IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

Convergence of MANET and WSN in IoT Urban Scenarios.

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ABSTRACT:

The power consumption and energy efficiency of wireless sensor network are the significant problems in Internet of Things network. In this paper, we consider the network topology optimization based on complex network theory to solve the energy efficiency problem of WSN. We propose the energy efficient model of WSN according to the basic principle of small world from complex networks. Small world network has clustering features that are similar to that of the rules of the network but also has similarity to random networks of small average path length. It can be utilized to optimize the energy efficiency of the whole network. Optimal number of multiple sink nodes of the WSN topology is proposed for optimizing energy efficiency. Then, the hierarchical clustering analysis is applied to implement this clustering of the sensor nodes and pick up the sink nodes from the sensor nodes as the clustering head. Meanwhile, the update method is proposed to determine the sink node when the death of certain sink node happened which can cause the paralysis of network. Simulation results verify the energy efficiency of the proposed model and validate the updating of the sink nodes to ensure the normal operation of the WSN.

Keywords: energy efficiency, path length ,clustering, multiple sink node.

I. INTRODUCTION:

Wireless sensor technology is playing a vital role in many of the commercialized industrial automation processes and various other real life applications [1–4]. It is particularly suitable for harsh environment applications where deploying of other network infrastructure is difficult and/or almost impossible such as in battlefield, in hazardous chemical plant, and in high thermal environment. It is not uncommon to see that most of the crucial surveillance and security applications also rely on sensor based applications. Sensors which are tiny in size and cheap in cost have the capabilities to be deployed in a range of applications as explained in [5–9]. Essentially all sensor networks comprise some forms of sensing mechanism to collect data from an intended physical environment either by a time driven approach or by event triggering approach. By these approaches a sensor will convey the sensed data to a destination or sink (multiple destinations/sinks are also possible) via some kinds of routing algorithm such as Minimum Cost Forwarding Algorithm (MCFA), Directed Diffusion Routing Protocol (DDRP), or one of the cluster-based routing protocols. Being very small in size, sensor nodes are built with limited computational capacity, small storage memory, and finite battery power capacity [10].

The structure of a typical WSN node [11] consists of four main components: a sensing element, normally used for sensing a physically measureable parameter; an Analog-to-Digital Converter (ADC), used for converting analog signals to some digital formats; a processing unit, providing simple/basic data processing and computation capabilities; and a power unit, responsible for sensor node's operation life span. It is a known fact that WSN is a resource constrained network in which energy efficiency is always the main issue since the operation of WSN depends heavily on the life span of the sensor nodes' battery [12]. The most energy consuming operation in WSN is the data packet routing activity. The characteristics of the WSN are different from the conventional networks [13, 14]. These unique characteristics are often taken into account for addressing the issues and challenges related to network coverage, runtime topologies management, node distribution, node administration, node mobility energy efficiency/consumption, network deployment, application areas/environment, and so forth [15–17].

Nodes in a WSN are generally energy, computation, and memory constrained. Consequently, there is a need for research and development into low-computation resource-aware algorithms for WSNs, targeting at small, highly resource constrained embedded sensor nodes. Energy consumption is of prime importance in WSNs and thus some algorithms [18–24] and hardware were designed with energy efficiency or energy awareness as a central focal point of interest. Enhancing energy efficiency of WSN with respect to the communication routing protocol is the primary concern of this research. We propose a new routing protocol entitled "Position Responsive Routing Protocol (PRRP)" and compare its performance with the well-known LEACH and CELRP protocols. The simulation results show a significant improvement over the aforementioned protocols in terms of energy efficiency and the overall performance of the WSN.

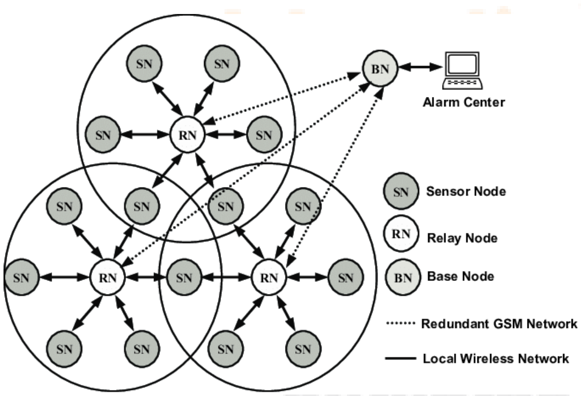


Fig 1: small world WSN topology

II.RELATED WORKS:

When comparing PRRP with LEACH on the basis of average energy consumed per packet, it is found that PRRP consumes less energy as shown in Figure 11. The observations show that, in PRRP with the initial data transmission periods, the average consumed energy is higher. On the other hand, when comparing PRRP and LEACH with more rounds of data transfer, it is found that PRRP is more efficient than LEACH. The reason for more average energy consumed in the initial round in PRRP protocol with single data transmission phase is that the initial setup cost is little higher and energy consumed in initial phases is considered to be overhead energy. However, PRRP outperforms LEACH for average per packet energy use after completing its entire round.

Factors	WSNs	CR-WSNs
Channels	Usually single channel (multiple channels possible)	Multiple channels are required
Protection of PU access priority	Not an issue	Must be protected; incumbent license holder for the channels must get priority
Hardware	Readily available (off-the-shelf)	Not readily available; still at the R&D level
Sensor form factor	Small	Moderate to large
Memory	Limited	High
CH	Any node can take a CH role	Mostly dedicated; role changes if all WS nodes have CR
CH as a single point of failure	Relatively less critical	Critical in case of dedicated CH
Computation capability	Moderate	High
Power	Power constraints	Comparatively higher power required
Global addressing scheme	Not required; not recommended	Generally not required, but recommended
Topology change handling	Relatively easy	Difficult
Trust and security	Relatively less critical	Highly critical
Duty cycle	Low	High; required to monitor PU arrival
Bandwidth deficiency	Yes	Generally not an issue
Metrics	Efficiency, resolution, latency, scalability, robustness	PU arrival prediction, channel switching, latency, robustness

TABLE I.

Relation between CR and Sink Node

Identify the Multiple Sink Nodes

Take the optimal value of sink nodes into cluster category and go for hierarchical clustering. Since the hierarchical clustering is the cluster method based on distance, the process of it can be divided into the following steps.

At first, find the similarity among objects and define the distance that can represent the differentiation of them. In this paper, the Euclidean distance that is calculated above is selected to realize the dissimilarity of them. When the objects and have a close relation, the value of is rather small, even close to 0.

Next, produce the hierarchical cluster tree with the linkage function. In accordance with the hierarchical clustering analysis for nodes topology, the distribution for sink nodes can be marked out; this process is shown in Figure 1.

Figure 1
Flow chart of the cluster process.

Just as Figure 1 shows, cluster nodes according to the matrix and sink nodes number which acts as cluster category; then separate individuals of the cluster based on the function *extract_clabel(T, K)* and name it as cluster point; put separated cluster points into the function *struct_property(a, b, c, d)*, to calculate for the solution of category node for cluster, sink node, and link distance between nodes and adjacency matrix. The details of function *extract_clabel(T, K)* and function *struct_property(a, b, c, d)* are given in Algorithms 1 and 2, separately.

function clust_point = extract_clabel(T, K)

% T: Number of the cluster, category that each individual belongs to

% K: Category numbers of the cluster

% clust_point: Divide data points of cluster, data points which have common points ascribed as one

```
nT = length(T);
num = 1;
for i = 1 : K
    num = 1;
    for j = 1 : nT
        if T(j) == i
            clust_point(i, num) = j;
            num = num + 1;
        end
    end
End
```

Algorithm 1
Function of *extract_clabel(T, K)*.

```
function struc_data = stuct_property(clust_point, num_categ, A, D)
% Work out value for individuals, adjacency matrix, distance matrix, give back the structure
struc_data
% clust_point: cluster individuals of per line
% num_categ: numbers of cluster
% A: initial data adjacency matrix
% D: initial data distance matrix
% struc_data
nc = size(clust_point); % size
for i = 1 : num_categ
    data(i).point = ; % individual of the cluster
    data(i).center = ; % cluster center
    data(i).A = ; % adjacency matrix of the cluster
    data(i).D = ; % distance of the cluster
    % cluster individuals
    for j = 1 : nc(1, 2)
        if clust_point(i, j) ~= 0
            data(i).point = [data(i).point, clust_point(i, j)];
        end
    end
    % adjacency + distance
    np = length(data(i).point);
    for j = 1 : np
        for k = 1 : np
            data(i).A(j, k) = A(data(i).point(j), data(i).point(k));
            data(i).D(j, k) = D(data(i).point(j), data(i).point(k));
        end
    end
    % cluster center
    sum_D = sum((data(i).D)');
```

```
    [sum_min_D, flag] = min(sum_D); % center with shortest path
    data(i).center = data(i).point(flag);
End
struc_data = data;
```

Algorithm 2
Function of *struct_property*().

2.4. Consider Dynamic Changes on Sink Nodes

For the realistic application, due to the complexity of detected environment and unknown factors for sink nodes, if they were broken and stopped working, the network may also get into trouble. So it is necessary to think about the backup to maintain the normal operation of the whole network. The sink node judgment process is shown in Figure 2.

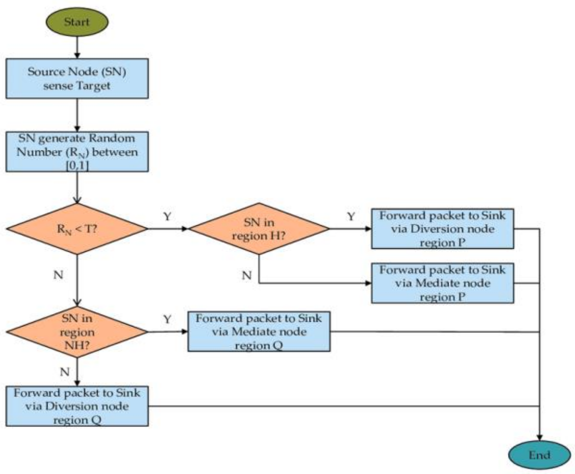


Figure 2
Flow chart of the sink node judgment process.

A flag that represents working state will be set up with the help of rand function. If the flag was set to be 0 which means this sink node was dead, the function *up_struct_property(data)* as shown in Algorithm 3 would help to replace the dead sink node with a new one. Then the new sink node was picked up according to the node link distance. If the flag was set to be 1 which means the sink node worked as usual, nothing would be updated for this sink node, and it would continue the node communication.

```
function struc_data = up_stuct_property(data)
% Utilized for updating the dead sink nodes
% Work out value for individuals, adjacency matrix, distance matrix, give back the structure
struc_data
% clust_point: cluster individuals of per line
% num_categ: numbers of cluster
% A: initial data adjacency matrix
% D: initial data distance matrix
% data: structure of different categories
% cluster center
sum_D = sum((data.D)');
```

[sum_sort_D, flag] = sort(sum_D); % distance arranged from small to lrge, the second small one as the center
data.center = data.point(flag(2)); % choose the second small one as the sink node center
struc_data = data

2.5. Energy Efficiency Measurement

The calculation for the energy consumption in the network is processed during the nodes communication. So firstly, the communication source and destination should be identified which concerns the judgment process of the state of sink nodes. Then, work out the calculation method for the energy consumption which is based on the formula for path loss while nodes are communicating. Within the path loss formula, the communication distance is required. And this will be achieved by the weighed shortest routing. Path loss is considered to measure the transmission loss in the topology as the energy consumption per sink node communication. Moreover, with the comparison between the initial energy of the network and total energy consumption, efficiency for the network is sure to be found out and go for optimizing. All the mentioned variables are summarized as follows.

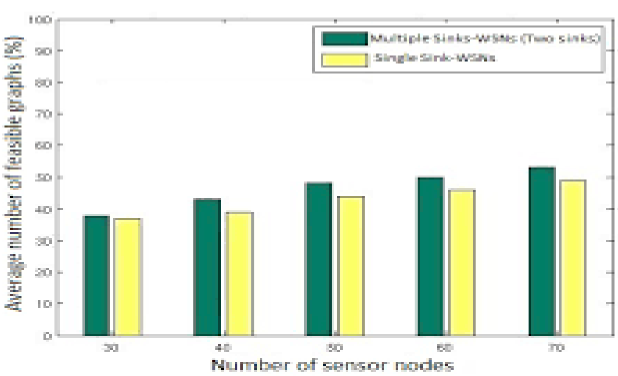
Variables Definition Pl: path loss for one time of communication among the sink nodes; : minimum transmission distance between nodes; : initial energy for the whole network; : energy efficiency of the network.
The energy efficiency of the network is measured by the Pl between communication nodes pair, so the energy efficiency can be worked out as

3. *Simulation Results*

In this section, we present the simulation results of the proposed energy efficient small world WSN model. The simulation is realized by MATLAB.

The simulation condition is selected within a square of 100 m × 100 m. Other variables in the simulation are shown in Table 1. Figure 3 shows the small world WSN topology with 64 sensor nodes. And the path

loss is defined as p1.



Conclusions:
In this paper, we propose a wireless sensor network model for energy efficiency, in which we first give the method of multiple sink nodes deployment and then consider the adjustment for dynamic change on sink nodes. In the proposed model, identification of the number and position of sink nodes has been

considered. According to the hierarchical clustering analysis, the small world WSN with multiple sink nodes marked finally worked out. When it comes to considering the realistic application of WSN, an update function helps to update sink nodes when some of them are out of work. Finally, we give the simulation results of the proposed energy efficient small world WSN node.**References:**

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