A Review on Designing of Data Encrypted Wireless Sensor Node for Energy Optimization

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Abstract: *For full development and expansion of wireless sensor hub, energy consumption remains an important factor to design and implement nodes. So to minimize the energy required for one to one communication, the distance between the transmitter and receiver is calculated before used for transmission and less power is required to transmit the measurement data is calculated and determined. To save energy, in this paper we have designed such a structure at hub level and network level which will save energy by going in sleep- wake mode when there is no work and sensing scheme to encrypt data packets.*

Keywords*: Energy efficiency, periodic sleep/wake-up scheme, received signal strength indication (RSSI), wireless sensor network (WSN).*

I. Introduction

Due to tremendous inventions and development going on in wireless sensing node made wide applications in industrial system monitoring and environmental sensing. The amount of remote sensors, which are ordinarily prompted as a remote sensor network (wsn), made for genuine applications has immediately expanded in most recent years, and this pattern is required to much more help in the one years from now. The traffic-adaptive medium access protocol has been designed to reduce energy consumption by allowing sensor nodes to assume a low-power idle state whenever they are not working in transmission or receiving mode. But also energy consumption remains a major hurdle for development. Energy can be saved at battery using solar harvesting method but to save energy at node level and network is an important factor. Many researchers had gone through many schemes and hardware. Many adaptive scaling methods, duty cycles are introduced. Further they introduced a combination of sleep schedule with transmitter to block energy. But in this paper we are introducing periodic sleep/wake up schemes to encrypt data both at hub level and network to optimize energy.

II. Literature Survey

M. Roseline Juliana, S.Srinivasan (Sep 2015)**:** Recent trends in wireless sensor networks lead to the development of new protocols for data gathering. In this paper, a secure energy efficient location aware data gathering approach is introduced to secure data gathering. An Elliptic Curve Diffie Hellman Key Exchange (ECDHKE) algorithm is utilized for key generation and key exchange between the sensor nodes to maintain security and prevent the data from malicious nodes. The performance of the proposed scheme is validated in terms of packet drop, throughput, energy consumption, residual energy and network lifetime. The proposed scheme achieves better performance than the existing EEHA and SMART schemes.

Rakesh V, Sarala S M (June, 2015): Wireless sensor networks (WSN) has been increased day by day to measure and monitor physical characteristics. It can implement in the area where human cannot be reached. Each sensor node depends on power to do their activities. As the WSN has limited battery life time it's important to optimize power. There are many methods to optimize power in WSN. Here compression and encryption techniques are used for optimizing power in WSN. Here optimization means reducing the amount of energy consumption. If the input data is large then automatically the transmitters and receivers will take more amount of energy. So here by reducing the data size by compression and by sending an encrypted version of the compressed data, we are making the antennas to transmit and receive fewer amounts of data than the actual data and also it will be more secured. At the receiving end by applying the decryption and reconstruction of the compressed data, we are able to recover the complete data. Then we will compare how much energy is optimized by different compression and encryption techniques.

Reshma Patil, Prof.S.M.Shinde (Aug 2014): Wireless sensor network is autonomous and infrastructure less network. Now day's different types of WSN applications are developed. Secure transmission of information in WSN is an important issue. In this paper we introduce new approach for WSN security, we propose Secure Energy Efficient Routing (SEER) schema that consider cost of providing security and effects on energy efficiency. Secrete sharing method used for providing security. In this method information is divided into multiple shares and sends via multiple disjoint paths from source to destination at different point of time. At the destination end the original information reconstructed by combining the shares received via different paths at

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different point of time. We also calculate cost for security in term of time and its effect on energy efficiency. Simulate the different types of attacks like wormhole, sink hole etc.

Pratik Agarwal (2013): Wireless Sensor Networks (WSNs) are made of sensor nodes with restricted battery life and transmission capability. In this work we propose an energy efficient multipath routing algorithm in WSN. This protocol is designed to improve the latency, resiliency and efficiency through discovering multiple paths from the source to the destination. It has a sink initiated Route Discovery process with the location information of the source known to the sink. There are two types of nodes which are used here one is primary and the other is alternate. At the end of the route formation one primary path and multiple number of alternate paths are built and all nodes except the primary are put to sleep mode which helps us to save energy and generate a collision free path, the primary path is used to transmit the data from source to the sink and if the route disrupts, the next best alternate route is used for the purpose and if no path exists between the source and destination then process starts from the beginning. Our simulation finds the latency, packet delivery ratio, average control packet overhead and total energy consumed. The protocol has 12% (approx.) less control packet overhead in comparison to MR2 and LIEMRO,5% less average energy consumption in comparison to MR2 and 28% less average energy consumption in comparison to LIEMRO. Regarding latency the proposed protocol has similar result to MR2 but in comparison to LIEMRO the algorithm is 24% faster. Lastly in case of Packet Delivery Ratio the proposed protocol gives 5 %(approx.) Better result in comparison to MR2 and , 12% better result in comparison to LIEMRO on an average.

III. Proposed Sensing Scheme

3.1 Sensing Scheme

The concept of wireless sensor node states that, except for the physical sensing capabilities, the nodes will also be able to process the obtained data and communicate the results without wire. In recent years, many energy conservation schemes have been proposed in the literature, which assume that data acquisition and processing have an energy consumption that is significantly lower than communication. In addition, since each of the sensor nodes in the network is energy constrained and each component in a sensor node consumes a certain amount of energy, power supply becomes important to ensure proper operation of the entire WSN as the number of sensors deployed in a network grows. Hence, constructing effective network structures for the application of WSN with consideration of energy efficiency is need importance.

3.1.1. Energy Consumption Calculation

After sensing the environmental parameters, the results should be transmitted to the central monitoring unit (CMU) or other sensor nodes. In order for two sensor hubs to be in contact , the energy consumption needed for data transmission can be expressed as

$$E_{\mathrm{Tx}} = E_{e\_\mathrm{tx}} \cdot k + \varepsilon_{\mathrm{amp}} \cdot d^{\alpha} \qquad (1)$$

where k is the number of transmitted data bits; α is a factor valued from 2 to 5, depending on the environment of wireless transmission; d is the distance between two sensor nodes; εamp (J/b/m2) is the amplification coefficient to satisfy a minimum bit error rate to ensure reliable reception at the receiver; and Ee_tx (J/b) is the energy dissipated to operate the transceiver, which is given as

$$E_{w\_\mathrm{tx}} = V_{cc} \cdot I_{TP}/K_{\mathrm{data\_rate}} \qquad (2)$$

where Vcc denotes the working voltage, ITP denotes the current for transmission, and K data rate denotes the data transmission rate. The energy consumed for receiving a data stream can be expressed as

$$E_{\mathrm{Rx}} = E_{e\_\mathrm{rx}} \cdot k. \qquad (3)$$

Equation (1) shows that, for a fixed distance, the energy consumed is proportional to the number of data bits. On the other hand, the longer the distance between two sensor nodes is, the more energy will be consumed.

3.1.2 Sensing Schemes

The network-level energy saving was realized mainly through the scheme switching of the network. Two different schemes of the network are shown as follows.

Scheme 1: The obtained data points are transmitted to the CMU from each sensor node. The energy consumption Edr in this case is calculated as

$$E_{dr} = \sum_{n=1}^{N} [(E_{e\_\mathrm{tx}} + \varepsilon_{\mathrm{amp}} \cdot d_n^{\alpha}) \cdot k_r] \qquad (4)$$
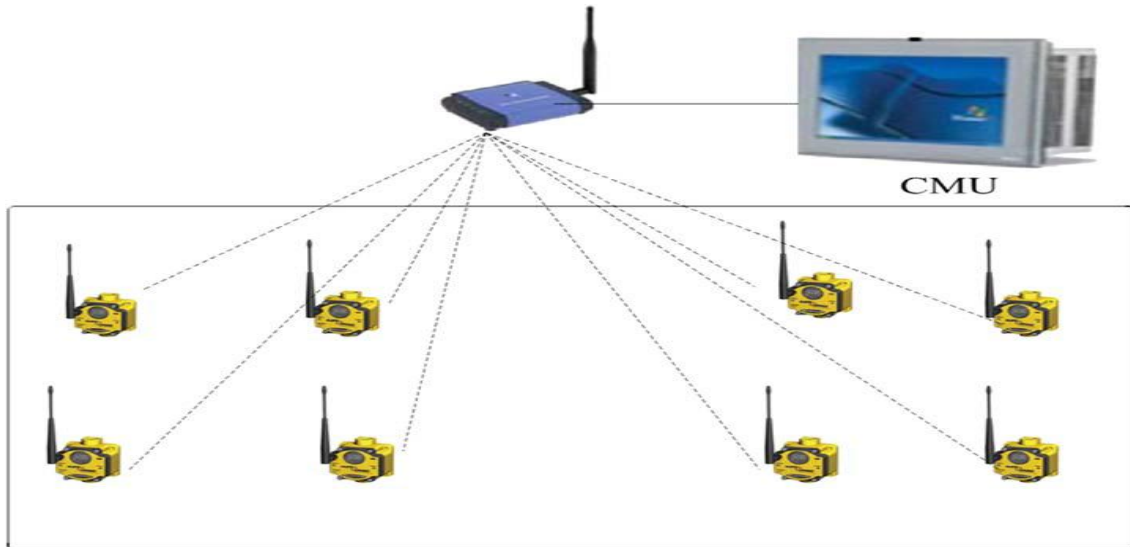
Figure 1. Scheme 1 used in the greenhouse.

where N is the number of sensors, dn is the distance between each sensor node and the CMU, and kr is number of data bits from the obtained data.scheme 1 being applied to the platform of greenhouse management in which temperature is measured by the sensors. In each greenhouse, the sensor nodes acquire the temperature data and transmit the data to the CMU directly without routing and relay.

Scheme 2: The sensors are grouped into different clusters, and the obtained data from each sensor node are transmitted to the corresponding cluster head (it is defined as the sensor node that collects the data from others in the cluster). Then, the cluster head will pack the data and transmit them to the CMU. The energy consumption Eds in this case is calculated as

$$E_{ds} = \sum_{m=1}^{M} \left[\sum_{j}^{N_m-1} \left(E_{e\_\text{tx}} + \varepsilon_{\text{amp}} \cdot d_j^\alpha + E_{e\_\text{rx}} \right) \cdot k_r \right.$$

$$\left. + \left(E_{e\_\text{tx}} + \varepsilon_{\text{amp}} \cdot d_m^\alpha \right) \cdot k_m \right] \quad (5)$$

where M is the number of clusters, Nm is the number of sensors in the corresponding cluster, dj is the distance between a sensor and its corresponding cluster head, dm is the distance between the cluster head and the CMU, and km is the number of packed data bits for data transmission. For example, Figure. 2 shows scheme 2 being applied to the platform of greenhouse management in which the network is grouped into different clusters.

In this scheme, each greenhouse is defined as a cluster, and the obtained data are transmitted first to corresponding cluster head; then, the CMU will ask the cluster heads for the temperature data.
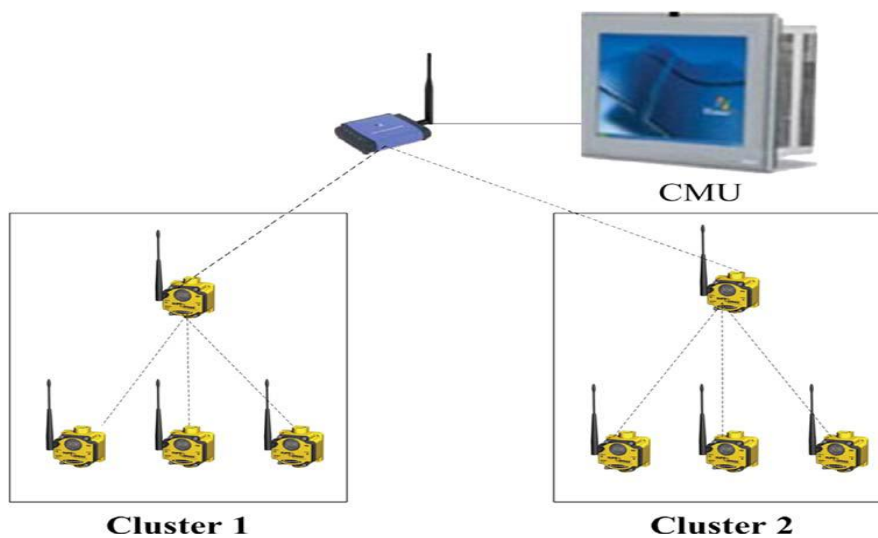

Figure 2. Scheme 2 used in the greenhouse.

IV. The Energy-Aware Sensor Node

MODEL

To design the energy less requirement model in this paper certain data packets less requirement model is suggested which will require less energy for communication is as:

4.1.1 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

$$P_{T_x} = (\varepsilon_{\text{amp}} \cdot R) \cdot \hat{d}^\alpha \qquad (6)$$

$$P_{\text{Rx}} = \frac{P_{\text{Tx}}}{d^\alpha} = (\varepsilon_{\text{amp}} \cdot R) \cdot \left(\frac{\hat{d}^\alpha}{d^\alpha}\right) = P_S \cdot \left(\frac{\hat{d}^\alpha}{d^\alpha}\right) \qquad (7)$$

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 $P_S = \varepsilon_{\text{amp}} \cdot R$ is the receiver sensitivity denoting the minimum signal power that the receiver can discern. From (7), it is seen that, if the estimated distance $\hat{d} < d$, then the received signal cannot be identified and the communication between sensor nodes fails. On the other hand, if $\hat{d} > d$ (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). For example, considering the case where sensing scheme 2 is applied for local data transmission from a sensor node to its cluster head, the cluster head sends a test code with maximum transmission power PTxmax to one of the sensor nodes in the local cluster first. By measuring the received power PRx on each sensor node, the distance to the cluster head can be calculated as

$$\hat{d}^\alpha \geq P_{\text{Tx max}}/P_{\text{Rx}}. \qquad (8)$$

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

$$P_{\text{Tx}} = P_S \cdot \frac{P_{\text{Tx max}}}{P_{\text{Rx}}}. \qquad (9)$$

In this paper, Chipcon CC1101 is chosen as the RF transceiver used in the sensor node design. CC1101 is a lowcost true single chip UHF transceiver designed for very low power wireless applications. The received signal power PRx in CC1101 is translated to a decibel (dBm) value—RSSI. The relationship between PRx and RSSI is defined as follows:

$$\text{RSSI} = 10 \cdot \log_{10} P_{\text{Rx}}. \qquad (10)$$

In Rx mode, the RSSI value can be read continuously from the RSSI status register, which is a binary complement number.

The following procedure can be used to convert the RSSI reading to an absolute power level (RSSIdBm).

Step1: Read the RSSI status register.

Step2: Convert the reading from a hexadecimal number to a decimal number (RSSIdec).

Step3: If RSSIdec ≥ 128, then RSSIdBm = (RSSIdec − 256)/ 2 − RSSIoffset.

Step4: Else if RSSIdec < 128, then RSSIdBm = RSSIdec/2 − RSSIoffset where RSSIoffset is a typical value corresponding to the data rate and the center frequency. CC1101 is programmed for operation at 100 kb/s with 433 MHz; therefore, RSSIoffset = 75. From (9), we can further obtain the following relationship as

$$10 \cdot \log_{10} P_{\text{Tx}} = 10 \cdot \log_{10} P_S + 10 \cdot \log_{10} P_{\text{Tx max}}$$

$$- 10 \cdot \log_{10} P_{\text{Rx}} \qquad (11)$$

where $10 \cdot \log10\ P_{Tx}$ is the transmission power in dBm and $10 \cdot \log10\ P_{Rx}$ is the RSSI. There is a register PATABLE in CC1101 which is used in selecting the transmission power. From (11), we can compute the minimum required power as

$$PATABLE = 10 \cdot \log_{10} P_S + 10 \cdot \log_{10} P_{Tx\,max} - RSSI. \quad (12)$$

In CC1101, the format of the data packet can be configured to include the following items:
1) Preamble;
2) Synchronization word;
3) Length byte;
4) Address byte;
5) Payload;
6) CRC word.

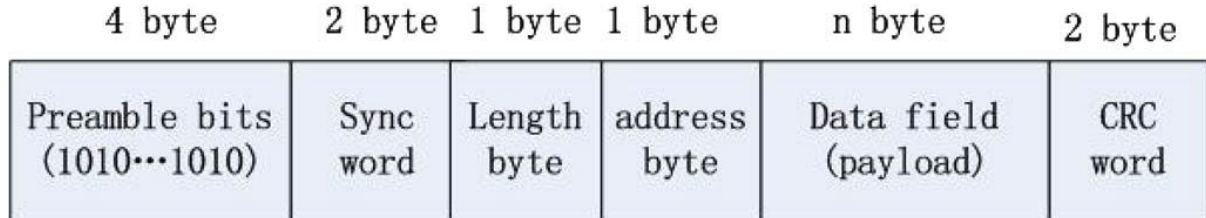| 4 byte	2 byte	1 byte	1 byte	n byte	2 byte
Preamble bits (1010···1010)	Sync word	Length byte	address byte	Data field (payload)	CRC word

Figure 3. Data packet in this paper.

Each item can be configured by setting the corresponding registers when initializing CC1101. In this paper, the data packet is configured as shown in Fig. 3.

As a result, each sensor node will transmit (10 + n) byte data one time, and the energy consumption can be computed as follows:

$$E_{Tx} = P_{Tx} \cdot \frac{(10 + n) \cdot 8}{R} \quad (13)$$

where n denotes the number of payload data bits needed to be transmitted. Here, temperature data are the payload data, and
R = 100 kb/s is used in this paper.
B. Periodic Sleep/Wake-Up Scheme

Except for the adaptive RF power supply as described in the previous section, the node-level energy saving is also achieved through the periodic sleep/wake-up scheme. As we know if a WSN is deployed in remote fields or under harsh environments where manually recharging batteries for sensors is not feasible, one typical alternative approach for energy saving is to turn off some sensors and to activate only a necessary set of sensors while providing a good sensing coverage and network connectivity simultaneously [26]. In slowly varying parameter measurements, such as temperature, not all sensor nodes are needed to stay in active mode. Therefore, in order to save energy consumption, the sensor nodes are designed to be put into a sleep mode with a timer that determines their sleep duration. When the timer overflows, an interrupt happens, and it will wake those nodes up and will then perform measurements and data transmission.

4.1.2 Sensor Node Design

Each sensor node should be able to collect environmental parameters and communicate with each other. At the same time, its corresponding hardware and software should be energy efficient and include the functionality described in previous sections. Based on these requirements, the sensor node has been designed and implemented as shown in Fig. 4. In this design, the MSP430F149 microcontroller is chosen as the core for fulfilling computation and control functions of the sensor node; this is because it possesses the capability of ultralow power consumption and short waking-up time (less than 6 μs) as compared to other commonly used microcontrollers listed in Table I. Also, from Tables I and II, the architecture of MSP430F149, combined with its five low-power modes (LPM0–LPM4), can be optimized to achieve extended battery life in portable measurement applications. Furthermore, when the CPU works at the same speed (1 MHz), the energy con-sumption ofMSP430F149 is lower than that of other commonly used microcontrollers (shown in Table I).
The supply voltage of the sensor node is 3.3 V, which is obtained using the AMS1117-3.3 voltage regulator with low intrinsic consumption current from two 3.7-V (2400-mAh) lithium batteries. The RS232 interface is designed for communication with the PC in environment monitoring. For example, when collecting the temperature parameters, these temperature values can be transmitted to PC and displayed in the computer monitor.
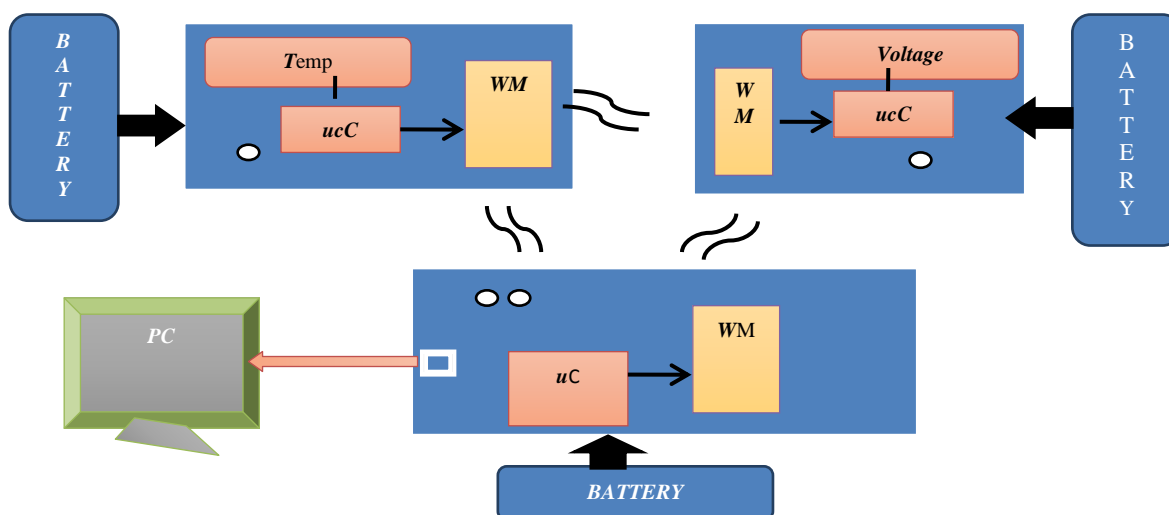
V. Methodology

Figure 4. Block diagram.

A. Research methodology to be employed

The "node level energy saving" is achieved by using the combination of adaptive transmission power setting, by the periodic sleep/wake-up scheme and data encryption. While the "network-level energy saving" is achieved by adaptive network configuration.

B. Tools to be used for research work

I) Hardware Used:-Microcontroller PIC18f252, RS232, UART, Zig-bee CC2500, Temperature sensor LM35,Transformer, Battery.

II) Software Used:- .net ,C compiler.

VI. Conclusion

In this paper, we have presented the design and implementation of an energy-aware sensor node, which can help in constructing an energy-efficient WSN through "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, while the "network-level energy saving" is achieved by adaptive network configuration. For further study, more functionality, such as local data processing and data fusion algorithm, will be added into the designed sensor node for improving the energy-saving protocol. In addition, the real-world applications, e.g., greenhouse management, of such a WSN will be explored. The full development model will be designed by reviewed this things.

Acknowledgement

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