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RESEARCH ARTICLE

ENERGY EFFICIENT SENSOR NODE DESIGN IN WIRELESS SENSOR NETWORKS

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Abstract*— A wireless sensor network consists of distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. and to cooperatively pass their data through the network to a main location. In the wireless sensor network energy consumption is one of the important concerns. In order to bring energy efficiency in WSNs an energy-aware sensor node is implemented. The objective of the energy efficient strategy is reducing the energy consumption from both the sensor node level and the network level in a WSN. In the sensor node to decrease the communication energy consumption, the distance between the transmitter and the receiver is predicted before available transmission, and then, the lowest transmission power needed to transmit the measurement data is calculated and determined. In addition to that the sensor nodes are also set to sleep mode between two consecutive measurements for saving the energy. By using this concept we improve the energy efficiency in the wireless sensor networks. Further to improve the energy-saving we introduce an innovative technique which combines energy efficiency and multiple path selection for data fusion in WSN. The network is divided into various clusters and the node with highest residual energy is chosen as the cluster head. For each cluster head the sink computes multiple paths for data transmission. In the cluster head the data from the sensor is compressed by using the distributed source coding and the lifting scheme wavelet transform method. To save the energy for each round of transmission the path is changed in a round robin manner. By utilizing this method, we achieve less energy consumption with increased packet delivery ratio.

Keywords: wireless sensor networks (WSN); multipath; data fusion; lifting scheme wavelet transform; round robin

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I. INTRODUCTION

The number of wireless sensors is typically considered as wireless sensor networks. The real time applications of wireless sensor network have been increased recently and this will increase even more in the next years. However for the full deployment of wireless sensor network introduces energy consumption problem. Previous research includes duty cycling and data driven approaches. Duty cycle-fraction of the time node will be in active mode. Duty cycling can be achieved using sleep/wake up protocol and mac protocol. Sleep/wake up protocol uses sparse topology and energy management approach to improve the network life time by setting some of the redundant nodes to be in sleep mode. The traffic adaptive medium access protocol is designed to reduce the energy consumption by assigning the nodes to low power idle state whenever they are not in transmission or reception mode. Disadvantages of duty cycling approach: not aware of which data is sampled by the sensor nodes. So the data driven approach is used. In data driven approach there are two categories: data compression and energy efficient data acquisition. For data compression the wavelet transforms and for energy efficient data acquisition, duty cycling and adaptive sampling is used. Other approaches for energy aware transmission includes modulation scaling scheme, multi hop routing scheme, network sectioning and low power hardware. Motivated by prior research the node-level energy saving is achieved by adaptive radio frequency power setting and the network level energy saving is achieved by adaptive network configuration. This paper is the extension of the above which includes periodic sleep/wake up scheme to further achieve node-level energy saving.

II. SENSING SCHEME

The wireless sensor node should sense, process and communicate the data wirelessly. In recent years many energy conservation schemes have been proposed and they assume that the processing energy consumption is less than communication. Sensor node is energy constrained and each element in the sensor will consume some energy so power supply becomes important to ensure the proper operation of the entire wireless sensor network. So energy efficiency is of critical importance.

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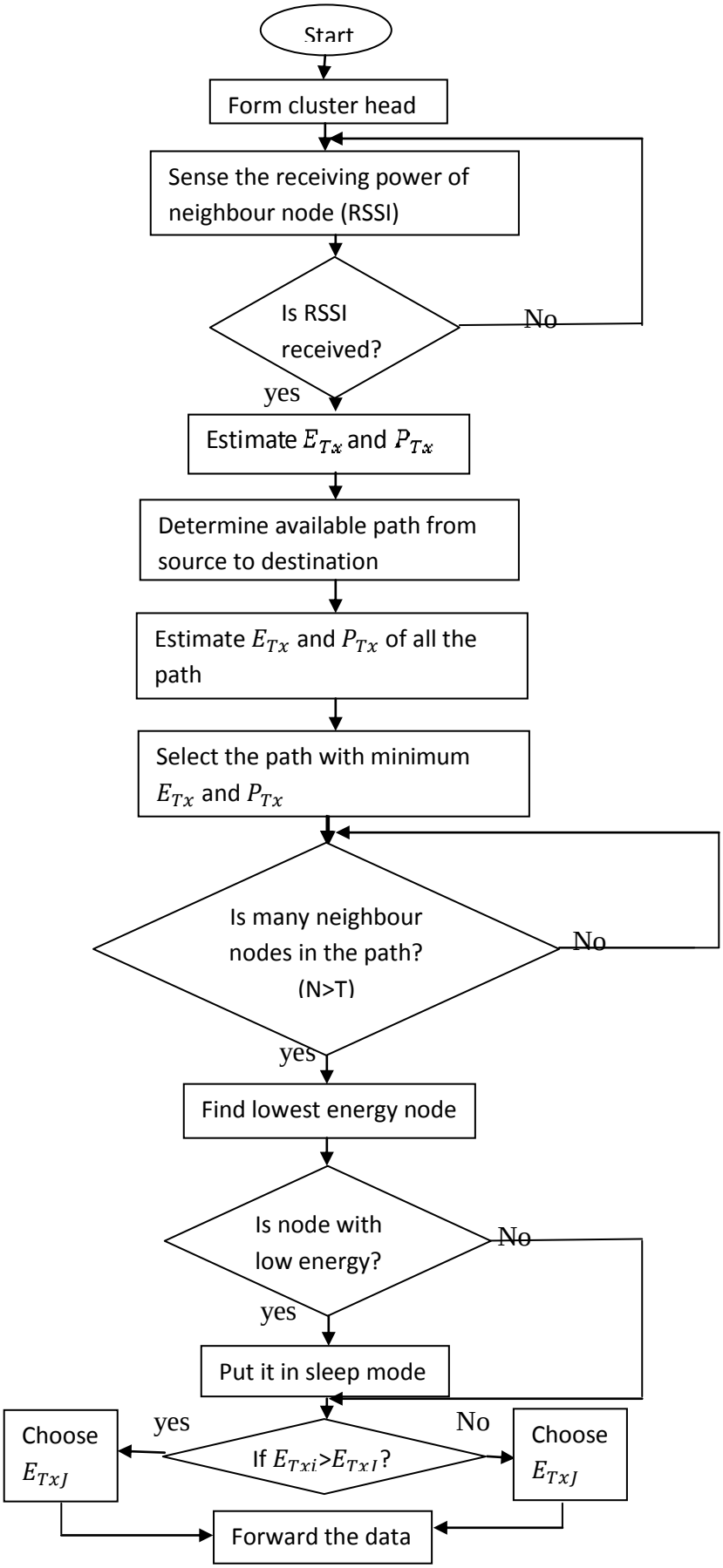
III. EXISTING METHOD



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A. ENERGY CONSUMPTION CALCULATION

In order for two sensor nodes to communicate, the energy consumed for data transmission can be expressed as

$E_{Tx} = E_{e_tx} . k + \varepsilon_{amp} . d^{\alpha}$ ----------> (1)

k-number of transmitted bits.

α- depends on environment of wireless transmission(2 to 5).

d- distance between two sensor nodes.

E_{e_tx} is the energy dissipated to operate the transceiver and is given by,

$E_{e_tx} = V_{cc} . I_{TP} / K_{data_rate}$ ----------> (2)

V_{cc} is the working voltage, I_{TP}- current for transmission, K_{data_rate}- data transmission rate.

The energy consumed for receiving a data stream is expressed as, $E_{Rx} = E_{e_rx}$. k. -------> (3)

Eqn 1 for fixed distance energy consumed is proportional to the number of data bits. For longer distance between two sensor nodes the energy consumption is also high.

B. COMMUNICATION MODULE

In the two sensing schemes designed for the WSN, it is assumed that the transmission power is minimized to ensure reliable reception at the receiver end, according to the communication distance between two sensor nodes. Hence, awareness of the communication power as well as the adjustability of the transmitter's output power becomes critical in performing the sensing scheme for the designed sensor node. By assuming a unit signal gain provided by antennas, the output power of the communication module is dominated by the consumption for power amplifier. To transmit 1 bit to the receiver, the output power and associated received power are expressed as

$P_{Tx} = (\varepsilon_{amp} . R) . d^{\wedge\alpha}$ ----------> (6)

$P_{Rx} = \frac{P_{Tx}}{d^{\alpha}} = (\varepsilon_{amp} . R) . \left(\frac{d^{\wedge\alpha}}{d^{\alpha}}\right) = P_S . \left(\frac{d}{d^{\alpha}}^{\wedge\alpha}\right)$----> (7)

where R denotes the data transmission rate, $\hat{}\ d$ and d are the estimated and actual transmission distances between the transmitter and the receiver, respectively, and $PS = \varepsilon_{amp} . R$ is the receiver sensitivity denoting the minimum signal power that the receiver can discern. From (7), it is seen that, if the estimated distance $d^{\wedge} < d$, then the received signal cannot be identified and the communication between sensor nodes fails. On the other hand, if $d^{\wedge} > d$ (overestimation), which means a received power that is higher than receiver sensitivity, then a portion of the transmission energy will be lost on the propagation path while not affecting the results of signal reception. In this case, the energy efficiency problem is translated to the effective estimation of communication distance between two sensor nodes. Since all of the sensor nodes are equipped with both transmission and receiving capabilities, we can estimate the distance between sensor nodes through received signal strength indication (RSSI). Here the cluster head will know about the energy of the sensor nodes in its cluster and there is no need for separate message or test code to know about the energy. By measuring the received power P_{Rx} on each sensor node, the distance to the cluster head can be calculated as

$d^{\wedge\alpha} \geq \frac{P_{Txmax}}{P_{Rx}}$ ----------> (8)

Hence, by minimizing the estimated distance for data transmission, the minimum required power to ensure data communication is expressed as

$$P_{Tx} = P_S \cdot \frac{P_{Txmax}}{P_{Rx}} \quad \text{----------> (9)}$$

The relationship between *P*Rx and RSSI is defined as follows:

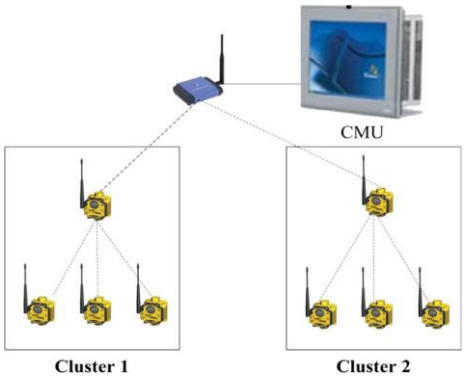
$$\text{RSSI} = 10 \cdot \log10\, P\text{Rx}.$$

In Rx mode, the RSSI value can be read continuously from the RSSI status register, which is a binary complement number. The obtained RSSI value is converted into absolute power level as

$$\text{RSSI}=10 \cdot \log_{10} P_{Rx} \quad \text{----------> (10)}$$

The format of the data packet is

1) preamble;
2) synchronization word;
3) length byte;
4) address byte;
5) payload;
6) CRC word



4 byte	2 byte	1 byte	1 byte	n byte	2 byte
Preamble bits (1010…1010)	Sync word	Length byte	address byte	Data field (payload)	CRC word

Here the temperature data is the payload data.
As a result the energy consumption will be calculated as

$$E_{Tx} = P_{Tx} \cdot \frac{(10+n)}{R} \cdot 8 \quad \text{----------> (11)}$$

C. PERIODIC SLEEP/WAKE UP SHEME

If WSN is deployed in harsh environment, the manually recharging batteries are not feasible. One alternate method is to turn off some sensors and to activate only necessary sensors. Here the temperature measurement is considered so all the sensors need not to be active since it is a slowly varying parameter. The sensor nodes are put in sleep mode if the sensor node is with low energy.

D. NETWORK LEVEL ENERGY SAVING REALIZATION

In this paper the energy consumption of each node is reduced by its associated modules and the total energy consumption is reduced by various techniques.

1. If the sensor node is with low energy then we need to put it in sleep mode till it regains its energy.
2. The distance between the transmitter node and the CMU are estimated and based on that the energy will be calculated and the path or scheme with lowest energy will be used to transfer the data.

IV. EXPERIMENTAL TEST

In this paper, the energy-efficient strategy that we designed on the sensor platform consists of: node-level energy saving and network-level energy saving. The node-level energy saving is achieved by adaptive transmission power setting and by the periodic sleep/wake-up scheme. The power consumption reduction in the node-level leads to network-level energy saving. In the experimental test, we first investigate the performance of node-level energy saving. Then, the performance of network level energy saving is investigated by comparing the energy consumption of fixed power settings.

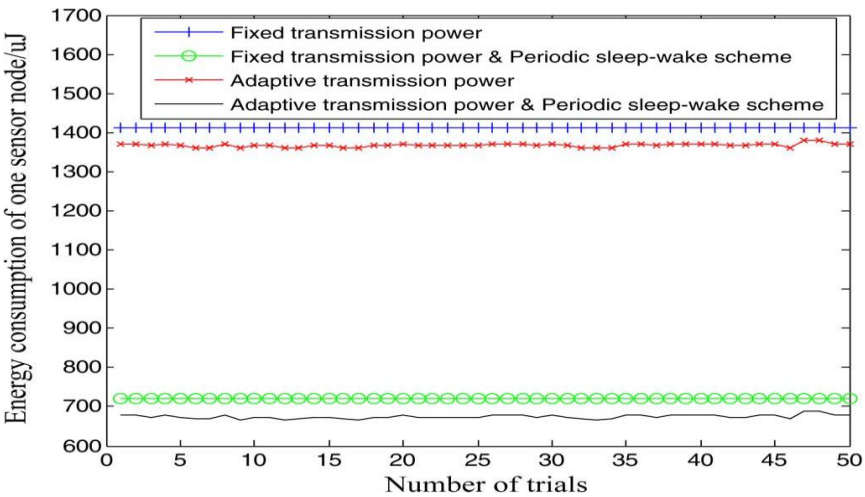
Traditional Versus Node-Level Energy-Saving Scheme

In this paper the energy consumption of the fixed power and adaptive power setting is compared and the adaptive power setting is performing better and consumes less energy than the fixed power setting. The performance of sleep/wake-up scheme is also considered and it plays a major role in reducing the total energy consumption. The fixed power uses for eg: 10 watt which is used for all the transmission. If it is a small distance transmission 10watt is maximum and unnecessary and so we are going for adaptive power setting which adjust the power according to the transmission distance.

Here the various techniques are compared. Their performance is analyzed by using three parameters such as energy consumption, throughput and packet delivery ratio and the graph is plotted.

DISADVANTAGES

- Not energy efficient
- Less packet delivery ratio



V. PROPOSED METHOD

In proposed system, further to improve the energy efficiency we propose a technique which combines energy efficiency and multiple path selection for data fusion in wireless sensor networks. We assume multiple paths from each cluster to the sink. Initially, the nodes form a cluster and the number of aggregators that minimizes the total energy consumed by transmitting and aggregating data is determined. Each sensor selects the closest aggregator as its cluster head. Then the sensors send packets to their respective aggregator. Each aggregator compresses the data it receives from the sensors of its cluster and finally forwards the data to the sink. In the initial round, from the aggregators, the aggregated data is transmitted to the sink using one of the established multiple paths. In WSNs we construct an algorithmic framework which supports distributed source coding for high and low frequency signal compression. To preprocess the original data for signal decomposition and noise deduction, we use a lifting scheme wavelet transform **(**LSWT) in order to separate the low frequency component from the high frequency component, and strength the correlation among distributed sensor data. Compared to the traditional transforms, LSWT is better suitable for WSNs. During each round of transmission, the path is changed in a round robin manner, to conserve the energy. This process is repeated for each cluster. Thus this data fusion technique is energy efficient and involves multiple paths for transmission of data.

DESCRIPTION

In lifting scheme wavelet transform, we can separate the low frequency component from the high frequency component and it is used to strength the correlation between the sensor data. Then the distributed source coding is used to compress the sensor data. Also here multi paths are chosen since the optimized path will lose its energy if we use the same path for all the transmission. The path is chosen in a round robin fashion.

ADVANTAGES

- High packet delivery ratio.
- Low energy consumption.

VI. CONCLUSION

In this paper the energy efficient sensor node is created which provides the energy efficient sensor networks. Various techniques like periodic sleep/wake up scheme, adaptive transmission power settings, lifting scheme wavelet transform, distributed source coding and multipath selection are used to design the energy efficient sensor node design.

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