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Role of Machine Learning in Wireless Sensor Networks to Solve Different Operational Issues

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ABSTRACT

ABSTRACT: *In recent days, Wireless sensor network is playing a vital role in various applications due its features such as reduced cost, flexibility, throughput, scalability, distribution, and efficiency. Despite its advantage, WSN must face some challenges in terms of energy efficiency and network lifetime due to the limited battery. The dynamic behaviour of the environment caused by external factors or by the system designer effects the selection of routing algorithms, clustering and localization mechanism used. Machine learning techniques can be adopted by WSN to avoid the need of superfluous redesign or restructure of nodes and enhance the lifespan of the network and maximize resource utilization. In this paper, we present the review of various machine learning methods for solving different operational issues.*

KEYWORDS: *Wireless Sensor Network, Machine learning, Energy efficiency, Clustering, Network lifetime.*

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I. INTRODUCTION

A wireless sensor network is a collection of spatially scattered discrete sensor nodes that has the capability to sense the environment to collect data such as temperature, humidity, light, sound, etc. The sensor nodes are wirelessly connected and often used for collection and dissemination of data to different applications. The sensor nodes are armed with different sensors such as chemical, temperature, sound, humidity and so on. With the advancement of Internet of Things technology, sensors are deployed to collect data from different applications. WSNs have great potential for developing applications based on the requirement, exhibiting individual characteristics.

Since WSNs are small sized, low-cost sensor nodes, they face problems with respect to memory, battery, and small communication range. As it is used to sense the surrounding, collect data and transmit the data, the energy usage in WSN is continuous which drowns the battery quickly. The transmission of data consumes more energy because to transmit a single bit of data over 100 m by radio costs the same amount of energy as executing 3000 instructions [1]. Due to this a lot of work is going on in clustering of nodes, localization, energy aware routing and energy harvesting. For WSN designer it is always a challenging task to design an efficient protocol for clustering, routing and localization.

Machine learning (ML) was introduced in the late 1950s as a technique for artificial intelligence [2]. Machine learning is a process that automatically and incrementally learns from its experience in the given environment without any explicit programming. ML produces model that can accurately analyse complex data effectively and efficiently. WSNs are using machine learning to solve various issues to improve the performance of WSNs and to reduce human intervention. Some of the applications of ML in WSNs include problems related to target area coverage, determining the optimal sensor node required to cover an area, forecasting the amount of energy to be harvested, accurate localization and to identify faulty sensors.

II. REVIEW OF EXISTING WORK

Ahmed, Mohammed & Taha, Ayman & Hassanien, Aboul Ella & Hassanein, Ehab [3] has used optimized K-nearest neighbors (KNNs) classification with metaheuristic whale optimization to search the sink node in wireless sensor networks. In this work authors have formulated a fitness function which determines the best position for sink node with high residual neighbor's sensor nodes energy to maximize the network lifetime.

The nodes having same capabilities were randomly and uniformly distributed in the given area. The assumption was all active nodes have same memory, power, and bandwidth capability. In whale optimization technique which is a swarm intelligence approach, N whales were produced randomly and fitness function was computed. Then whales are used in evolutionary progress. This proposed method saves approximately 11% of energy consumption when compared with PSO-KNN method.

To improve the lifespan of WSNs a fuzzy based clustering and machine learning based data reduction mechanism was proposed by S. Radhika and P Rangarajan in their paper "On improving the lifespan of wireless sensor networks with fuzzy based clustering and machine learning based data reduction" [4]. In this method, each sensor node can act as cluster head (CH), cluster member or supplementary node. To reduce the overhead on CH, clustering was performed periodically using the fuzzy inference system. In comparison the methods that employ energy-based clustering such as LEACH, DDCD, and EECRU, simulation results of ECFU shows the energy efficiency, and in enhancing network lifespan.

Rahiminasab et. al.(2020) [5] proposed and designed a novel method which is similar to Base station Controlled Dynamic Clustering Protocol (BCDCP) based on multi-feature decision making. Considering the four issues i) energy , ii) distance to base station, iii) mobility and iv) data queues length they applied Cluster splitting and Analytical hierarchy to solve the problem. Simulations were carried out to validate these issues by proposed method. The experimental result shown the better result than existing BCDCP method. In the proposed method, the energy reduction is almost 5% more than the BCDCP method, and the packet loss rate is almost 25% lower than in the BCDCP method.

M. Sahraoui and A. Bilami, propose an Energy-efficient method for Reinforcement Learning based Multi-channel MAC (ERL MMAC) that performs a hybrid channel assignment using a decentralized tree for multi-channel data gathering in WSNs [6]. They used least chosen default channel allocation in two hops instead of one hop to reduce the conflict links and parent selection strategy during learning phase to avoid redundant data messages. The results of simulation experiments showed the effectiveness of ERL MMAC in improving network lifetime with a rate of 97.53%.

Sneha S and Dipti D has used APTEEN protocol with a threshold and genetic algorithm to improve the network lifetime. In their proposal threshold energy is set to 70 J, which reduced the energy consumption by 55%. The proposed system reduces the maximum number of packet loss, never attain zero energies and remove the dead nodes.

Anna Merine George in her research work combined intelligent clustering and routing protocols in order to improve energy consumption and the lifetime of sensor nodes. Smart Mesh IP Power is used to collect dynamic parameters. They designed a predictive model in which hop depth, nodes, routing, reporting interval, data size, are the predictors, and the present consumption, latency, and build time are the response variables for estimating the power and performance of the network. The residual energy of each node, distance of source to sink, and throughput are the predictors, and the priority of the cluster head is the response variable to establish models for achieving an optimal routing path in a wireless sensor network.

III. ISSUES IN WIRELESS SENSOR NETWORKS

ENERGY ISSUES

Wireless sensor nodes operate mainly on battery and are deployed in remote, inaccessible locations. Managing energy consumption in these nodes are of significant concern for the prolonged life of the node. The major limitation includes the small batteries of the nodes which can become non-functional if batteries are depleted, leading to failure of the network. Different components of the nodes consume energy at various levels and managing the energy efficiently is an art of the designer. Data collection, transmission and reporting also consumes lot of battery. Strategy such as how often to collect data, periodic reporting, data aggregation and compression along with optimized routing can reduce the energy consumption.

Energy consumption also depends on the design of the network. In WSNs a coordinator is mandatory to imitate and manage the communication. In addition, these multiple nodes may be operating in the sleep mode which also consumes lot of energy. Energy provisioning in WSN can be categorized as shown in the figure 1.1.

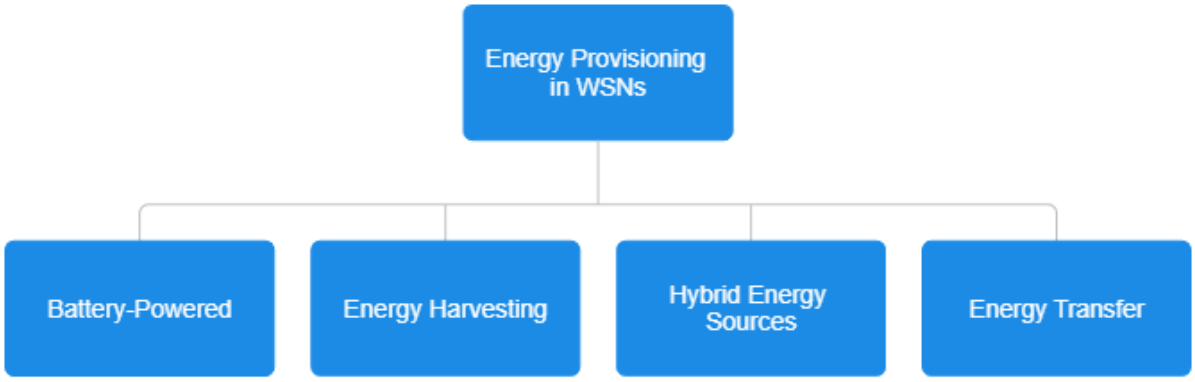

Figure 1.1 Categories of energy provisioning in WSNs

Batteries are used for powering sensor nodes. Secondly energy harvesting using solar, wind, vibration and thermal can be used to supply more power to sensor nodes. In some case battery and alternate energy can be combined to ensure long lasting power. Energy can also be transferred from central charging stations or using inductive and resonant charging. Other methods such as scavenging, efficient hardware and software, dynamic power management, reservation and budgeting, predictive maintenance can also be used.

ROUTING ISSUES

Every sensor node in the network is responsible for reporting predetermined data or for transmitting sensed information to base station/sink. The transmission may follow a single hop or multi hop transmission method. Selecting efficient routing mechanism that can minimize energy and latency is a challenging task in WSN. The WSN may contain heterogenous nodes that will have different energy and communication capabilities. The routing protocol should scale to handle the varying network while maintaining acceptable performance. Dynamic protocols must be used to adapt to varying topology. Routing methods must employ techniques to avoid the routing overhead and balance the lode among nodes for efficient energy management. WSN cannot proficiently use classical IP based protocols. Redundancy of data can be observed as many nodes may sense the same data.

IV. ROUTING IN WSN USING MACHINE LEARNING

Machine learning (ML) techniques are deployed in WSN to solve many issues. Applying ML techniques in WSN reduces the manual intervention for analysing the complex data and to improve the system performance. ML methods can be use for energy harvesting, solving target area coverage problem, localization, routing, data abstraction at different levels and to detect faulty nodes. Despite these advantages, ML technique has found limitation for deployment in WSN due to its large data requirement and processing power. The designers of WSN must find the trade off between the computational complexity and the learned model accuracy.

V. CONCLUSION

Energy efficiency is the primary concern in WSN and plays a major role in the design of routing protocols for wireless sensor networks. It directly effects the network lifetime. To achieve energy efficiency data centric routing can be employed to reduce local optimum and uneven energy consumption by nodes. To balance the load in required area ML techniques can by deployed. By combining machine learning techniques with available solutions for routing in WSN, we can improve network lifetime, balance the load among nodes and energy distribution can be optimised.

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