A Survey of Stochastic processes in Wireless Sensor Network: A Power Management Prospective

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Abstract: A wireless sensor network consist of large number of low cost, low computational and limited power sensors. Routing is a process which consumes lot of WSN nodes power. On the other hand WSN nodes have limited power, therefore it is required to intelligently design and select the routing algorithm for the WSN field. This will increase the node and the network life. Statistical tools are quite famous for the decision making procedure in artificial intelligence, self-learning and neural network. A huge research has been done in the recent era on power management and energy efficient protocols to improve the efficiency of the WSN. This survey is focusing on the stochastic process based power management algorithms for the WSN field. Famous power efficient routing algorithms hierarchical structures and format are discussed in this survey.

Keywords: WSN, Stochastic process, power management,

1 Introduction

Wireless sensor network (WSN) has recently become the most modern technology used for monitoring and communication at small scale [1]. WSN replace all the traditional expensive communication and monitoring systems, with cheap and less energy consumable technology. Recently WSN become the most attractive choice at this age of technology in almost every field of life

Multi-functional nodes are the basic unit of WSN for current era of sensing the environmental changes, communication and computation aptitudes [2]. Wireless sensor network can be deployed in different fields of science, engineering etc. For example VANET is one of the examples of adhoc implementation of WSN, which monitor and update traffic management system. WSN can also be used in monitoring the movement and behavior of animal migration in different seasons.

WSN nodes communicate over small distance using wireless medium with each other and with the data center to record the changes in surrounding like in agricultural environment, military based monitoring and industrial process observation [3, 4]. WSN field normally be constructed a huge number of low power consumable, multi-tasking sensor nodes deployed in particular area of interest. Sensor node contains microprocessor radio receiver, transmitter and power battery to enable the node for communication and acquisition of data. These components are incorporated on a small size board. The sensor node size is sometime in millimeters. The sensor node normal provided 2AA power battery which can work for 24 to 36 months with a 1-2 % low burden working mode. Figure 1 shows the simple architecture of the WSN. The sensor nodes are self-responsible for establishing an appropriate network with other nodes sometime multi-hop communication on first time deployment. After deployment (adhoc) Sensor node are responsible to launch network and communicate with other nodes. The sensor starts sensing and acquisition of the surrounding information using either continues or event base monitoring modes. The location of the node can also be localized through (GPS) or local location positioning algorithm. The sensor nodes are compactly mounted with the sink or very near from it and have small battery power, processing capability and memory. Sensor nodes are very disposed to damages. Sensor nodes may not have global identification (ID) because of the large amount of overhead. Sensor nodes are closely mounted in large number. The basic technique of

transfer data from base node to a sensor node is called flooding. In this way data is dispersed by the all nodes in the network as well the base station[19]. The dissemination process consumes large amount of the node sources, e.g. power and bandwidth. The fundamental goal of a WSN is to convert the raw data sensed by the sensor nodes about an event from the surrounding where nodes are applied to meaning full information.

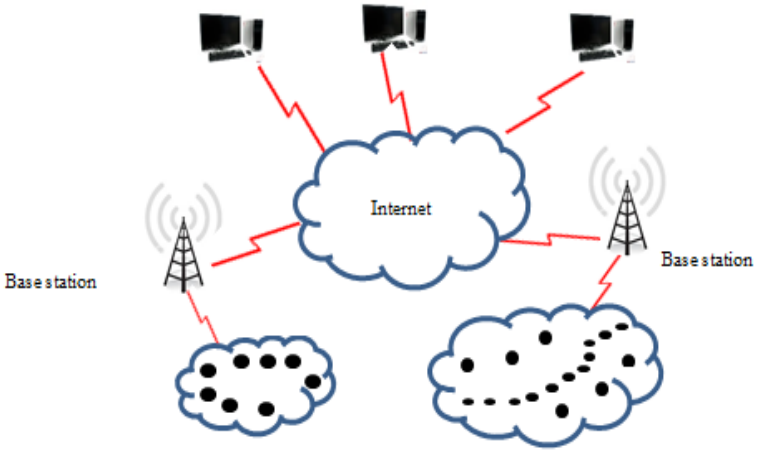

Fig. 1. Wireless sensor network Architecture

Fig.1. shows the WSN simple architecture; consist of Sensor, base station and sensor node sends data via sink node to the base station and the base station to the end user through internet from the base station.

1.2 Wireless sensor mote Architecture

Radio interface is controlled by the communication unit and power unit have a battery for power resources. The sensor mote life time is defends on the life time of the power resource, but often the deployment of wireless sensor node is impossible to change the battery of wireless sensor node. It contains cheap and limited power supply. Due this limitation energy efficient communication in WSN becomes a vital research issue in this emerging, efficient energy technologies decade [3]. WSNs with large number of energy consumable nodes required to design an efficient energy algorithm to capitalize on the network life.

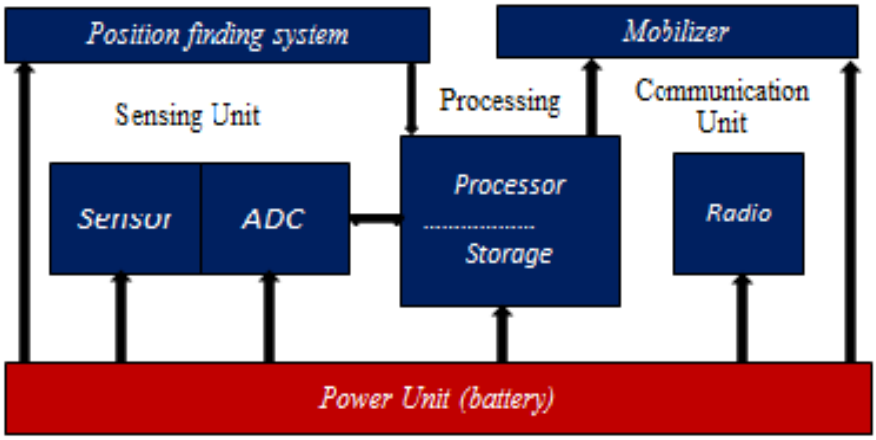

Fig. 2. Wireless sensor mote blue print

Fig.2. is representing the sensor mote which is consist of four parts sensing, processing, communication and power unit. A sensing unit consists of ADC (Analog to digital converter), the sensors & position finding system. Processing unit contain processor and a small storage.

1.3 Stochastic Processes

Stochastic processes which are sometime refer as random processes, are probabilistic theory. In stochastic the decision is made by collecting the random variables. Rather it differs from simple probabilistic models, even if the initial value is known. There are infinite ways to get results.

The rest of the paper is organized in 4 sections; in section 2 energy efficient protocols are discussed. In section 3 few of important energy efficient protocols structures described briefly. Section 4 concludes the survey. Conclusion is added in the last section.

2. Literature Survey

In [7], LEACH is a cluster based WSN data routing algorithm prosed.in this clustering concept is implemented, nodes were responsible to form the cluster.in each cluster a node with high energy level become the cluster head and send massage to all the nodes for authentication. LEACH used the randomize technique to select the cluster head according to the energy level of the node. Each node near the cluster head join the local cluster and Each node send data to the cluster head in that cluster and cluster head aggregate the data form all nodes and send it to the base station. In this way less energy for each node consumed less energy in transmitting the data to base station

PEGASIS [8] is the advance version of the LEACH. The main idea of PEGASIS is greedy chain formation for data transfer. Each node sends and receives data from its nearest neighbor node. In this approach one node become the leader node which is responsible to collect data from all nodes and send the data to base station. In PEASIS, unlike LEACH there are no clusters and multiple cluster heads, all the nodes had global information about the network nodes and sends data to only one leader node. When any sensor dies in the chain, the chain is reconstructed by greedy chain approach bypassing that inactive node. The leader node is selected randomly in each round from the chain, will send aggregate and sends the collective data to base station, due to this approach PEGASIS saved more energy as compere to LEACH. Results showed improved the life time of network due to less energy consumption as compare to LEACH. The better result is gained due to elimination of multiple clusters, still PEGASIS need to improve in terms of the node energy information the nodes in network.so data routing will become more efficient.

In [9], wireless sensor networks efficient energy consumption is considered as a major criterion for better performance of network lifetime .The objective of this work was to develop a new protocol for WSN routing operation for stable nodes. An ant colony optimization is used to maximize the network life by efficient energy consumption. The shortest way from starting node to end node is used through intelligent swarm ant colony optimization. An acknowledgment signals technique is used for data transfer confirmation. They used the multi-path routing data technique for grunted communication and also they consider the energy level for each node before transferring the data. Matlab is used for simulation and also experiment is done by using wireless routing chip. The results were compared with Energy-Efficient Ant base routing (EEABR) algorithm which showed 10% of better results than previously implemented environments. Although the work is so promising but there are some limitations in this work. They used stable nodes and multi-path data routing. It is not favorable as energy efficient routing. Rather it's more energy consumable then single path routing

In [10], authors have been proposed a new routing algorithm for wireless sensor network a novel data routing algorithm particle swarm optimization based routing protocol (PSOR). In this work they used the Partial Swarm optimization, which is

based on best optimal shortest path that can consume less energy as compare to other routing technique. They considered this efficient energy consumption as major criteria for their research work. Authors comment that the routing optimization algorithm will help to increase the overall network life by optimizing the shortest path to transfer data from sensor node to base node. The practical swarm optimization routing (PSOR) used the fitness function to find the most optimal short path to transfer data from sensor node to base node, which leads to less consumption of energy it enhanced the overall network life. The PSOR is compared with GA. The proposed work didn't consider any information about the energy level of the sensor nodes or overall network. This work had proposed a new routing algorithm for wireless sensor network.

In modified Low-efficiency adopted clustering hierarchy (MLEACH) [11,17], data routing protocol is prosed for wireless sensor network. This work is mainly focus on the improvement of previous work (LEACH) […]. In LEACH algorithm they didn't use the node location information but in this work they considered the node location information to the base station. The main disadvantage of the LEACH was the random number of the nodes in cluster and the distance between the two cluster heads was leads to more energy consumption. In this proposed routing algorithm they overcome on these two issues which prolong the cluster and over all network life. The GPS is used for the nodes location information, in addition delay time is used between the two cluster heads selection. If the two cluster nodes are too near, so the base station will discard the new cluster head and again all the remaining nodes will compete for cluster head [9]

In [12] authors proposed a new genetic algorithm inspired by routing protocol is presented. In this heuristic randomized approach each node can communicate with the base station defending on their residual energy. Location information is known by the each node as well as the base station. In proposed algorithm the probabilistic search technique is used in which every node produced a packet of data and has sanded it to the best probable node and the receiver node collect the data and aggregate it with its own data and send it to the next more probable node. Each node has the energy and location information of all the nodes. In this way the data reach to the leader node and the leader node transmit it into base station. The result showed less energy consumption in (GROUP) than the LEACH and PEGASIS [10].

The LEACH-DCHS [13, 14], improved the communication time of the cluster steady-state phase to reduce the energy consumption of the cluster head and overall WSN. The cluster maintenance technique based on previous work LEACH-DCHS is used. They describe that the regular formation of the clusters is bottleneck for energy consumption in LEACH and LEACH-DCHS. In WSN each node produce a random number if the number is less than the threshold number of a node the node become a cluster head. After each round of data process all the intra cluster nodes generate their energy level and send it to cluster head the CH compare the results and choose new cluster head rather than new cluster formation. This process reduced the energy consumption of the WSN which lead a long life for the WSN. The results showed a large energy reduction of this algorithm as compare to LEACH-DCHS

In mobile based agent-LEACH [15], a reduced energy consumption model is proposed for WSN. A dynamic Mobile agent used in the low energy adaptive cluster head algorithm. This intelligent mobile agent is collects the aggregate data from all the intra cluster nodes. The data from each node is compared with the data of previous visited node and only accurate data is transferred to the cluster head (CH) This technique reduce the energy consumption for communication of the cluster head and intra cluster nodes. The mobile agent also filters the data for exceptional error removal[18].

In [16], the two main disadvantages of leach of the L-DCHS (low energy adaptive Clustering Hierarchy with deterministic cluster head selection) have been improved. The cluster head in WSN clustering algorithms communicate with intra cluster nodes to collect the aggregated data and also to send that data to base station. This two way communication causes huge energy consumption which decrease the life time of the WSN node and overall network. In this work new technique of the VCH (voice cluster head) or double cluster head is presented. The voice cluster head is choosing by the cluster head after getting all the energy information from the intra cluster nodes. The

cluster head chose the high energy level node to be a VCH [20]. The VCH communicate with the cluster head and with base station. These VCHs techniques also prolong the steady state phase. The result showed less energy consumption as compare to L_DCHS.

3. Proposed Schemes and Algorithms

This section is discussing about different schemes and algorithms proposed by researchers using stochastic processes in wireless sensor networks.

3.1 LEACH (low-Energy Adaptive Clustering Hierarchy

LEACH [6] a WSN clustering-based self-organizing adaptive protocol it implements the concept to distribute the equal energy consumption in all the sensor nodes in the network .LEACH improves the overall energy efficiency of WSN and as well each node as compere to conventional clustering algorithms as a result the life time of the sensor network is improved.

LEACH uses the randomized, self-configuring and adaptive cluster formation the nodes in the network dived themselves in to different local small clusters. One node among each cluster become as sink node (cluster-head).each node in cluster will send data to local cluster head. The unique technique uses in LEACH is the randomized selection of the CH depending the remains of the node, which make each node energy life long lasting. LEACH uses many rounds for cluster formation. Each round consists of two phases, setup phase in which cluster from in adaptive manner and steady phase in which data is transfers in the cluster

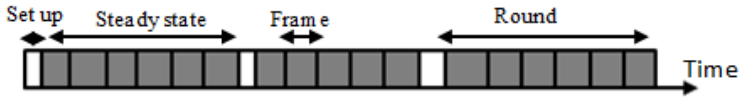

Fig. 3. Time line of LEACH cluster formation and data transfer operation

Fig. 3. Describes the operation of LEACH is divided into rounds, in each round when the clusters are organized, initiates with a set-up phase, next is steady-state phase in which data transfer operation, from node to CH and base station take place.

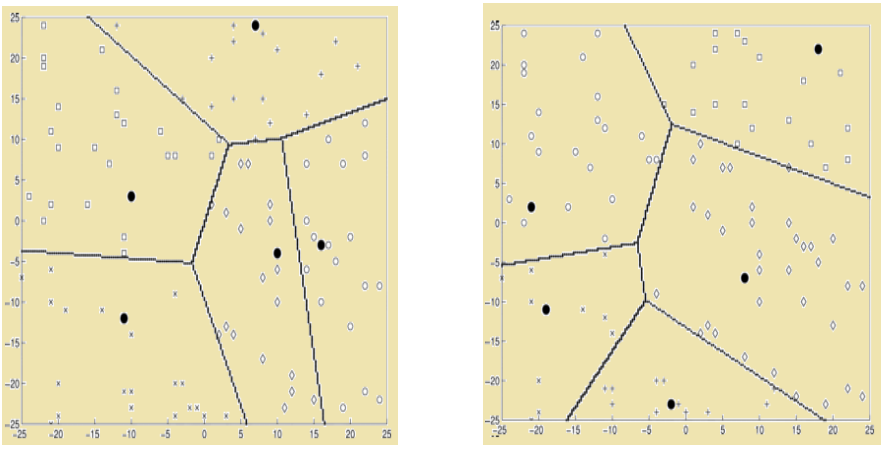

Fig. 4. Cluster formation and CH selection in different rounds

Fig.4. shows the random cluster formation and CH selection in two rounds, of cluster formation in WSN. CH is not fixed in every round the CH is changing randomly defending on the energy level of the nodes, due this technique the energy dissipation in sensor nodes is spread.

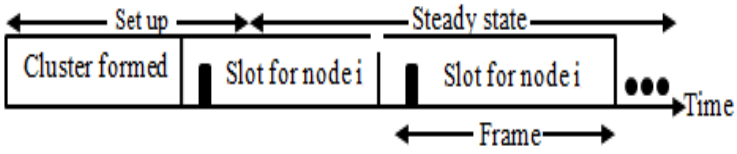

Fig. 5.Time line of LEACH data transmission

Fig. 5. Shows the data transfer scheduling in details to avoid of any collision and prolong the time sleeping time period of the nodes other than CH. In this scheme when nodes become the cluster heads (CH) they broadcast a message to all the network nodes about their position. Each sensor node then decide to join which cluster on the basis of distance from the cluster head that need less energy consumption for data transmission. Every cluster head generate a TDMA schedule for the nodes in the cluster. This lets the radio modules of non-cluster nodes to be turned off except during data transmission time. When the cluster head received data from all the nodes in the cluster it aggregate and then transmit the compressed data to the base station.

3.2 Power Efficient GAthering in Sensor Information System (PEGASIS)

It is an improved data routing protocol in which only one node become the leader node which receive the data from other nodes and sends data to the base station .Greedy chain algorithm is the fundamental theme of PEGASIS. Each sensor node have the global information about the network and sends data to its nearest neighbour node by using that global information. When the node receives data from neighbour node, it pause the data with its own data and send to next nearest neighbour. The greedy chain starts with the farthest node from the base station.

Leader Node: The leader node selection is on random basis. After the selection, the leader node sends a token to all nodes for data gathering purpose. Each node sends data to its nearest node and in last all data reaches to leader node. It pause the data and send it to the base station. When any node is died in the chain, multi hope data transfer is take place and a new chain is reconstructs in next round. The leader node is also changed to distribute the energy consumption in all nodes thus over all network life is improves.

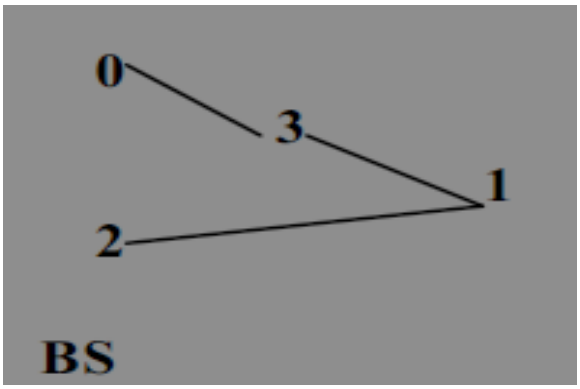

Fig. 6. Greedy chain approach data transfer in PEGASIS

In Fig.6 the greedy algorithm for data transfer is presented. It starts from node 0 contacts with node 3 to1 with node and node 1 to the last node 2 which is nearest to the base station. As the nodes in the chain cannot be revisited so the distance between nodes will be increase slowly. When any node in the chain dies because of power limitation, the chain will be reconstructed using the same procedure and avoids the die node.

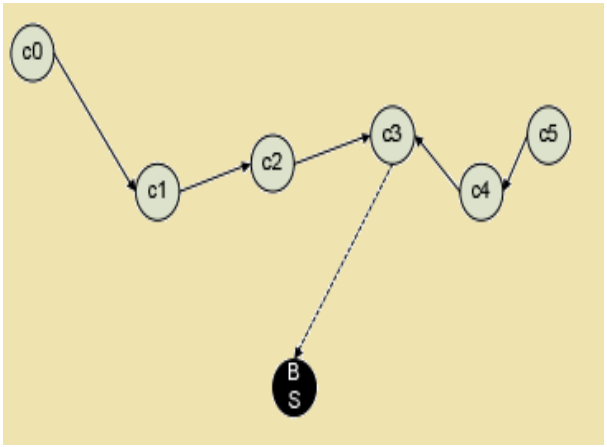

Fig. 7. Data transmission process in PEGASIS

Fig.7. Shows the data communication and data fusion process in the power efficient gathering in sensor information system. Each node receives the data from neighbour node and fuses it with its own and sends to the next neighbour. In this figure C3 get data from C0 viaC1, C2.C2 also sends token to C5 for data gathering and wait for reply when it gets the data from C5, it fuse the data and sends the fuse data to the base station.

3.3Ant colony optimization

The frame work of ant colony optimization is based on stable nodes, a few mobile nodes and a base station. In ACO artificial ants are used for data transfer. ACO approach runs the source node which divides data into parts and sends it to the base station using multi paths. In case of failure during the transmission of data, the transmitted packet not reaches to the base station. To avoid this situation, acknowledgment signals are used. When the source node did not receive any acknowledgment from base station, it resends again the same data package by using different paths. While using multi paths, the source node will use shortest path (by considering energy level) for data re-transmission of data to the base station in order to save energy level of nodes falls in current path.

Broadcasting data: several nodes have data about an event occurs, to sends it to base station via neighbor nodes. The data package sends by the source node is known as raw data, which contain the information about event, source node ID and next node ID.

The architecture of the ACO is based on three parts. Layer one is disseminating the data, layer 2 provides acknowledgment procedure and layer 3 provides information about the energy level of the nodes to each other. In layer one the first step is used to split the raw data according to the buffer size of the WSN chip. Fig.8. is explaining the splitting procedure of raw data.

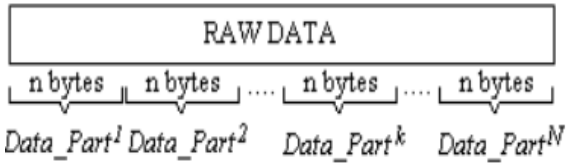

Fig. 8. (Disseminating) splits raw data

Secondly after splitting procedure, it adds header to each packet of the raw data. Header contains full information about the source node, next node, and number of the ant agent and also the information of the nodes visited so far. Fig.8. is representing the data package with header and raw data part

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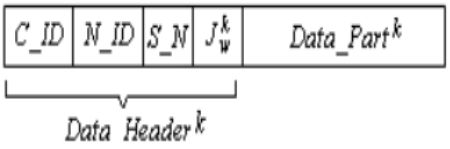

Fig.9. Data Package for transfer

When a data package becomes ready to sends, the next node is selects on the bases of the higher response value. The node have high value will be selected to transfer the package.

Acknowledgment process: As base station receives data from several paths, therefore an acknowledgement procedure is required to reduce packet loss. After the base station receive the data it produces an acknowledgement signal for the source node and sends it by using same path as representing in fig.9.

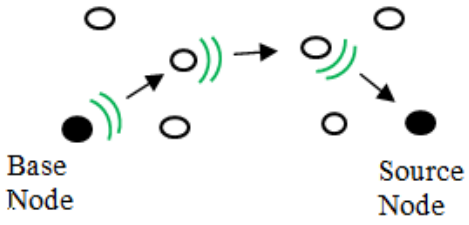

Fig. 10. Acknowledgement signal

The source node waiting for the acknowledgement signal from the base station, in case of missing acknowledgement the source node disseminate again the same data through different paths. In the ACO protocol each node provides its energy level information to its neighbour nodes. The change in energy comes due to participation in data transfer operation. Whenever any change occurs in energy level of any node it informs the neighbour nodes about new energy level.

3.4 Particle Swarm Optimization based routing (PSOR)

Particle swarm optimization is a single criteria routing algorithm for WSN. Fitness value is the only condition used to consider in PSOR. This fitness value is directly proportional with the power of the WSN node. Author relates the power calculation

with distance as they quoted" more the distance more the energy will be lost in sending data" [10].

Calculation of fitness value: As fitness value (energy level) is calculated based on the distance covered by the node previously, therefore distance becomes main criteria in the calculation of fitness value.

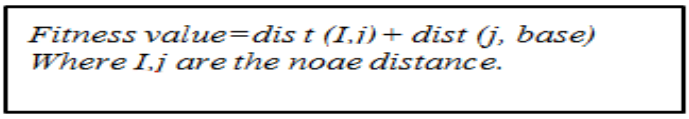

Fig.11. Fitness function for PSOR

From Fig.10 one easily can predict that the calculation of the fitness in based on the source node receiving node. The most optimal path is chosen by using the above equation.

4. Conclusion

One of most basic challenges in the modern wireless sensor network design is the consumption of the energy of sensors while in routing data. The main goal of the all routing protocol designing is to improve the lifetime of the sensor and overall network for long period as much as possible. In WSN the sensors consume more energy due to the data transmission processes. Therefore the design of the protocol for the WSN is required to be more energy efficient to prolong the lifetime of the WSN. In this paper we have surveyed and summarised some of the main energy efficient protocols for WSN using Stochastic processes. In addition the structure of few most common protocols has been described briefly; however still there are some critical issues that need to be addressed in power management domain of WSN.

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