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Efficient Energy Utilization of Wireless Sensor Node by Solar Powered S-MAC

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ABSTRACT: Energy scavenging technology potentially solves the difficulty of energy efficiency, which is the main dispute in wireless sensor networks. One of the most significant constraints in conventional wireless sensor networks is the inadequate amount of energy available at each sensor node. The sensor node, which has an ability of harvesting energy from the nearby environment, is able to attain infinitive lifetime. Instead of saving power as much as possible, the protocols should assure that the harvested energy is equal to or larger than the consumed energy. In conventional WSNs, sensors are generally equipped with capacity limited battery sources that can carry on longer or shorter period, depending on the energy usage model and the liveliness level of sensor nodes. Hence, the proposed research work provides a fundamental principle to design efficient SMAC (Sensor Medium Access Control) protocol solar energy harvesting from a photovoltaic cell. The simulation outcomes show that SMAC provides good network performance and infinitive lifetime of sensor networks.

KEYWORDS: WSN, Medium Access Protocol (MAC), Sensor-MAC, Active Modes, TDMA, CDMA.

I. INTRODUCTION

Wireless sensor networks includes hundreds of distributed sensors to monitor a specific parameters which can be the level of pollutants, sound, temperature, pressure, vibration and etc. These nodes as networks have been utilized in a variety of applications, like, military civil and industry applications [1]. The typical wireless sensor node design is shown in the figure 1. The WSN nodes have also been widely used in object tracking, healthcare monitoring and line sensing. Typical Wireless Sensor Networks is composed of different layers. The first layer of WSNs is MAC (Medium Access Control) layer, which gives access of the wireless channel to various nodes. According to the type of MAC protocol, the wireless sensor networks are categorized into two general categories.

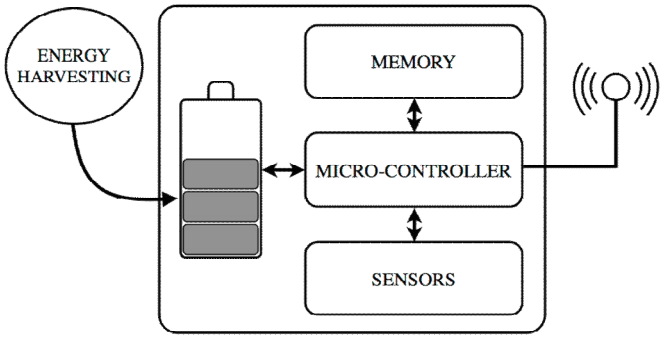

Fig1. Conventional wireless sensor node

The first is scheduled networks and the second is contention-based networks. The wireless channel is separated into sub channels in terms of time or frequency or orthogonal codes and each of these sub channels are allocated to each node. But each of those protocols has its own disputes like time synchronization, frequency generation and bandwidth requirements, and the power control in CDMA.

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The above requirements cannot satisfy using incapable sensors which are typically situated in a place with no replacement or maintenance possibility. Hence the disputation based access methods are more appropriate due to their autonomous, scalable and simple nature. All the nodes will compete with each other to win the access to the shared medium. The other most significant constraints in conventional wireless sensor networks are energy management / power consumption. The power consumption must be consistent over the network to whole lifetime [2]. Or else there will be some section of the network having of dead sensors which will corrupt the overall Quality of Service.

II. RELATED WORK

In current years, self powered wireless sensor nodes have raised in popularity. The Kinetic, Thermal, Solar and Piezoelectric harvesters have been implemented. For the long-standing sensors with low sampling rate, self-powered nodes usually harvest energy from the sun, batteries, rechargeable modes and etc such as WATTR [2] and the MIT Pushbutton [3]. On the other hand, there is a need to build power harvesting systems that are more common reason. Solar is a general example to provide that need, and thermal is the other. Research in sensor networks is aggravated by the ability of sensor networks to strongly connect the physical world and the existing pc infrastructure, as described in [3], [5], and [7]. The issue of low power utilization in sensor networks is indicated as one of the important requirements. Low power hardware components and universal sensor network structural design are developed in and project [6], [7].

III. PROBLEM DEFINITION

The main idea of our paper is on Wireless Sensor Nodes, which are tiny devices that gathers and transmits data about the nearby environment ambient temperatures, air pressure values, or wind velocities. Hence these devices rely on ambient energy sources, including solar energy, and wind energy. Main usefulness of WSN's is their ability to stay alive for lengthy periods of time, which needs careful administration of the collected ecological energy. In WSN, the communications of information consumes more energy than sensing and data processing. So, the needs of distributed and highly localized solutions for different levels of communication protocols are increased. The MAC layer allows the successful operation of the sensor network and the protocol already implemented attempts to avoid collisions by not permitting two interfering nodes to transmit at the same interval. Hence, the proposed research work provides a fundamental principle to design efficient SMAC (Sensor Medium Access Control) protocol solar energy harvesting from a photovoltaic cell [3]. The simulation outcomes show that SMAC provides good network performance and infinitive lifetime of sensor networks.

IV. PROPOSED SYSTEM ARCHITECTURE

The ability of the wireless sensor node of networks should consist of major power generation and distribution factors in order to get long life time. Hence the proposed research identifies the problems in wireless sensor nodes and rectifies with the efficient power scavenging and power sharing mechanism using the protocols used for data communication.

V. SOLAR POWER HARVESTING

There are two key ways in enhancing the life time of WSN. First one is saving energy. By reducing methodical energy consumption and steering protocol with low energy expenditure, the energy will be saved to the maximum extent. Second is to acquire energy from the surroundings. WSN nodes can increase and store energy from its neighbouring environment. In recent years, researchers have done some research and prepared some progresses among which how to build use of solar energy gathering machines has become a research spotlight. This paper designs the wireless sensor node based on solar energy power supply as in fig 1. The experiment shows that the node design has Energy saving and Energy harvester design [7].

During implementation, we have given complete consideration to energy saving principles. The collection process of solar energy includes solar collector, regulating circuit, energy storage unit and power sharing unit to sensor node as depicted in figure 2. The total solar energy harvesting system architecture is given in the figure 3.

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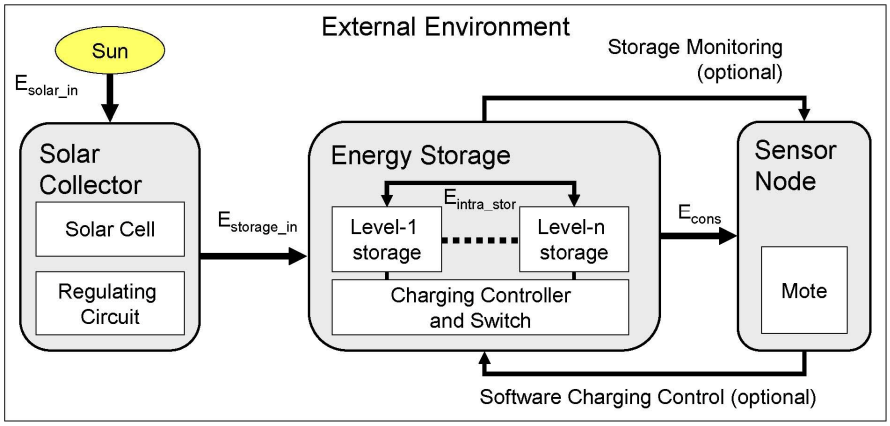

Fig2. Proposed architecture for harvesting energy

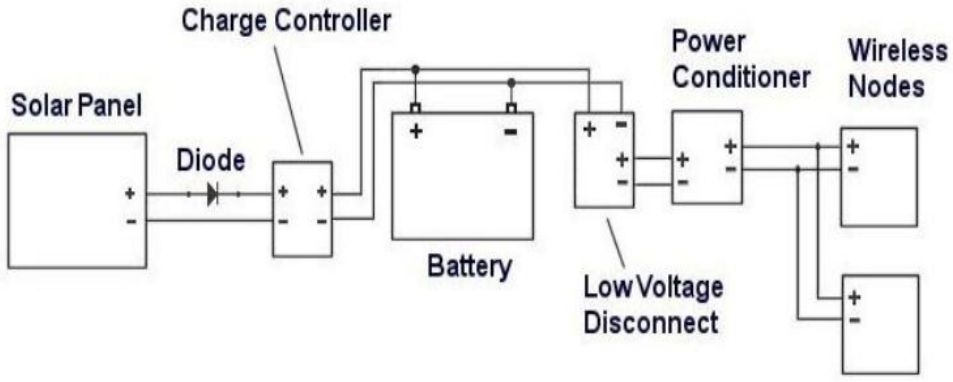

Fig3. Charge / Discharge characteristics of battery

VI. MAC PROTOCOL

In all shared medium networks, the medium access control (MAC) is a significant technique that enables the thriving operation of the network. The main fundamental task of the MAC protocol is to avoid collisions so that two interfering nodes do not broadcast at the same interval. There are lots of MAC protocols that have been urbanized for wireless data and voice communication networks. Usual examples include the time division multiple access and code division multiple access (TDMA & CDMA) [4].

To design an excellent MAC protocol for the wireless sensor networks, we have to consider the energy efficiency. A MAC protocol should with no trouble accommodate such network changes. Additional important attributes include throughput, latency, and fairness and bandwidth.

VII. SENSOR-MAC PROTOCOL DESIGN

Sensor-MAC (S-MAC) is a novel MAC protocol unambiguously designed for wireless sensor networks. Reducing energy consumption is the primary goal in the proposed design. The protocol designed also has superior scalability and collision avoidance ability. And it achieves excellent scalability and crash avoidance by utilizing a joint scheduling and contention scheme.

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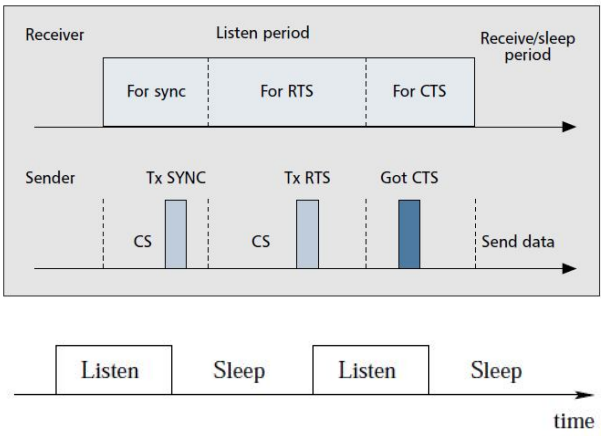

Fig5. SMAC Data flow Diagram

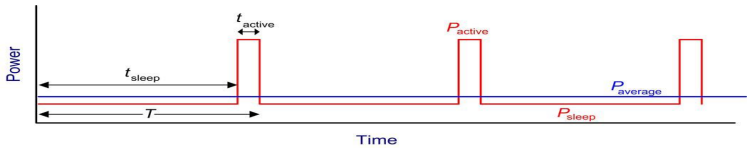

Fig4. Generic power profile of a node in SMAC

In order to achieve the primary goal of energy competence, we need to recognize what are the major sources that cause incompetent use of energy as well as what tradeoffs we can create to reduce energy consumption.

Table1. Cost Comparison and Savings of powering nodes

Nodes Powered By Limited life Batteries	**Nodes Powered By Solar Power System**
Level Transmitter Maintenance - battery ($25) + 1 hr labor ($50) = $75	10W, 18V Solar Panel $29 3.6V Power Conditioner $35
Requires battery replacement 10 times over 6 years - $750 Temperature Transmitter Maintenance - battery ($25) + 1 hr labor ($40) = $65	12V, 7A Charge Controller $35 12V, 7 ah Battery $26 Low Voltage Disconnect $40 NEMA Enclosure $30
Requires battery replacement 6 times over 6 years - $390	Mounting Accessories $35 Installation Labor $100
Total 6 year cost = $1,140	Total 6 year cost - $330

VIII. WSN NODE PROTOCOL POWER CONSUMPTION COMPARISON

Fig 4 to 8 shows the total power consumption of SMAC based approach is directly proportional to the inter arrival time [5]. SMAC consume less energy than LPL and other MAC. This result occurs not from the energy efficiency of MAC but the ineffectiveness of MAC in heavy traffic situations due to a huge number of collisions, that is clear in the below results.

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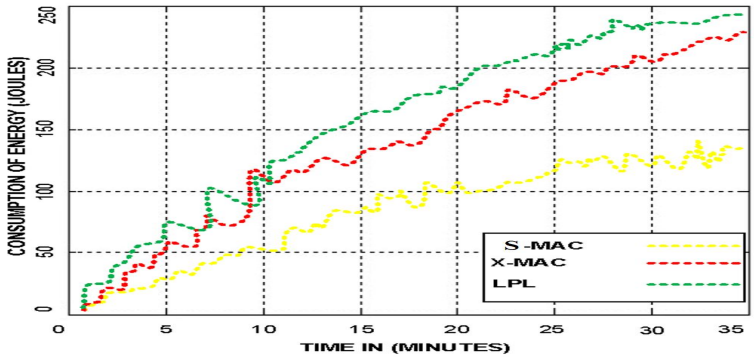

Fig6. Generic power profile of a node

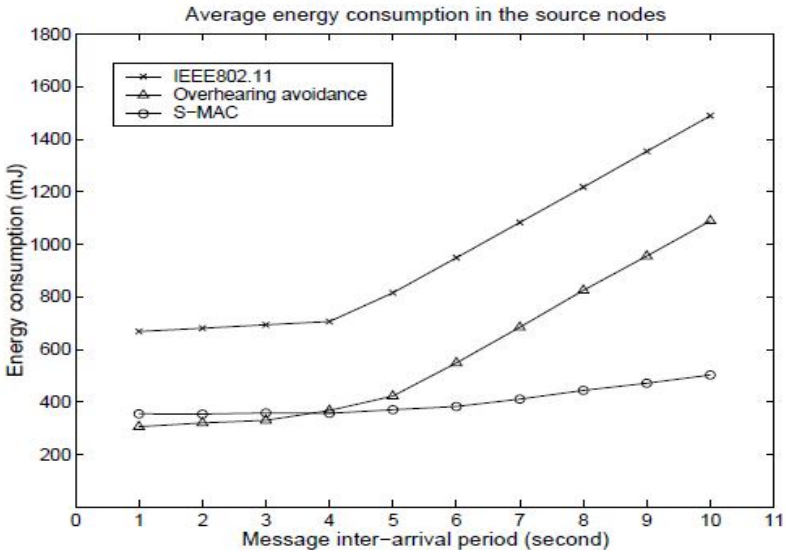

Fig7. Measured energy consumption in the source nodes

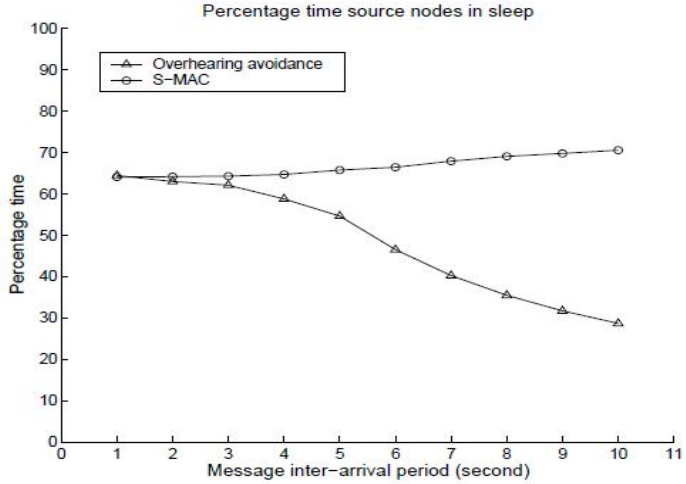

Fig8. Measured percentage of time that the source nodes in the sleep mode.

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IX. CONCLUSIONS AND FUTURE WORK

This proposed paper presents a novel MAC protocol for wireless sensor networks. And it has very good energy conserving properties comparing with other protocols. The other interesting property of the protocol is that it has the ability to make tradeoffs between energy and latency according to traffic conditions. Proposed protocol has been implemented on our test bed nodes, which shows its high efficiency. Future work will be done on larger test beds with different number of nodes and system complication.

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