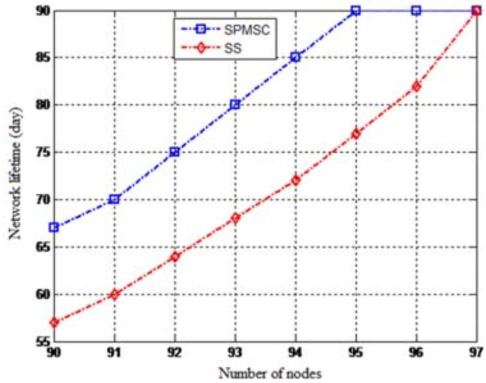


Fig. 8. Network lifetime ($200m \times 200m$)

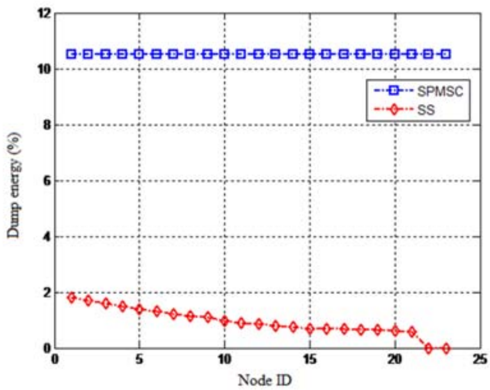


Fig. 9. Dump consumption

all higher than SS scheme and the energy is in a homogeneous distribution.

5. Conclusion

This article put forward SPMSC-BoC scheme in which scheduling mobile node is used to increase coverage rate and obtain solar energy to the best aiming at node coverage issue of agricultural region. The most suitable node mobility is selected for SPMSC-BoC scheme by forecasting consumed energy, which results from mobility, of node and obtained solar power. Simulation results demonstrate that the node number of SPMSC scheme proposed reduced 4% and network lifetime improved 10% compared with similar schemes.

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