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PERFORMANCE ANALYSIS OF RF MODEL OF WIRELESS SENSOR NETWORKS

MAHUA BHOWMIK[1], SUMA DUPALLI[2], DHANASHRI SAINDANE[3] & GITANJALI MURUMKAR[4]

[1,2]Professor, Padmashree Dr. D. Y. Patil Institute of Engineering and Technology, Pimpri, Pune, Maharashtra, India

[3,4]Padmashree Dr. D. Y. Patil Institute of Engineering and Technology, Pimpri, Pune, Maharashtra, India

ABSTRACT

This paper describes the modeling of a micro sensor node for wireless sensor network. This model allows studying the impact of hardware and software choices into the node autonomy. This model is used to evaluate the best configuration of a sensor node according to the application specifications and eventually to underline to need to design a specific element for the target application. We are presenting the model of micro sensor node and energy model in order to verify the various aspects of minimizing the energy consumption of sensor nodes according to application. We evaluated MAC and routing protocol in terms of all energy parameter.

KEYWORDS: Energy Model, Micro Sensor Node, Power Constraint, Wireless

INTRODUCTION

A sensor network is composed of a large number of sensor nodes that are densely deployed either inside the phenomenon or very close to it. The position of sensor nodes need not be engineered or predetermined. This allows random deployment in inaccessible terrains or disaster relief operations. On the other hand, this also means that sensor network protocols and algorithms must possess self organizing capabilities. Another unique feature of sensor networks is the cooperative effort of sensor nodes. Sensor nodes are fitted with an onboard processor. Instead of sending the raw data to the nodes responsible for the fusion, they use their processing abilities to locally carry out simple computations and transmit only the required and partially processed data.

SENSOR NETWORKS COMMUNICATION ARCHITECTURE

The sensor nodes are usually scattered in a sensor field as shown in Figure 1. Each of these scattered sensor nodes has the capabilities to collect data and route data back to the sink. Data are routed back to the sink by a multi hop infrastructure less architecture through the sink as shown in Figure 1.

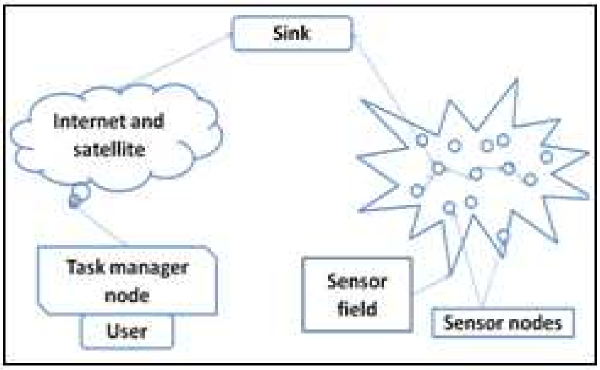

Figure 1: Sensor Nodes Scattered in a Sensor Field

The sink may communicate with the task manager node via Internet or satellite. The design of the sensor network as described by Figure 1 is influenced by many factors, including fault tolerance, scalability, production costs, operating environment, sensor network topology, hardware constraints, transmission media, and power consumption.

DESIGN FACTORS

The design factors are addressed by many researchers as surveyed in this article. However, none of these studies has a fully integrated view of all the factors driving the design of sensor networks and sensor nodes. These factors are important because they serve as a guideline to design a protocol or an algorithm for sensor networks. In addition, these influencing factors can be used to compare different schemes.

Hardware Constraints

A sensor node is made up of four basic components, as shown in Figure 2: a *sensing unit*, a *processing unit*, a *transceiver unit*, and a *power unit*. They may also have additional application-dependent components such as a *location finding system*, *power generator*, and mobilize. Sensing units are usually composed of two subunits: sensors and analog-to-digital converters (ADCs). The analog signals produced by the sensors based on the observed phenomenon are converted to digital signals by the ADC, and then fed into the processing unit. The processing unit, which is generally associated with a small storage unit, manages the procedures that make the sensor node collaborate with the other nodes to carry out the assigned sensing tasks. A transceiver unit connects the node to the network. One of the most important components of a sensor node is the power unit. Power units may be supported by power scavenging units such as solar cells. There are also other subunits that are application-dependent. Most of the sensor network routing techniques and sensing tasks require knowledge of location with high accuracy. Thus, it is common that a sensor node has a location finding system. A mobilizer may sometimes be needed to move sensor nodes when it is required to carry out the assigned tasks. All of these subunits may need to fit into a matchbox-sized module. The required size may be smaller than even a cubic centimeter, which is light enough to remain suspended in the air. Apart from size, there are some other stringent constraints for sensor nodes. These nodes must consume extremely low power, operate in high volumetric densities, and have low production cost, be dispensable and autonomous, operate unattended, and be adaptive to the environment.

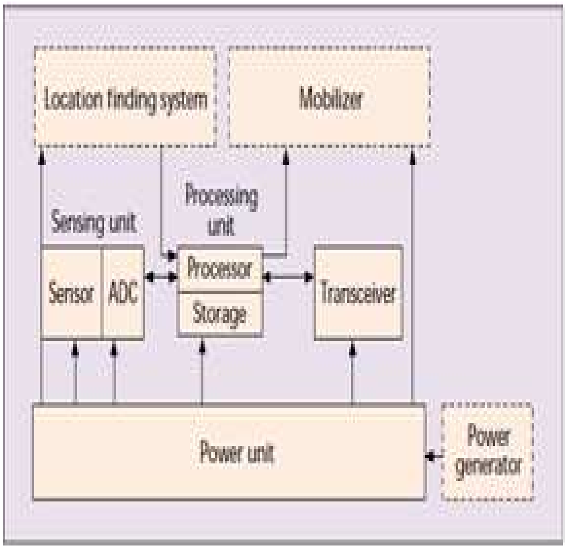

Figure 2: The Components of Sensor Node

Transmission Media

In a multi hop sensor network, communicating nodes are linked by a wireless medium. These links can be formed by radio, infrared, or optical media. To enable global operation of these networks, the chosen transmission medium must be available worldwide. Much of the current hardware for sensor nodes is based on RF circuit design. The AMPS wireless sensor node described in uses a Bluetooth-compatible 2.4 GHz transceiver with an integrated frequency synthesizer. The low-power sensor device described in uses a single-channel RF transceiver operating at 916 MHz the Wireless Integrated Network Sensors (WINS) architecture also uses radio links for communication. Another possible mode of internodes communication in sensor networks is by infrared. Infrared communication is license-free and robust to interference from electrical devices. Infrared-based transceivers are cheaper and easier to build. Another interesting development is that of the Smart Dust mote, which is an autonomous sensing, computing, and communication system that uses the optical medium for transmission. Both infrared and optical require a line of sight between the sender and receiver.

Power Consumption

The wireless sensor node, being a microelectronic device, can only be equipped with a limited power source (< 0.5 Ah, 1.2 V). In some application scenarios, replenishment of power resources might be impossible. Sensor node lifetime, therefore, shows a strong dependence on battery lifetime. In a multi hop ad hoc sensor network, each node plays the dual role of data originator and data router. The malfunctioning of a few nodes can cause significant topological changes and might require rerouting of packets and reorganization of the network. Hence, power conservation and power management take on additional importance. It is for these reasons that researchers are currently focusing on the design of power-aware protocols and algorithms for sensor networks. The main task of a sensor node in a sensor field is to detect events, perform quick local data processing, and then transmit the data. Power consumption can hence be divided into three domains: Sensing, communication, and data processing.

Energy Module for Micro Sensor Node

As demonstrated in the literature7, it is necessary to maintain sensor node switched-off as long as possible in order to increase the node autonomy. A node is composed of sensors, analog to digital converters (ADC), processing unit, memory, RF transceiver and battery. The total energy dissipated by the sensor node could be expressed as the sum of the energy dissipated by each element:

$$Enode = Esensor + EADC + E\mu C + Etrans + Erec \qquad (1)$$

The energy dissipated by an element depends on its state: active or idle. First, the energy dissipated by the sensor is expressed as follow:

$$Esensor = Pon\_sensor(t\_stabilization + tmeasure) + Poff\_sensor(Tcycle - (t\_stabilization + tmeasure)) \qquad (2)$$

Where t_stabilization corresponds to the stabilization time of the sensor and t_measure to the duration of the sensing phase which depends on the number of measure to realize and on the ADC conversion time8. T_cycle defines the periodicity of the micro sensor node activity. Moreover, during the sensing phase, ADC converts sensor measures from analogical to digital data. The energy consumed by the ADC in on state is defined as:

$$Eon\_ = Pon\_\,(e{-}up\_ADC + tmeasure) \qquad (3)$$

After the sensing phase, the microcontroller could proceed to data processing, formatting and coding in accordance with the application and communication protocols. The energy dissipated during the data processing phase is expressed as:

$$E\ data\ proces = (t/S\mu C)\ Pon\_\mu C \quad (4)$$

Where Nsoft indicates the number of instruction per cycle according to the embedded software and SμC is the microcontroller speed.

After that, transmit data depends on the goal of the application. In fact, in some cases, it is possible to aggregate several measurements before sending data. In other applications, data is sent only when an event is detected. Moreover, in several cases, a receiver is needed to relay data from another node, to treat an acknowledgement or a station base request. The energy consumption of the transmitter and receiver in on state is defined as:

$$Eon\_trans = (twake - up\_trans + (Nbits\_trans\ /Dinst))\ Pon\_trans$$

and

$$Eon\_ = (\_delay + (Nbits\_rec\ /\ D\_inst))\ Pon\_rec \quad (5)$$

Where Nbits_trans and Nbits_rec are respectively the number of bits to transmit or to receive. Dinst is the instantaneous data rate. tdelay corresponds to the delay between the end of the transmission and the reception of the first data bit.

Finally, concerning the microcontroller, its on-state energy consumption is expressed as follow:

$$Eon\_\mu C = Pon\_\mu C\ (\_wake{-}up\_\mu C + ton\_sensor + (Nsoft/\ S\mu C) + ton\_trans + ton\_rec) \quad (6)$$

As demonstrated by (6), the on state time of the microcontroller depends on the other element. In fact, the role of the microcontroller is to manage the different operating modes of the node: measure, process, transmit and receive.

MEDIUM ACCESS CONTROL

The MAC protocol in a wireless multi hop self organizing sensor network must achieve two goals. The first is the creation of the network infrastructure. Since thousands of sensor nodes are densely scattered in a sensor field, the MAC scheme must establish communication links for data transfer. This forms the basic infrastructure needed for wireless communication hop by hop and gives the sensor network self-organizing ability. The second objective is to fairly and efficiently share communication resources between sensor nodes.

THE NS_2 SOFTWARE

In the network research area, it is very costly to deploy a complete test bed containing multiple networked computers, routers and data links to validate and verify a certain network protocol or a specific network algorithm. The network simulators in these circumstances save a lot of money and time in accomplishing this task. Network simulators are also particularly useful in allowing the network designers to test new networking protocols or to change the existing protocols in a controlled and reproducible manner.

Network simulators are used by people from different areas such as academic researchers, industrial developers, and Quality Assurance (QA) to design, simulate, verify, and analyze the performance of different networks protocols. They can also be used to evaluate the effect of the different parameters on the protocols being studied. Generally a network simulator will comprise of a wide range of networking technologies and protocols and help users to build complex networks from basic building blocks like clusters of nodes and links. With their help, one can design different network topologies using various types of nodes such as end-hosts, hubs, network bridges, routers, optical link-layer devices, and mobile units.

SENSOR NETWORK APPLICATION

Although computer-based instrumentation has existed for a long time, the density of instrumentation made possible by a shift to mass-produced intelligent sensors and the use of pervasive networking technology gives WSNs a new kind of scope that can be applied to a wide range of uses. These can be roughly differentiated into

- Monitoring space,
- Monitoring things, and
- Monitoring the interactions of things with each

Other and the encompassing space. The first category includes environmental and habitat monitoring, precision agriculture, indoor climate control, surveillance, treaty verification, and intelligent alarms. The second includes structural monitoring, ecophysiology, condition-based equipment maintenance, medical diagnostics, and urban terrain mapping. The most dramatic applications involve monitoring complex interactions, including wildlife habitats, disaster management, emergency response, ubiquitous computing environments, asset tracking, healthcare, and manufacturing process flow.

RESULTS

As per the discussions, here we are presenting the result obtained from simulation work done over estimated MAC protocol and Routing protocol. As scenarios presented, we have recorded the metrics such as average energy consumption, total energy consumption and residual energy consumption for MAC protocol and Routing protocol

Below is the comparative analysis graph based on practical readings.

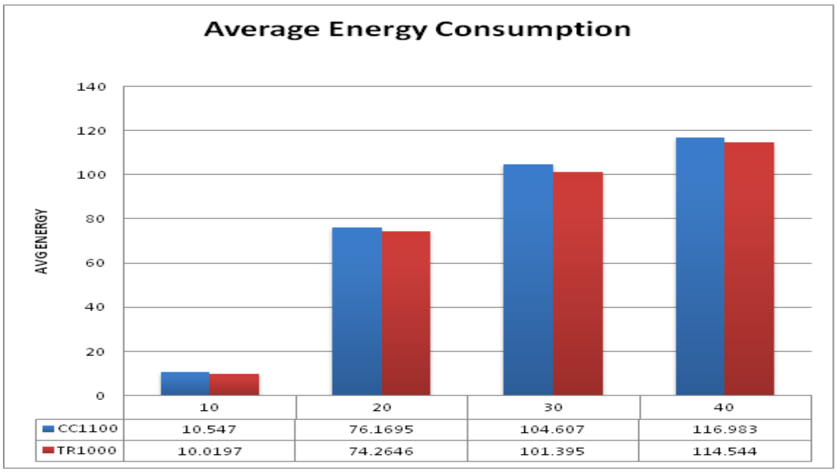

Figure 3: Average Energy Consumption

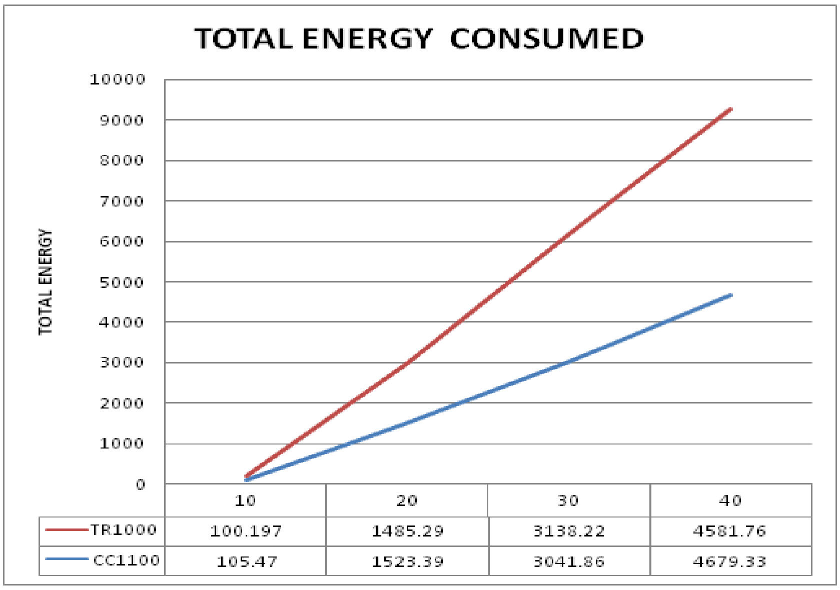

Figure 4: Total Energy Consumed

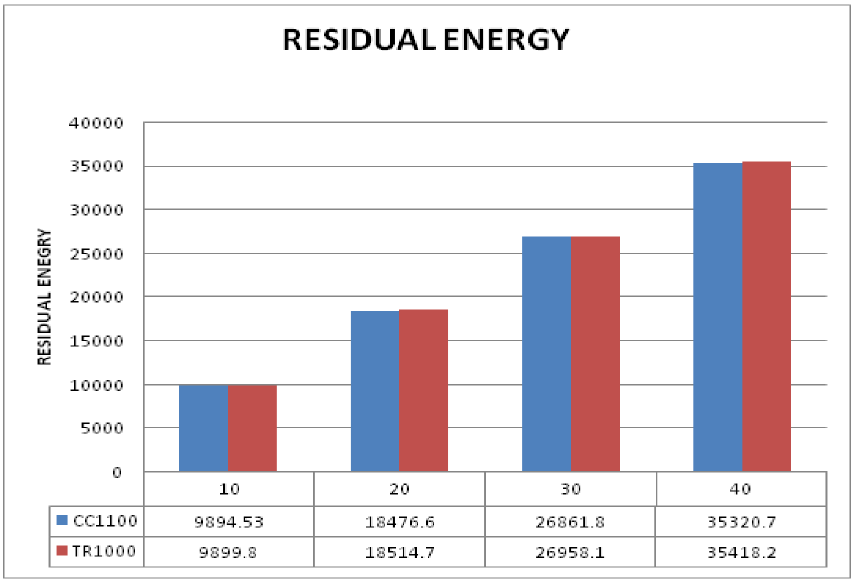

Figure 5: Residual Energy

CONCLUSIONS

Here we have concluded that the developed model allows studying the impact of the hardware and software choice into the node autonomy. It could be used to evaluate the best configuration of a sensor node according to the application specifications and eventually to underline the need to design a specific element for the target application. The flexibility, fault tolerance, high sensing fidelity, low cost, and rapid deployment characteristics of sensor networks create many new and exciting application areas for remote sensing. In the future, this wide range of application areas will make sensor networks an integral part of our lives. However, realization of sensor networks needs to satisfy the constraints introduced by factors such as fault tolerance, scalability, cost, hardware, topology change, environment, and power consumption. Since these constraints are highly stringent and specific for sensor networks, new wireless ad hoc networking techniques are required.

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