A Survey on Energy Harvesting in Wireless Sensor Network

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Abstract— Wireless Sensor Network are in great demand from the recent years, as nowadays we have seen a wide growth of wireless devices including cellular phones, laptops, mobiles, PDA's etc. Wireless Sensor Networks consists of thousands of tiny sensor nodes. In a wireless sensor network a node is no longer useful when its battery dies, so to avoid this problem many protocols were introduced but most of the rank is given to hierarchical routing protocols. WSN needs the security mechanism which efficiently works with high security methods which provide the proper authorization of nodes in the network to avoid malicious activities and provide the better performance of the ad-hoc network. To provide the better security and energy efficiency this paper presents a survey on energy harvesting mechanism and security features of WSN.

Key words: Wireless Sensor Network (WSN), Energy Harvesting, Security

I. INTRODUCTION

A wireless sensor node consists of multiple modules, including battery, data process units, storage, transmitter/ receiver pair, and one or several sensor devices. These sensor nodes collect the information about the surrounding environment and forward it to the base station through a one hop or multi-hop manner. As such, WSNs serve as bridges between the physical world and human societies, resulting in a cyber-physical system. However, due to limited resources, sensor nodes shall cooperate with each other to carry out complicated tasks. For example, mobile crowd-sensing has proved to be an effective and efficient way to collect and process environmental data, as well as reconstruct the spatial field of a physical quantity.

Energy consumption can be efficiently managed through adjusting the network topology and regulating the nodes transmission power levels in the routing protocol. The clustering technique is useful in reducing power usage in routing protocols. In a clustering architecture, sensor nodes are organized into clusters, where the sensor nodes with lower energy can be used to perform sensing tasks, and send the sensed data to their cluster head at a short distance. A node in a cluster can be chosen as the cluster head (CH) to eliminate correlated data from the members of the cluster, with the objective of reducing the amount of the aggregated data transmitted to the BS.

A wireless sensor networks consist of tiny sensor nodes to monitor physical or environmental conditions such as temperature, pressure, sound, humidity etc. The network must possess self configuration capabilities as the positions of the individual sensor nodes are not predetermined. Routing strategies and security issues are a great research challenge now days in WSN but in this paper we will emphasize on the routing protocol. A number of routing protocols have been proposed for WSN but the most well known are hierarchical protocols like LEACH and PEGASIS Hierarchical protocols are defined to reduce energy consumption by aggregating data and to reduce the transmissions to the Base Station. LEACH is considered as the most popular routing protocol that use cluster.

II. ARCHITECTURE

Most common architecture for WSN follows the OSI Model. Basically in sensor network we need five layers: application layer, transport layer, network layer, data link layer and physical layer. Added to the five layers are the three cross layers planes as shown in Figure 1.

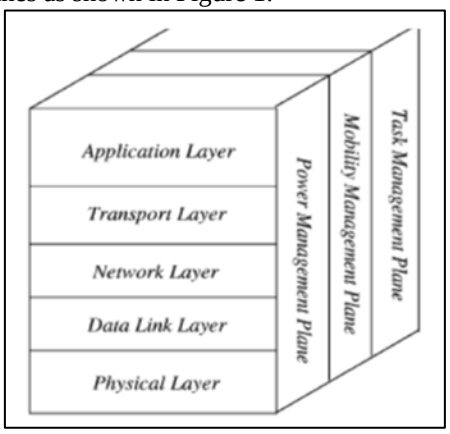

Fig. 1: Architecture of WSN.

The three cross planes or layers are; power management plane, mobility management plane and task management plane. These layers are used to manage the network and make the sensors work together in order to increase the overall efficiency of the network.

The difference of architectures between OSI, WLAN and WSN are shown in Table 1.

Wireless sensor network	WLAN	OSI Model
WSN Application	Application programs	Application layer
WSN Middleware	Middleware	Presentation layer
	Socket API	Session layer
WSN Transport protocols	TCP/UDP	Transport layer
WSN routing protocols	IP	Network layer
Error control WSN MAC protocols	WLAN Adapter & device driver WLAN MAC protocols	Data link layer
Transceiver	Transceiver	Physical layer

Table 1: Difference of architectures between OSI, WLAN and WSN

III. RELATED WORK

The author K. Muralidhar, IEEE[1] et.al. Enhancing the lifetime of WSN through fuzzy logic based hierarchical cluster head information approach, has suggested two level of hierarchy is used in creating a cluster which reduces the energy consumption using LEACH protocol. One chief

cluster head(CCH) is selected from the different cluster heads were the entire cluster heads are synchronized with this chief cluster head and CCH is communicating with the base station. The nodes in the cluster will only communicate with the respective cluster head and CH to CCH will eventually save node energy.

Residual energy of nodes considered to form the cluster head and the fuzzy logic based method *if/then/else* used for selection of CCH. Drawback of selecting cluster head with local information is removed using fuzzy rules which provide the optimal set of cluster heads.

With a fuzzy logic based selection of CH and CCH compresses the data and send it to the base station which reduces the transfer of redundant data ultimately save the energy of nodes and network.

The author Asma Rafiq [2] a consistent approach towards clustering in LEACH, has proposed extension to LEACH protocol with data gathering mechanism using spanning tree base provided with minimum distance spanning tree. LEACH protocol has a drawback of selecting cluster head and continue with the same will reduce by treating all the nodes as CH and eventually will maintain the energy balance and prolong the network lifetime. Author has compared the results with the classical LEACH protocol and the altered LEACH protocol and has found the less energy consumption in altered one.

The author Alex king [3] Estimating node lifetime in interference environment has proposed to estimate the node energy to set the lifetime of the node and of network. It also finds the maintenance report for nodes and network lifetime.

With the tinyOS the simulation carried out on nodes lifetime. Heterogeneous interference impact is studied on the network lifetime in WSN.

The author Hsiang Hung Liu [4] the rumor routing is a classical random walk routing protocol but it is not providing efficiency at energy consumption constrain. The author proposed straight line routing algorithm which will help to construct a path with two hop without information if geographical statistic. Random walk algorithm is defined for collection of data in adhoc wireless network. SLR constructs path hop by hop manner. Rather than visiting multiple nodes only two nodes are visited to reach to base station. Random walk does not guarantee straight line path and number of nodes are not fixed. Straight line routing will fix with two hopes to reach to BS which ultimately reduce the energy consumption.

The author Haudong Wang [5] paper on Research on efficient-efficient routing protocol for WSN based on improved artificial bee colony algorithm attempt to solve the problem of energy consumption by considering residual energy of the nodes, node locations and density energy consumption of the node is balanced using swarm intelligence algorithm or with quantum ABC algorithm. Algorithm works on unbalanced load by considering topology, residual energy and node positions to optimize energy consumption. The quantum ABC algorithm used to provide computation mechanism to ABC algorithm that provides the best result using artificial bee colony algorithm. The quantum ABC algorithm used to apply on WSN network to balance the load and define the relative position of node, topology and residual energy to facilitate balanced utilization of node energy.

Author Mai Abdelhakim [6] in the paper mobile access coordinated wireless sensor network, SENMA(Sensor network with mobile aceess) mobile access (MA) points traverse over the network to collect information directly from individual sensor. Limitation is speed of MA point and delay to transfer data. This provides optimal topology by reducing number of hops between source and its nearest sink. Author calculated the throughput and illustrates the effect of number of hops on throughput. Traffic at each cluster can be modeled as an independent M/M/1 queue. SENMA widely used for military applications where unmanned aerial vehicles serve as mobile access point. Topology for MCWSN to reduce number of hops from any sensor to MA that will provide the optimal solution to the problem. Queuing model for MCWSN architecture which provides minimum energy consumption to transfer data to MA. Cluster based mechanism ultimately helps to maintain the energy level of the nodes and eventually increase the network life time. The solution provides the hierarchical and heterogeneous structure to the MCWSN nodes that work on minimum number of hops between source and MA.

Author Jetendra Joshi [7] in Secure and energy efficient architecture for sensor network, a hierarchical network topology is formed that enables end to end communication between sensor node and the architecture also support detection and isolation of malicious nodes. LEACH protocol is used for creating clusters and cluster heads. Sink is used for communicating with nearest node from the cluster with security in between node and sink. It helps in data security. LEACH is having is standard limitations related to selection of cluster heads. Data aggregation is for creating small size data. Encryption used for secure communication between CH and sink .

Author Djamel Djenouri [8] in paper Energy aware constrained relay node deployment for suitable WSN has defined Problem of communication coverage for sustainable data forwarding in WSN where an energy aware deployment model of relay node (RN). One tier and Two tier model is presented for this solution for forming a cluster and cluster head to reduce the energy consumption. RN Energy rich node (ERN) and Energy Limited Node (ELN) are found to define classification and to find the count to introduce the number of RN. Relay node introduced in the WSN to do the communication to the base station. Number of relay nodes will help in reducing energy consumption of the sensor network and will eventually do the communication with base station. Relay node is an intermediate between sensor node and base station with a energy rich mechanism. Classification is done by energy rich node and energy limited node which helps to find the no of RN into WSN will directly in communication with SN and BS. With an integer linear program (ILP) defines the exact number of RN to introduce into the network. The combination of one-tier and two tier model is used for solving the consumption problem.

Author Zhexhuang Xu [9] in Joint Clustering and routing design for relaible and efficient data collection in Large scale WSN proposed Energy efficiency will be

increased by considering the joint analysis of clustering and routing protocol. LEACH and HEED are the clustering protocol which work on the energy efficiency on the WSN nodes but clustering and routing are two different mechanisms are considered and jointly are not analyzed together. Detailed analysis on jointly relations on the clustering and routing protocol for reliable and efficient data collection in large scale provides better efficiency. Joint Clustering and Routing (JCR) protocol to provide reliable and efficient data collection in large scale WSN. Random back off and gradient routing scheme are adopted in JCR for Cluster Head selection and multichip routing. JCR compared with BSC which provides the better lifetime of network using limits to the area and no of hops.

Author XUAN LIU [9] in Joint Design of Energy efficient clustering and Data recovery for WSN proposed Novel clustering algorithm considers both energy efficiency and data consistency by recovery mechanism and data correlation.

1) Nodes clustering approach
2) Data forecasting algorithm
3) Node clustering based on location and data correlation.

Reduction of cluster distance data prediction mechanism by average error rate. Clusters are formed. Cluster heads are defining correlation of data and nodes are with less distance compared the approach with the yesterday, auto regression, and MUSCLES approach with joint approach.

Author Hamid Mahboubi [11] in paper an energy-efficient target tracking Strategy for Mobile Sensor Network energy efficient strategy is proposed for tracking a moving target in an environment with obstacles using network of mobile nodes. Small grids are identified with few nodes and grid considered as a node. And connecting lines are the links to connect the nodes edge which provide the proper weight to define energy consumption. After that shortest distance find to define the exact position of the node in the network with energy efficiency. It divides the network into graph with node and link. Which reduces usage or more data and only one node in grid is communicating with the other node in other grid. The field first divided into grid and is then converted into graph. Weights are assigned to edges to efficiently model the energy consumption due to sensing, communication, movement. Finding proper route and energy efficient tracking is translated to well known shortest path problem.

Author ADNAN M. ABU-MAHFOUZ [12] proposed Energy efficiency through localization dynamic power control and incremental and exponential requesting rate. Localization Algorithm for Wireless ad-hoc sensor network with high accuracy (ALWadHA) developed to enhance the performance of the localization algorithm and achieve several objectives such as improving the accuracy and robustness of the position estimation. Investigated the impact of three technique Single estimation approach where node estimated positions only once. Dynamic power control based on that reduces the distance with other nodes incremental and exponential requesting rate approach reduces the energy consumption of ALWadHA by 51%. With the three technique i.e single estimation of location, dynamic power control and incremental and exponential request rate will reduce the energy consumption using ALWadHA algorithm.

Chinmaya Mahapatra [13] in paper optimal power control in Green Wireless sensor network with Wireless energy harvesting wakeup radio and Transmission Control proposed energy efficiency increased through WEH, WUR and ECC enabling solution to enhance the performance of WSN while reducing the carbon footprint. Formulate the data utility trade-off problem by taking approximated life time function, energy harvesting, wake up radio duty cycling and retransmission into the utility function. The energy harvesting and error coding can jointly reduce carbon footprint generated per year and make the network green. Wireless energy harvesting is investigated as a remedy to prolong the lifetime of sensor node and enable maintenance free operation.

Author Kenith Li-Minn Ang [14] in Optimizing energy consumption for big data collection in Large scale WSN with mobile collector Large Scale WSN energy optimization approach with MDC with single and multi hop for mobile data collection, gives model for determining the optimal number of clusters for minimize energy consumption. Big data collection method for LSWSN MDC roam over geographically distribute d network to perform collection task. Work related to optimize energy consumption, collection latency, and network reliability. Calculate the energy consumption for node and determine the optimal number of clusters for two representative data collection model MULE and SENMA. MULE: reducing the number of cluster defines the best effect on the energy consumption problem SENMA: will help to maintain sufficient amount of energy to transmit to mobile AP.

Author Kyund Ah Shim [15] in paper BASIS: A Practical multi-user Broadcast authentication scheme in WSN proposed to allow large nnumber of mobile user of WSN to join in and send broadcast message to WSN dynamically and authenticate the users. To minimize computation and communication cost a new provably secure paring free ID based signature with message recovery(MR) mechanism and partial MR. New pair free IBS schemes with message recovery MR-IBS and PMR-IBS which reduce communication overhead and energy consumption of a sensor node.

IV. CONCLUSION

The main aim of this paper is to focus on energy consumption and management in wireless sensor network architecture that provides efficient energy system for a WSN to update lifetime of sensor node. It also focuses on clustering mechanism which adequately maintain the number of nodes in the cluster and provide efficient way of communication with base station. Advancement of classical protocol such as LEACH and HEED will provide the energy efficiency mechanism to maintain the lifetime of network. The consideration of residual energy of node is carried out to find the network lifetime and increase the efficiency of the WSN.

It also provides the solution for clustering mechanism in novel way to provide the energy efficiency improvement schema. The collection of data with mobile

collector will help to improve the data collection mechanism. By providing spanning tree based data gathering mechanism the optimal cluster heads are chosen and spanning tree is formed to send data to base station.

Performance of network is calculated in the environment of heterogeneous interference which calculates the node and network lifetime and maintenance time for the wireless nodes. The straight line routing works to reduce the number of hops limited to only two nodes which ultimately reduce the energy consumption.

The energy consumption compared with other algorithms like LEACH, HEAD, ABC and QBAC routing algorithms and QABC provide the less utilization of energy The quantum ABC algorithm used to apply on WSN network to balance the load and define the relative positions of the node, topology and residual energy to provide balanced utilization of the node energy. Also Data aggregation is used for creating small size data. Encryption is used in sink and node for secure communication.

Future scope: Degree of mobility is not considered in this paper which will have a great impact on the cluster selection [1]. Current status of the network and residual energy is not taken into consideration [2]. Optimize contiki MAC procedure for performing operation in noisy channel upgrade the energy saving level [3]. Application of quantum ABC algorithm is not considered in network clustering and data acquisition of mobile network WSN [5]. In SENMA more reducing hop number will reflect to reduction of energy consumption [6]. Residual energy, routing mechanism and capacity of nodes are not considered which help to reduce energy consumption much at adequate level [8]. Joint clustering and routing design can further tuned to provide security in different way to reduce computation time can help to maintain the energy balance over the network [9]. In joint design of energy clustering and data recovery author not Focused on data processing mechanism will reduce the bandwidth consumption helps to maintain the energy level in the node can increase lifetime of network.

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