Artificial Intelligence Usage in Wireless Sensor Network: An Overview

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Abstract:

Many writers have concentrated their research on wireless sensor networks over the past 10 years. Power consumption, MAC protocols, self-organizing network algorithms, data aggregation techniques, routing protocols, QoS management, etc. are just a few of the numerous research topics that have been substantially studied. The application of artificial intelligence has historically been abandoned because to limitations on data processing and power consumption. However, in some unique situations, neural network characteristics may be used to create difficult tasks like path finding. In this research, we compare the performance of directed diffusion and energy-aware routing, two widely used routing paradigms, with our own routing method, called SIR, which is innovative in that it is built on the integration of neural networks into each sensor node. In-depth simulations have been run using our wireless sensor network simulator, OLIMPO, to examine the effectiveness of the addition of neural networks. Analyzed is a comparison of the outcomes produced by each routing protocol. The goal of this work is to promote the application of artificial intelligence methods in wireless sensor nodes.

Keywords: Wireless sensor networks (WSN); Ad hoc networks, Quality of service (QoS); Artificial neural networks (ANN); Routing; Self-Organizing Map (SOM), ubiquitous computing.

I. Introduction

Recent technological developments have made it both technically and economically feasible to manufacture compact, inexpensive sensors. The environmental conditions in the area around them may be measured using these sensors. These sensor nodes are typically found in hundreds or thousands in wireless sensor networks (WSNs). Self-organizing networks are the most appropriate network architecture to serve applications in such a scenario because to the sensor properties (low power consumption, short radio range, low memory, low processing capacity, and low cost). Goals including effective energy management [1], high availability and dependability, secure communication, and resilience are now crucial factors to take into account. This is only one of many reasons why it is important to investigate the impact of noise and collisions.

This type of networks has been the subject of research at several places across the world, particularly in Europe and the United States. Holger Karl et al. [3] and Ian Akyldiz et al. [2] have worked hard to characterise the state-of-the-art in this area.

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In order to enable Supervisory Control and Data Acquisition (SCADA) applications, our research team at the University of Seville, Computer Science for Industrial Applications, is creating protocols and system architectures for wireless sensor networks. In this research, we describe a novel routing algorithm that uses artificial intelligence (AI) methods to gauge the QoS provided by the network[13].

II. WIRELESS SENSOR NETWORKS

A system made up of thousands of minuscule stations known as sensor nodes is known as a sensor network (SN). The primary duty of sensor nodes is to track, document, and alert other stations to a certain condition at various places. Additionally, an SN is a collection of specialised transducers equipped with a communications network that is designed to track and record conditions at various places. Temperature, humidity, pressure, wind speed and direction, light intensity, vibration intensity, sound intensity, power-line voltage, chemical concentrations, pollution levels, and critical physiological functions are among the characteristics that are frequently monitored.

III. Wireless Sensor Networks and Artificial Intelligence

In order to maximise its capacity to gather data from the real world and convey it in a timely manner to a base station or a host system, an intelligent sensor alters its internal behaviour. Self-validation, self-compensation, and self-calibration are all features of intelligent sensors. With self-calibration, the sensor may keep track of its measurement conditions and determine whether or not a fresh calibration is required. The application of knowledge-based approaches or mathematical modelling error isolation and dissemination is known as self-validation. In order to attain high accuracy, the self-compensation employs compensatory procedures. Artificial Neural Network (ANN), Fuzzy Logic, and Neuro-Fuzzy are examples of artificial intelligence approaches that are commonly utilized in business. Wireless intelligent sensors are created by intelligent sensor structures integrated into wireless sensor networks. Building intelligent sensor architectures relies heavily on the application of artificial intelligence techniques. Focused on the coverage, connection, network longevity, and data quality are the main research questions for WSNs. The study of artificial intelligence, distributed artificial intelligence, and their approaches to overcoming WSN constraints, developing new algorithms, and developing new WSN applications have attracted more and more attention in recent years[15].

IV. SIMULATION MODELS FOR WSN

Current simulation models attempt to depict how a WSN functions. For instance, Egea-Lopez et al. (2006) suggested an universal simulation model that takes into consideration the current WSN simulator's components. Deterministic models are therefore available to describe hardware, the environment, power, radio channels, and other variables. These models are helpful for understanding how a WSN functions in real life, but they do not provide the ability to compare various deployment strategies. In addition, the number of simulation nodes is much lower than that of a real network because scalability is impacted by all the processing necessary to simulate all the hardware. Later,

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Cheong in Cheong makes a fresh proposal (2007). The usage of several simulation tools that have previously been described for WSN by Levis et al. (2003) and the ability to execute simulation in a guided manner are two of this work's strengths. However, Cheong suggests a paradigm for programming that is built on actors, a term that lies in between objects and agents. Actors are objects having data flow for communication, but they have no awareness of their surroundings and are not capable of making decisions[15].

V. DESIGNING THE NETWORK TOPOLOGY

The overall WSN architecture must consider a variety of factors, including the protocol architecture, Quality-of-Service, dependability, redundancy, and imprecision in sensor readings, addressing structures, scalability, and energy requirements, geographic and data-centric addressing structures, data aggregation techniques, integration of WSNs into larger networks, bridging various communication protocols, etc.

The OSI model serves as the foundation for the protocol stack that our research team has suggested. In the lowest levels, we can employ either our proprietary protocol, Arachne, or the well-known IEEE wireless sensor network standard 802.15.4 [4]. There are more protocols in the top levels, including our SIR protocol, ping, data aggregation, and transmission clock to base station.

We would arrange the sets to optimise the total amount of time that all sensor sets are used if an application, like a standard SCADA programme [5], can function at an acceptable level using data from a number of distinct sensors sets. We want to determine route selection in combination with the sensor schedule since we are aware of the effect that route selection will have on network longevity. In general, the routes should be selected to route as many times as possible through nodes that are more important for usage as sensors. This issue has been investigated by several writers . We simulate the situation in which the sensors are operating in this part, and in section 3 we formalise the routing algorithm, SIR, that has been suggested as a solution to the issue.

It is necessary to have a communication plan because of the necessity to cover a vast territory. The issue of high connectivity in wire-free ad hoc networks has been the subject of several research [13]. In our study, we take into account a sensor distribution that is random, as shown in figure 1.

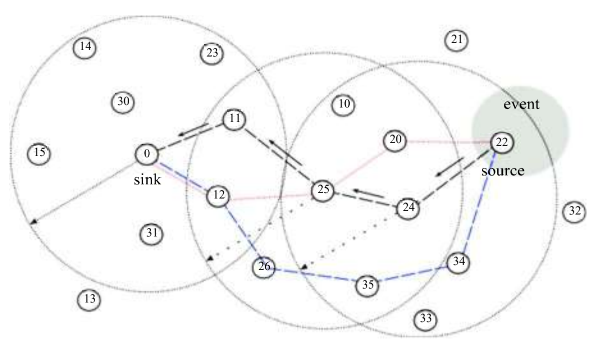

Figure1: *Event transmission from a source to a sink.*

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In this case, the average radio range is defined by the radio transmitter power and radio receiver sensitivity of each node. In the context of wireless sensor networks, a number of network routing protocols that have been developed for wireless networks can be investigated. Direct communication and minimum-transmission-energy multi-hop routing protocol are the two fundamental concepts. Each sensor uses a direct connection protocol to deliver data to the base station. Direct communication will take a lot of transmitting power from each node if the base station is far from the nodes. The nodes' batteries are quickly discharged as a result, shortening the lifespan of the network. Data is sent through intermediary nodes using the minimum-transmission-energy routing technique to reach the base station. As a result, nodes serve as data routers for other nodes. The challenge is choosing intermediary nodes when reducing global energy consumption is the end goal.

Generally speaking, there are three types of routing in WSNs: flat-based routing, hierarchical-based routing, and location-based routing. In this article, we examine networks in which each node is meant to have an equal number of roles or functionalities. Accordingly, flat-based routing works well for these networks.

To assess the impact of the use of AI approaches, we have selected directed diffusion and Energy-Aware Routing (EAR) out of all the currently available flat routing protocols.

By measuring events and producing information gradients in their local areas, sensors use directed diffusion [12]. Data requests from broadcasting interests are made to the base station. Each sensor that gets the interest creates a gradient toward the sensor nodes from which it has got the interest. Gradients from the sources back to the base station are not established until this phase is completed.

Similar to directed diffusion is EAR [16]. However, it differs in that it preserves a variety of pathways rather than preserving or enforcing a single optimal path at greater rates. These routes are kept up and selected using a specific probability. The value of this chance varies according to how little energy each method may use. The energy of any one path will not run out rapidly since multiple pathways were picked at different times.

VI. INTRODUCING NEURONS IN SENSOR NODES

The routing issue is brought about by the requirement for connection among nodes. In a WSN, a multi-hop method is required to go from a source to a destination. The pathways that the packets must take can be determined using a certain criteria. Minimum hop count, minimal latency, maximum data throughput, minimum error rate, etc. are examples of possible criteria. Consider, for instance, that each node wants a way to send data to base station 1. In this case, a method known as network backbone construction is used to remedy the issue.

VII. CONCLUSIONS AND FUTURE WORK

A network of dispersed wireless sensors may be optimised using the theories, methods, and applications of distributed artificial intelligence. The WSN optimization employing logical agents is made possible by the MultiAgent System methodology. The proposed model makes use of multiagent systems along with layered architecture to facilitate intelligence and simulate any WSN, making it possible to implement a solution that allows a sensor network to behave as an intelligent multiagent system. All that is required is knowledge of the final application, where the WSN is going to be deployed. A layered design can also give a WSN system structure and modularity. Additionally, the suggested model stresses how a WSN functions and how to make it intelligent.

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Testing the model with a genuine WSN is still an ongoing task. To conduct a thorough test, certain research examples of multiagent systems for particular applications are needed. The Solarium SunSPOT emulator is a helpful resource. Without a hardware platform, this emulator enables realistic testing for the development and testing of SunSPOT devices. Following the completion of this testing, the model could be applied to a real WSN of SunSPOT devices.

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