INTEGRATED ENERGY MANAGEMENT FRAMEWORK AATRAL FOR ENERGY ENGINEERING IN WIRELESS SENSOR NETWORK

M. THANGARAJ, S. ANURADHA

Abstract: Energy scavenging, energy optimization techniques and energy harvesting unit development are the current research interests in the field of Wireless Sensor Networks(WSN). Most of the researches addresses the energy issues at the architecture-topology level, hardware level, algorithmic, protocol or data handling level and shows the energy improvement by making the inevitable process as the energy aware one but ignores the other aspect. This paper highlights how this study lacks the holistic, integrated approaches and proposes a solution energy management framework with the energy model that validates the overall energy improvement by measuring the energy with activity and different units of WSN.

Keywords: Energy Economics, Energy Engineering, Wireless Sensor Networks, Energy Framework, Energy Model

Introduction: Each of the researcher or institution, even the industry vendor focuses on their own aspects of energy scavenging/harvesting methods in WSN at the architectural level, algorithmic level, protocol level or at the physical layer level by introducing a mathematical model correction or redefining the existing approaches as energy aware ones. But one Energy Engineering approach considers one aspect of WSN and leaves other aspects. So, we couldn't really assure in reality, the approaches will surely give the desired results at the overall network level for the longer duration [1]. Most of existing energy models only analyzes the energy status of the communication module, being lack of studying the overall energy consumption from the view of nodes. By modeling the energy consumption of different node components in different operation modes and state transitions still need focus. These factors lead to the conscious design of the hardware and software components that support the energy study and energy improvements [2]. The energy conscious and energy efficient Wireless Sensor Network came out with the same objective. Before getting into the energy efficiency factors we have to consider the various energy consumption activities and processes in a WSN.

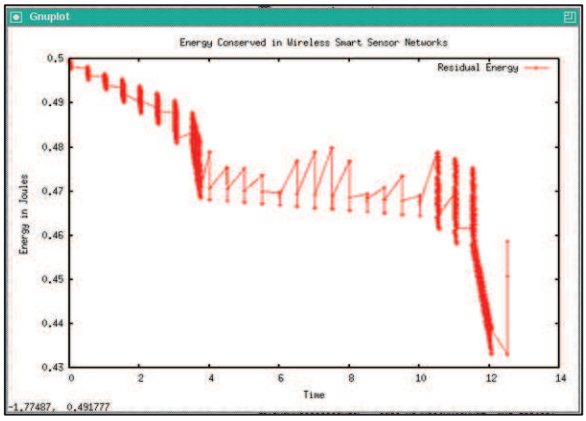

Fig 1: Traditional Energy Recording with Residual Energy

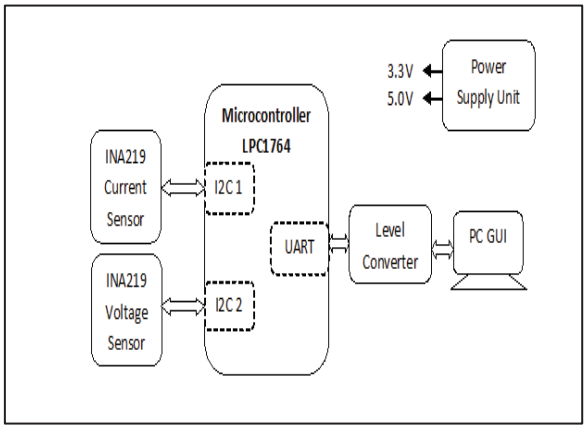

Fig 2: Design of Energy Auditing Device - Block Diagram

Energy Engineering in WSN: All the energy engineering initiatives in WSN can be summarized as energy auditing or monitoring, energy optimization or energy scavenging and energy harvesting for improved energy and extended life of WSN.

A. Problem Formulation

(I) A standard on Power Budgeting which validates the investment on energy improvements across the cost getting saved out of the initiatives is still at the infant stage for the WSN. It's become a fashion or passion for the researchers to work on the energy aspect of WSN as the motes survive with the limited power supply and the energy efficiency in WSN is the very critical issue [6] .

(II) Even at the application interface level, there is no readymade solution across platforms or hardware to monitor and control energy in WSN [3]. It becomes the overhead for the team who sets up the application bed of sensors. Initially the application bed setup is considered and proposed for the particular purpose like precision agriculture, body area monitoring, smart homes, military intruder detection system with the traditional Quality of Service Parameters throughput, channel utilization, latency delay, bit rate. But the sensors in the network have to live with the limited battery [4]. So, later the team started worrying about the extended life of WSN with the limited power and tries to build up an application interface to monitor and optimize the energy for WSN [5].

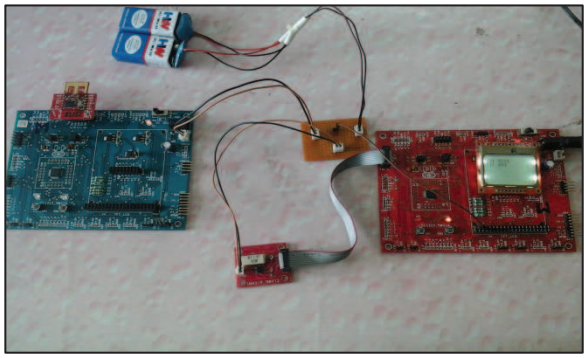

Fig 3 : Energy Measurable Node Design

Even certifications and auditing firms and auditing institutions have been established in the past decades for electrical energy but not for the WSN system.

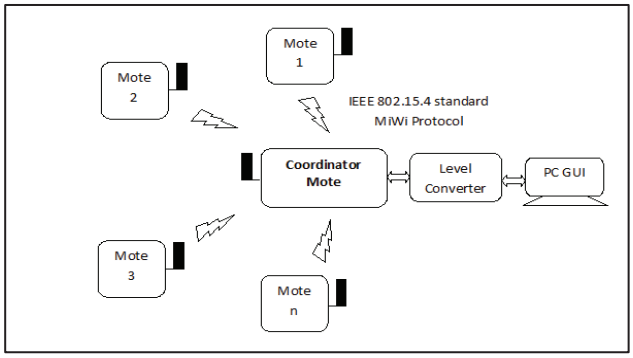

Fig 4 : WSN setup of Aatral

(III) None of the most of inventions in this field has been offered as a service which can be fine tuned or configured to any domain specific real time need of WSN. So there are redundant efforts and cost invested on Energy Engineering in the different WSN applications and WSN platforms [7].

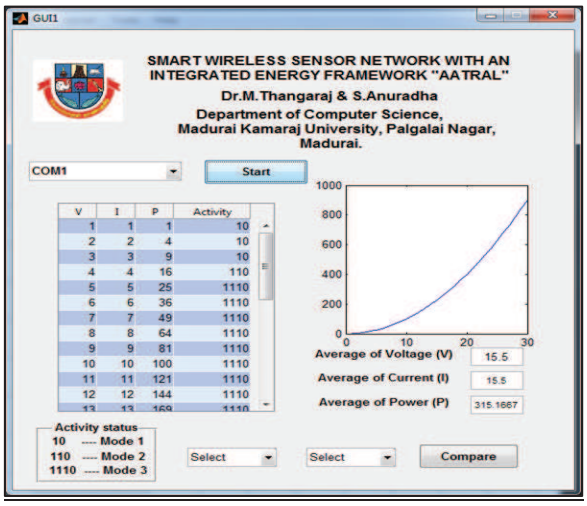

Fig 5: Integrated Energy Framework Aatral For WSN

B. Related Work

1) **National Status Review:** Energy efficiency and energy consumption are now more and more crucial for the economic success of companies. www.energyauditingindia.com team and BEE identify where there is potential for optimization in industrial energy management, analyze possibilities for savings, and implement measures to permanently reduce energy costs [8]. The team consists of certified Energy

Auditors from BEE having over 2 decades of expertise in carrying out energy audits across all kinds of industries, power plants, buildings, hospital,

Hotel and more. Team evaluate organizations complete electrical and thermal consumption with own instrument and measure their efficiency and recommend energy saving proposal with a payback period to reduce your electrical and thermal cost. But similar initiatives are missing for the Wireless Sensor Network, which is going to be the future network.

2) **International Status Review:** Dobontechs TERATRACK product has the extensive user friendly GUI based energy monitoring and auditing system; PS4500 POWERQUALITY ANALYZER from summit Technologies is a versatile, easy-to-use power monitors suitable for all types of power studies. It is a data logger, energy and demand meter, power quality monitor, harmonics analyzer and "live-view" scope and millimeter - all in one solution. Federal Energy Management Program (FEMP)- The evaluated technology consisted of a network of wireless sensors – including branch circuit power monitors, temperature sensors, humidity sensors, and pressure sensors, along with an integrated software product to help analyze the collected data [9]. These are some of the initiatives at the international level on energy auditing and monitoring systems for various domain specific needs.

C. Our Contribution

A holistic consolidated service panel with users options, parameters to manage the entire WSN system in all aspects and helps us to monitor - audit the energy efficiency and energy health of the system.

A standard on energy monitoring and auditing system is formed with defined policies and energy measurable hardware design, because unless we measure we may not able to control [10]. An energy efficient system as a service panel has been developed which will consolidate all the best research inventions on Energy Engineering (EE) at the various levels of WSN. Alternate energy sources are to be availed as a service for any given WSN.

A one stop service panel is created with configurable, user friendly multimedia Graphical User Interface (GUI) and useful reports to manage multiple aspects of the WSN. Historical DB of valid results on different Quality of Service Parameters is to be made available for an efficiency comparison in a given environment of chosen Parameters [11].

System Architecture and Design:

The Integrated energy framework Aatral consolidates all the energy initiatives and provides the service panel for monitoring, optimizing and harvesting the energy.

i) A software service that helps to monitor and audit the given WSN

ii) A consolidated service panel that identifies the energy leakages in the WSN communication at various levels and suggests the fixes and gives energy efficiency recommendations for it

iii) An online service that helps the WSN administrator to fix the energy leakages and provide energy scavenging service for the WSN system

iv) Alternate energy resources can be availed as a service based on the WSN administrator option

v) A master DB of the historical data matrix of WSN for comparison.

A. Energy Auditing System

An energy monitoring and auditing system with a defined energy model of configurable QOS parameters which can identify the nodes in a specified range and generate the energy graph, energy auditing checklist, methodology, principles, policies -energy effective action plans energy monitoring and auditing methodologies, tools software, data matrix collected on energy auditing for energy efficiency reference.

B. Energy Optimization System

Identifies the energy leakages in the EE WSN

system by comparing the energy model QOS parameter values with the standard values in the defined master DB and suggest the best way to heal the issue and try to heal on its own when the user consciously select the "Fix" option of the given suggestion.

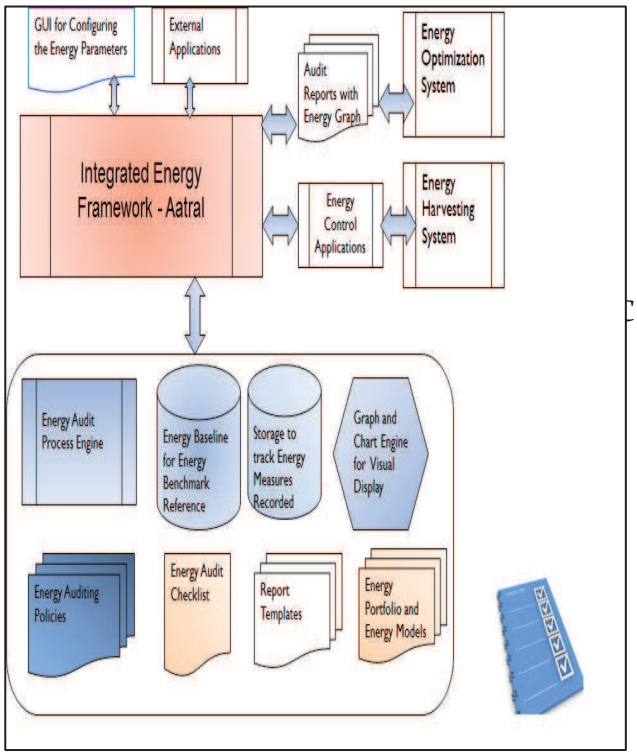

Fig 6: Architecture of Integrated Energy Management Framework Aatral for WSN

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WSN Design Details	
Component	**Device**
Micro Controller(Processor)	ARM LPC1313 processor
Protocol	IEEE 802.15.4 standard MiWi Protocol
Current Sensor	INA219 Current, Voltage Sensors
Environment Sensor	MCP9800 Temperature Sensor
Trans Receivers	MRF 24J40MA
Nodes and Gateway	3 Nodes - 1 Gateway
Application Interface	Mat Lab - Lab view

TABLE I. WSN Profile with Energy Monitoring and Scavenging Enhancements

There are two aspects in the WSN

(i) Hardware components

(ii) Software Components

The prior ones energy readings vary for the vendor and readings is vendor specific hardware selected. Whereas the software component energy expenditure is almost same across the hardware. For eg. The energy for transmission energy varies based on the selection of hardware where as the routing and data aggregation, energy on a particular protocol is the same across the hardware.

C. Energy Harvesting System

Proved techniques and methods to provide the alternate energy sources (solar, polar, vibrant) for the longer lifetime of WSN which user can avail as a service. The Complete online service configurable software model of the following WSN that can be fine-tuned to any specific application need.

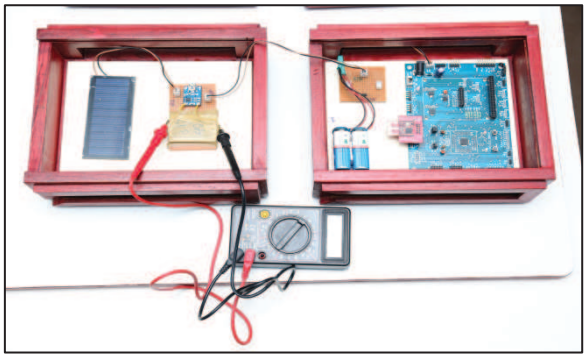

Fig 7: Energy Harvesting Unit of Aaatral

D. Energy Economics Calculator

The best part is after energy optimization, the cost saved out of the energy improvements are recorded for different energy scans accumulated with time stamp. The energy variance over the period of time and the cost saved over the period of time can be calculated. If we compare it with the power budget and the investments for energy improvement, we can find out a realistic cost saved [12].

Conclusion and Future Work:

Now, the Energy Management framework has been evaluated and tested with a specific set of

hardware. The extended research will make the framework portable across hardware and platform so that Aatral can be made as the energy backbone for any wireless sensor network with minimum configuration. The services with the extensive library functions, application interfaces will be exposed for the co researchers to conduct the test. There will be extended on software scaling up to 100 -1000s of node test bed simulation setup based on the realistic reading on the hardware. The stack of software components will be provided to choose and set different WSN profiles. The test bed setup is based on the thermistor sensor, it is planned to have the stack of sensors as well, so that any application specific WSN test bed can be set with the energy management framework Aatral. There will be an automated report on a user account for the number of test runs, energy economics calculated value, contribution and usage for a time interval.

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M. Thangaraj, Associate Professor, Department of Computer Science, MKU,
thangarajmku@yahoo.com
S.Anuradha, Research Scholar, Department of Computer Science, MKU,
sa_radha@hotmail.com