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A Review Paper on Power Consumption Improvements in WSN

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ABSTRACT: Wireless Sensor network (WSN) is a network of low-cost, low-power, multifunctional, small size sensor nodes which are densely deployed inside a physical environment to collect, process and transmit the information to sink node. As Sensor nodes are generally battery-powered, it is necessary to balance between power consumption and energy storage capacity to sustain sensor node's operational life. Therefore one of the important challenge in WSN is to improve power consumption efficiently to prolong network lifetime by minimizing the amount of data transmissions throughout the network and maximizing node's low power residence time. In this paper, two energy optimization techniques, Cluster-Based energy efficient routing (CBER) scheme and extension to IEEE 802.15.4 standard by dynamic rate adaption and control for energy reduction (DRACER) protocol for wireless sensor networks has been reviewed. CBER technique increases network lifetime by reducing Hot Spot problem and end-to-end energy consumption using multi-hop wireless routing whereas DRACER protocol reduces network latency and average power consumption by minimizing network overhead using automatic data rate selection process. So, both of these techniques, if utilized in combination, it is possible to achieve very high energy efficiency in WSN.

Keywords: Wireless Sensor Networks (WSNs), low-power, power consumption, CBER, DRACER protocol, IEEE 802.15.4.

I. INTRODUCTION

With recent technological advancements in micro-electro-mechanical systems (MEMs), wireless communication and digital electronics; it is now-a-days possible to design and develop low-cost, low-power, multifunctional, small size sensor nodes that communicate unrestrictedly in short distance. Large number of sensors nodes are densely deployed either inside a physical phenomenon or very closer to it, to form a wireless sensor network. WSN carries out sensing, data processing and communication between components to make it feasible for a wide range of potential applications, such as military applications, environmental (e.g. humidity, temperature etc.) and disaster monitoring as well as health care areas [2]. Due to low-power and small size sensor nodes, Data rate of WSNs are limited up to 1 Mbps and its wireless coverage limit is up to 1 Km. The actual limit of a WSN application depends on its adopted technologies and constraints introduces by that specific application [1].

Figure 1 shows the general architecture of Sensor nodes. Processing unit is the head part of sensor node, it is a microprocessor with limited amount of memory. The processing unit is connected to sensors via one or more analog to digital converters (ADCs), that combines to form Sensing unit. Sensing unit sense the data and transmit it to processing unit to process it. This processed data is then transmitted to sink node or a base station through transmission unit. Transceiver unit is capable of bidirectional communications. Some nodes may integrate a location finding system that helps the node to discover its position, relative to its neighbors or global. Power unit and Power generator are the key element in the architecture as power unit is responsible to provide the electrical power to all other unit of the system. Smart power units are also capable to provide information on the residual available energy in order to apply energy aware decisions.

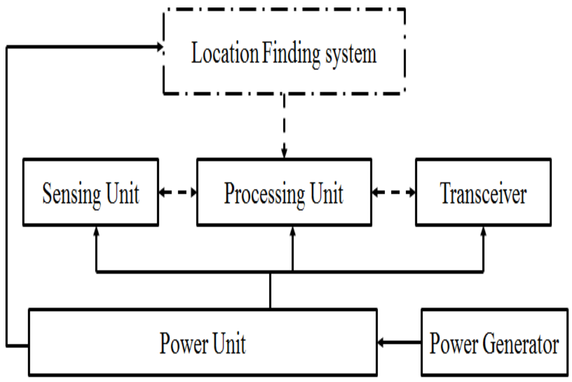

Fig. 1 Architecture of a Sensor node.

Since the power generator usually consists of batteries, sensor nodes have limited amount of energy available, thereby limiting lifetime of the node. Thus another parameter of WSN is sensor nodes operational life, mainly depends on balance between power consumption and energy storage capacity [1]. Densely deployed sensor nodes are battery-powered, that makes it quite challenging to recharge or replace nodes batteries. Radio interface of nodes are the main contributor to power consumption that makes energy efficiency as a critical issue. Hence, one of the important challenge in WSNs is to improve power consumption efficiently to sustain network lifetime by minimizing the amount of data transmission throughout the network and maximization of nodes low-power residence time.

In Wireless Sensor Network, use of multi-hop transmission for passing information to its neighbor, then to the sink node is more energy-efficient than single-hop transmission which forwards information directly to the sink node. Multi-hop transmission faces one critical issue is that sensor nodes closer to the sink node forwards more packet than compare to the nodes away from the sink node, therefore these nodes consumes energy resources quickly that tends to disconnection from network in early stage[4]. This problem is called hot spot problem[7]. Hot spots decreases the networks lifetime. Cluster based multi-hop transmission is more energy efficient than other technique[3].Cluster based energy efficient algorithm balances energy consumption and traffic load in the network by selecting different cluster heads CHs among all nodes and by determining cluster size for selected cluster heads in WSN[5].

If congestion occurs during packet transmission and reception, packets are discarded. So, it is necessary to retransmit discarded packet which causes additional processing time. This results into wastage of power consumption. Dynamic rate adaption and control for energy reduction (DRACER) technique, reduces wastage of power and minimizes the occupied channel time by adapting variable data rate for packets. In this technique, link quality indicator or received signal strength is extracted to identify signal-to-noise ratio (SNR). Based on the SNR of most recent packet, data rate for the next packet is determined [6].

In this paper, I have reviewed Cluster-Based energy efficient routing scheme and extension to IEEE 802.15.4 standard for variable data rate adaption for power consumption optimization under section II. This section contains discussion on power consumption improvement techniques. Section III contains conclusion and future scope.

II. LITERATURE SURVEY

A. Cluster Based Energy Efficient Routing Algorithm (CBER)[5]

It is a self-Organization Technique in which CH selection is based on Optimal Cluster head distance and energy state of nodes. For this technique homogeneous sensor nodes and four modes of nodes viz., Cluster head, Cluster Member, Dead node (energy below 0.005J), Isolated node (node doesn't have any neighbors to transmit and receive data) and constant traffic rate are considered.

Operation of CBER Algorithm is divided into two phases, they are Setup Phase and Steady Transmission Phase. Steps of setup phase are as follow:

- Create equal size hexagonal cluster using optimal cluster side (r), Maximum Transmission range of node (R) and Distance Between each Cluster Head (D). Figure 2 shows the equal size hexagonal cluster.

$$r = \frac{1}{\sqrt{13}}\left(\frac{2e_e}{(\beta-1)e_a}\right)^{1/\beta},$$
$$= \frac{1}{\sqrt{13}}\left(\frac{2e_e\lambda^2 d_R}{(\beta-1)p_{thr}(4\pi)^2}\right)^{1/\beta} \tag{1}$$

$$R = \sqrt{13}\cdot r, D = \sqrt{3}\cdot r \tag{2}$$

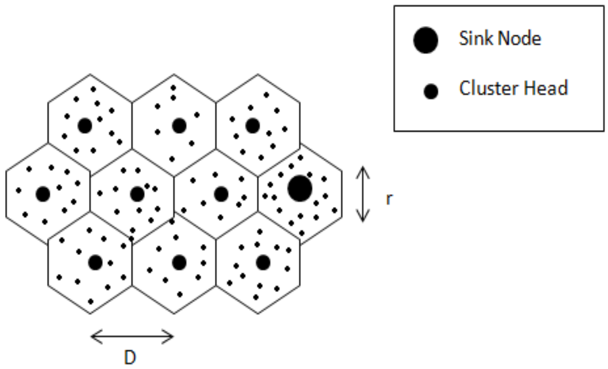

Fig.2 Cluster Based end-to-end Multi-hop transmission in hexagonal structure

- Create Cluster Member in each cluster finds 'Average Distance from node i to all its neighbors (r^i)'.

$$\sum_{j=1}^{N}\frac{R_{ij}}{N} = r^i \qquad \forall i = [1, N] \tag{3}$$

- After specified period of time, select CH for next section based on node that minimize equation 4, where E_{res} is remaining energy of neighbors in the cluster, E_{cap} is default energy capacity of each node and α is the weight function that determines relative importance placed on E_{res} and r^i.

$$f(E_{res}, r^i) = \alpha\frac{r^i}{2r} - (1-\alpha)\frac{E_{res}}{E_{cap}} \tag{4}$$

In steady transmission phase, intra and inter cluster routing takes place within the cluster network. Creation of route for inter cluster routing is based on three modes. In initial mode, all CHs are at initial state. In Route broadcasting mode, signals are broadcasted to establish inter-cluster route and routes are established from CH to its neighboring CHs in Route established mode.

CBER generates overhead of control packet during end-to-end packet transmission and unbalanced utilization of nodes near sink.

B. Dynamic Rate Adaptation and Control for Energy Reduction (DRACER) Protocol [6]

This technique have extended IEEE 802.15.4 standard from single data rate to highly dynamic and accurate data rate selection and extended MAC layer to select appropriate data rate.

In IEEE 802.15.4 standard, Pseudo-Orthogonal Coding scheme is used where 4-to-32 bit-to-chip encoding technique is used for physical layer encoding. Generated signal is transmitted using OQPSK-HSS at rate of 2 Mchips/s resulting to throughput of 250 Kb/s. According to this standard, receivers sensitivity is measured by Packet Error Rate (PER) and Symbol Error Rate (SER).

In proposed additional coding scheme, coding rate {1/4, 1/2} are added for data rate of 500kb/s and 1000kb/s. Orthogonal scheme is used for adding coding rate. By taking orthogonal set C of k' bit/symbol and inverting it to form a new code set $\overline{C}$, Biorthogonal code C is formed by,

$C \cup \overline{C}$ with $k = k'+1$ bit/symbol

This biorthogonal code is added to PHY layer, PHY layer is also responsible for automatic detection of incoming data rate at receiver using RSS, PER. Using data rate acknowledgement of signal, MAC layer automatically selects data rate of next packet based on RSSI or LQI. For automatic rate selection process thresholds are set to minimum energy configuration and previous time period's LQI or RSSI is used as a selection criteria for next packet. Steps are given as:

- If LQI $\leq$ 99, send Packet at legacy 802.15.4 rate.
- If $100 \leq$ LQI ≤ 103, send Packet at 500kb/s,
  Else if fails, send remaining packet at legacy 802.15.4 rate.
- Use If LQI ≥ 104, send Packet at 1000kb/s,
  If fails, try once more at 500kb/s,
  Else if both fail, send remaining packet at legacy 802.15.4 rate.

DRACER Protocol reduces network latency and average power consumption, it improves scalability and minimizes network overhead.

III. CONCLUSION AND FUTURE SCOPE

Reducing energy consumption is the most important metric for WSN performance improvement. In CBER Algorithm, after specified period of time, CH selection is made based on nodes in a cluster using optimal cluster head distance and residual energy of a node for next section. This technique extends network lifetime of homogenous node but increases overhead of control data. DRACER protocol works by adding biorthogonal code set, automatic detection of data rate at Physical Layer and automatic data rate selection process at Mac Layer of IEEE 802.15.4 node. This protocol handles more traffic of network and thus save more energy and reduces Overhead.

So, if we use DRACER Protocol for IEEE 802.15.4 nodes in CBER technique, it will reduce Overhead of Control data by variable data rate adaptation.

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