Energy Aware Wireless Sensor Network Through Meta Learning Prediction Technique

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ABSTRACT
Energy consumption is a key point of wireless sensor network. Wireless Sensor Networks (WSNs) introduces very special requirements in order to be efficient that is the energy consumption and the extension of the network's lifetime. In this paper, we highlight the recent research efforts like energy efficient routing protocols, dynamic power management, behavior model of wireless sensor node using meta data for saving the allocated energy. Here, we propose meta learning prediction technique for energy awareness in wireless sensor network.

Keywords
wireless sensor network, Energy efficiency, Network life time, energy consumption.

1. INTRODUCTION
A sensor is an object whose purpose is to detect events or changes in its environment, and then provide a corresponding output. A sensor's sensitivity indicates how much the sensor's output changes when the input quantity being measured changes. A Wireless Sensor Network(WSN) is defined as a collection of nodes organized into a cooperative network, which are capable of computing, transmitting and receiving data for the purposes of communication, control, sensing and actuation[1][2]. In 1999, scientists mentioned that WSNs are one of the most important technologies for the 21*st* century [1]. WSN have a wide range of potential applications to industry, science, transportation, civil infrastructure, and security, agriculture, medical, military, smart homes etc. In WSN, tiny sensors are deployed and left unattended to report parameters such as the pressure, humidity, temperature, wind, vibration, power, stress, ultra sound, radiation, infrared, sunlight, colour and chemical activity, pollution etc. Below, the general architecture of WSN will be elaborated in more details.

A sensor node normally consists of four basic components:
A sensing unit, a processing unit, a communication unit, a power unit [1].

A sensor node can perform tasks like computation of data, storage of data, communication of data and sensing/actuation of data. A controller is to process all the relevant data, capable

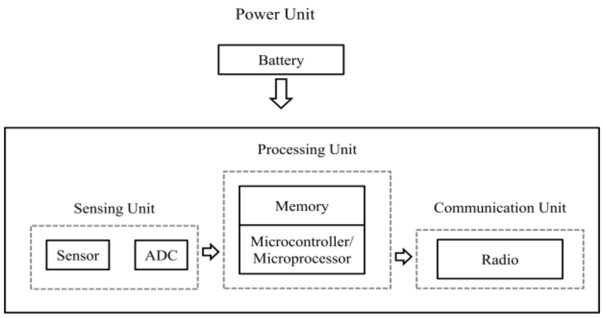

Figure 1: A generalized architecture of a wireless sensor node

of executing arbitrary code. Memory is used to store programs and intermediate data. Sensors are the actual interface to the physical world [1]. These devices observe or control physical parameters of the environment. The communication device sends and receives information over a wireless channel [1]. And finally, the power unit (Battery) is necessary to provide energy [1].

In this paper, we highlight the recent research efforts like energy efficient routing protocols, dynamic power management, Public-Key Cryptographic Primitives, behavior model of wireless sensor node using meta data for saving the allocated energy.

Energy efficient routing protocols are classified into four main schemes: Network Structure, Communication Model, Topology Based and Reliable Routing [3].

The selection and integration of appropriate cryptographic primitives into the security protocols also determines efficiency and energy consumption of the Wireless sensor network (WSN) [4].

In WSN, It is necessary to optimize battery usage by predicting its future behavior. This will lead the users to take early decisions, thus minimizing network downtime [2]. Hence, authors explore the possibility of using meta-data on each node, to represent and predict node behavior using machine learning models [2].

2. RELATED WORK

Table 1: Energy Preservation Techniques in Wireless Sensor Network

Local Techniques	Description	Scheme	Remark
Scaling	The processors operating voltage and frequency can be dynamically adapted based on instantaneous computational load requirements [1].	Dynamic voltage scaling (DVS) Dynamic modulation scaling (DMS)	DVS optimization algorithm takes time synchronization error [5]. DMS may increase system latency [6].
Data Compression	Radio power consumption strongly depends on the packet size [1].	Lossless- Huffman coding, Arithmetic coding Lossy- wavelet transform, Fourier	Lossless- exact original data to be reconstructed from the compressed data [1]. Lossy- retrieves data that may well be

		transform	different from the original [1].
Virtual Sensors	Implementing a virtual sensor for minimizing the main sensor duty cycle [1], Virtual Sensor Network (VSN) [7].	VSN is formed by a subset of sensor nodes of a WSN, with the subset dedicated to a certain task or an application at a given time [7].	
Energy-efficient Cognitive Subsystem	In WSN, the protocol stack of WSNs was modified by adding *a Knowledge Plan* (KP) to build a network that has the ability to adapt itself to changes [1].	Data acquisition and Adaptive sampling [1]	
Memory Leakage Control	The leakage current can be optimized to save energy [1].	Performance feedback, application-intensive manner, feedback from the program behavior [1].	
HW/SW Optimization	Micro-operating systems (μOSs) in WSNs are classified into *event-driven* μOS and *multithreaded* μOS [1].	Energy-aware task scheduling and resource management, Compilers, spill code reduction, Power-aware instruction scheduling	The platforms are designed dedicated for specific task which in turn reduce the redundant H/W components for a certain task [1].
Distributed Techniques	**Description**	**Scheme**	**Remark**
Mobility	Either employing mobile sinks or mobile relay nodes in order to reduce the number of multi-hops and thereby minimizing the transmission cost [1]	Mobile sinks- Linear Programming mobile relay- Message ferrying scheme [8]	
Data driven	Distributed processing is made through the entire network in order to prolong the WSN lifetime	Compressive sensing- reading is processed to remove redundancy by exploiting spatial correlation [1] Data prediction- identical predictors, implemented in the source and sink nodes, are utilized in order to minimize the number of transmitted packets [1]	
Duty Cycling	Radio transceivers, in most cases, consume the majority of the energy available. Hence, switching the transceiver into sleep mode helps to greatly prolong the network lifetime [1]	Aggregation techniques, Redundancy control, or on mac protocols [1].	
Energy-efficient Networking	Routing is the process of delivering information to the destination through a hopefully short path. Many optimization techniques have been proposed to improve the performance of this task in terms of energy consumption [1]	Network Structure, Communication Model, Topology Based and Reliable Routing protocols [3].	All the details and comparison, advantage, disadvantage about routing protocols is given in [3].

Energy consumption and Network lifetime are key points of wireless sensor network. There are many different ways to increase network lifetime in Wireless Sensor Network. Among them we highlight the recent research efforts like energy efficient routing protocols, dynamic power management, behavior model of wireless sensor node using meta data for saving the allocated energy.

Following are some sources of wastage of energy [3]:

- *Control packet overhead:* To guarantee the expected QoS parameters such as reliability and throughput, network exchanges these types of packets.
- *Idle listening*: In WSNs nodes have to switch the receiver *ON*, waiting for possible incoming packets, because traffic behavior is not known.
- *Overhearing*: Sometime through idle listening motes could detect false packets which are actually for other nodes which could cause wastage of energy.
- *Over-emitting*: Due to lack of flow control mechanism and synchronization problem, a MN could transmit packets to a neighbor which is not ready for receiving packets at this moment.

Table 2: Dynamic Power Management Techniques in Wireless Sensor Network [9].

Technique	Description	Scheme	Remark
Timeout	The timeout scheme can make a power manageable component off, if no activity within fixed interval of time.		The timeout policy is appropriate when idle period is larger in length to compensate the switching overhead power consumption.
Predictive policy	Predictive policy adopts the prediction concept to check the future input characteristics and timing for taking the decision about next idle period duration.		The system switches the components to power down state if predicted idle duration is more than specified breakeven time.
DPM using Stochastic Control Model	The system component states and input arrival probabilistically using Markov decision process.	discrete time Markov decision process(DTMDP), Continuous time Markov decision process (CTMDP), time indexed semi Markov decision process (TISMDP).	The wrong decision taken once can consume more power than saving if there is no provision of correction within long enough idle duration.
DPM using Dynamic Scaling	Dynamic scaling reduces power consumption of a controller device by operating it at low voltage during its active mode.	dynamic voltage and frequency scaling (DVFS), processor acceleration to conserve energy (PACE), A DVS algorithm for Sporadic Tasks (DVSST)	
DPM using power-aware scheduler	The leakage current can be optimized to save energy [1].	Performance feedback, application-intensive manner, feedback from the program behavior [1].	

- *Collisions*: Because of bad link quality or the inefficient medium access protocol, multiple transmissions are initiated simultaneously which is call collision.
- *State transitions*: Switching between modes of operation highly increases the power consumption due to leakage currents.

In table 1 different energy preservation techniques is mentioned there are also another techniques.

There are some dynamic power management (DPM) approaches that can be used individually or together and dynamically manage wireless sensor node operations in order to minimize its power consumption after deployment.

In this approach sensor node architecture consists of power management unit and power manageable components (processor, embedded sensor, analog to digital converter, memory and the RF transceiver etc) [9].

A power management approach is worked at micro-operating system level to control the sensor node. Advantage with operating system level power management is that its possibility of implementation using software program only and thus reduces hardware cost and overhead also [9].

The Dynamic Power Management (DPM) scheme decreases power consumption at sensor node level by minimizing active period as much as possible and operating the node's power manageable components in different power down states during

active period [9]. There are several factors which affect the DPM techniques: event arrival rate, event priority, deadline violation, service rate, length of waiting request and battery consumption rate [9].

In table 2 various techniques of DPM is described briefly.

3. PROPOSED WORK

Energy aware routing & scheduled sensing have been introduced for careful use of battery. It is necessary to optimize battery usage by predicting its future behavior. This will lead the users to take early decisions, thus minimizing network downtime [2]. Hence, another technique for optimize battery usage is using meta-data on each node, to represent and predict node behavior using machine learning models.

Node voltage level is an important metric which is proportional to node's energy consumption, which is a good measure of node lifetime. Hence, by being able to measure and model voltage level, it is possible to predict the future lifetime of each node. Now, after doing some literature survey we come to know that temperature and voltage is also highly correlated. So, to predict the node's energy consumption we will also take temperature as a metric.

Here different clustering algorithm can be used to classify node voltage level in high, medium and low. This technique will enable WSN users to optimize energy aware/energy efficient protocols and applications with a valuable input, where future node energy consumption can be anticipated with high accuracy [2].

Design of proposed system

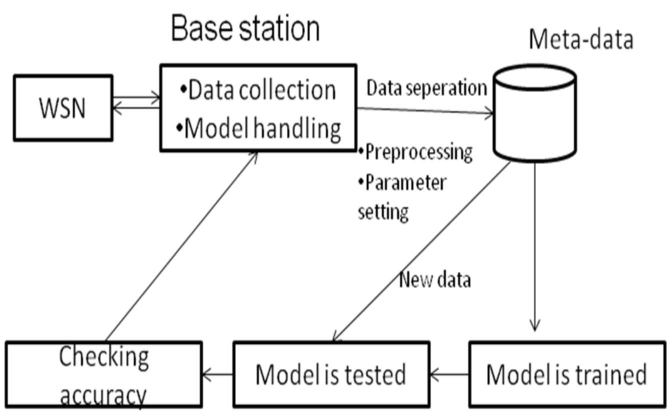

Figure 2: design of proposed system

Following are the steps of the proposed system:

1. Enough data to represent nodes behavior (voltage, date, time, nodeid, temperature).
2. Acquire data from storage back to base station.

3. Data separated according to nodeid to create time series data for each node
4. Model is trained by considering time series.
5. Newly received time series data fitted to model so new knowledge is reflected.
6. Predicts voltage level and temperature for analyzing with the time to determine energy consumption behavior.
7. Three stage of energy consumption high, medium, low.
8. Check accuracy of classification and prediction.

Here, to classify node in high, medium or low, we can use different clustering algorithm. For example K-means Algorithm, K-medoids algorithm. But which algorithm will be more accurate that can be known by **Land mark Meta learning.** Land markers are quick estimates of algorithm performance on a given dataset. They can be obtained in two different ways. The estimates can be obtained by running simplified versions of the algorithms [11]. An alternative way of obtaining quick performance estimates is to run the algorithms whose performance we wish to estimate on a sample of the data, obtaining the so-called sub sampling Land markers [11]. We will use second way in our research.

4. CONCLUSION

Energy efficiency is a major goal in wireless sensor network domain. Due to the diversity in the WSNs applications and their requirements, it is difficult to define standard energy-efficiency protocols. We decided to work in Energy Aware Wireless Sensor Network Through Meta Learning Prediction Technique. For that we will use the techniques of data mining like data preprocessing, classification, clustering, meta learning in that land mark meta learning, prediction etc. we explore the possibility of using meta-data on each node, to represent and predict node behavior using meta learning model. In this research, we will use node voltage level and temperature as an indicator of the energy used, as voltage is proportional to available energy and node voltage is highly correlated with temperature. We will classify nodes as high, medium & low use, with respect to its current and future usage, thus allowing user to take early decisions maximizing network throughput (lifetime).

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