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Research paper

Optimized design for data processing and power consumption for wireless sensor node

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Abstract

The primary processing of data collected in the sensor node is a major aspect of the performance of wireless sensor networks. This paper provides an experimental description of a smart algorithm in which the sensitivity node operates. The specification is based on measuring the current that is discharged from the power source in data transmissions. The measurements allow for the definition of an analytical model for the number of data packets to be sent from the terminal sensor node, a function of sensor operation and the level of change of sensor data. Conventional sensor nodes are not effective in terms of productivity, flexibility, energy consumption and work interference. The sensor node is programmed according to the conventional method, which sends the data every minute, and then reprogrammed according to the intelligent algorithm in which the transmitter unit is activated when there is a difference between the averages of ten readings in one minute with the previous average reading. Temperature and humidity were measured over a 12-hour period. The conventional sensor node needed to send 60 packets of data within an hour, which could be repeated data. The use of the smart node algorithm improved current consumption by 93% compared to the commercial node. The integration of the wireless sensor node with the smart algorithm has several advantages, such as the number of packet data sent is lower and of high accuracy, the total power consumed for the node is lower. In addition to the possibility of increasing the number of sensor nodes in the wireless sensor network.

Keywords: *Smart Sensor Node; IEEE 802.15.4; ZigBee PRO; Greenhouses; Smart Algorithm*

1. Introduction

Wireless sensor networks that including sensors and actuators are currently one of the most important technological developments of our time. Wireless sensor networks that combine sensors and engine holding are currently one of the most important technologies in the information age. [1] [2].

Smart sensors in WSAN networks have significant cost, flexibility, independence and power advantages compared to wired sensors. The application of wireless sensors extends to civilian and military aspects such as environmental monitoring, home automation, and early disaster forecasting and battlefield observation [3]. The environmental conditions of the green houses must be controllable in order to provide suitable environmental conditions for agricultural crops. To achieve this, a large amount of wires are connected to the sensors and motors in the greenhouses. The addition of sensors / contract triggers deployed inside greenhouses will increase the costs of establishing control and control systems and the complexity of their work [4]. Therefore, it requires the use of automatic control, which contributes substantially to the possibility of expansion and to reduce the rationalization of spent energy [5-8]. The use of sensors embedded in wireless networks used to control the climate of greenhouses shows a significant improvement in crop production. This is done according to the accuracy of the monitoring of climatic factors in the covered houses on which the resolution is based. The greenhouse climate is closely monitored and monitored around the clock through the use of a remote base station [11]. The success of protected agriculture as an alternative to traditional agriculture has been demonstrated by the introduction of automation and artificial intelligence techniques in greenhouses [10-12].

This paper presents a smart algorithm for the processing, detection and evaluation of sensor readings and the method of transmitting the information in one intelligent sensor module and evaluate it performance within a wireless sensor network. In addition the issues such as data collection, data processing, and optimal power consumption in sensor nodes will be addressed.

2. Greenhouse climate control

Greenhouses provide healthy growth for agricultural crops, as they are closed environments where climate standards are easily controllable [5] [15]. In order to facilitate the understanding of the design of an intelligent algorithm for the sensor, two parameters (RH and RH) have been studied because these parameters are closely related in addition to its significant impact plant production. The use of an intelligent sensor within the WSN shows great success in building an independent GH. Plant growth is very influenced by changes in several factors, in particular temperature and humidity in greenhouses. Therefore, to achieve the purpose of the sensors, the greenhouses are equipped with heating devices, humidifiers and fans that are outputs related sensors [6-10] [16].

The data collected and processed are sent from the sensor nodes to the main node, where the received data are analyzed and processed to execute the output orders for the engine contract. In the design of the main node algorithm, the optimal variation of the temperature and humidity parameters during the day and night must be considered within the default configuration values for each type of culture [3][5]. Managed to build a system with a fairly reliable data collection every 30 seconds using the wireless network, where the success rate of data transfers up to 70%.

3. Technologies of WSNs

The platform was built using a 32-bit wireless microcontroller. This microcontroller can be supplied with the MAC and PHY levels of IEEE 802.15.4 of ZigBee PRO.
The 32-bit wireless microcontroller has suitable ROM and RAM size, in addition to coding technique to integrate their application and the ZigBee stack.[7]
In this research Jennic wireless node is used to develop an economical wireless sensor nodes.
It consumes 18 mA in the reception state while 15 mA in the transmission state with + 3dBm, the table -2- show the technical specification of Jennic. Several factors influence the power consumption, the supply voltages of the radio and the microcontroller, the active current absorbed by the radio and the microcontroller, the clock frequency at which the controller operates, the number of external components required in the system and the code size , to the extent that it affects the MCU clock frequency. The controller must support a MAC run at the minimum number of clock cycles. However, the most important factor influencing energy consumption and endpoint battery life is power consumption in sleep mode. Most battery-powered 802.15.4 / ZigBee nodes will be in idle mode 99.9% of the time, wake up periodically for a few milliseconds to check a sensor or query the other radios. The total current consumption of the node will actually approximate the sleep energy consumption (Figure 1). The total current consumed (Icc) only by the controller and the radio is 0.0062 mA and the power of the standby mode represents more than a third of the total. This is why you need to pay close attention to the energy of the suspend mode and to the active energy.[18]

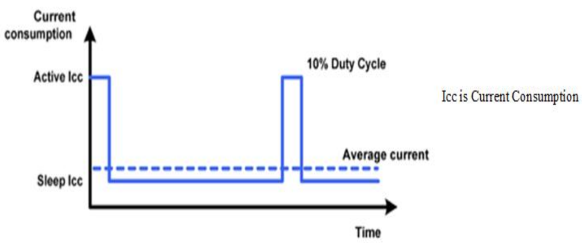

Fig. 1: A Power Budget [18].

The greenhouse network has been built with star topology of one main node and four sensor nodes, as Figure 2 explain the position of sensor node. The Main node (coordinator node) hanged into the middle of GH of 3m above earth. The nodes of the SHT75 temperature / humidity sensor plate were installed 1.2 m from the side wall and 1.5 m from the front / rear of the greenhouse. Periodically, the nodes are activated and send their data to the main node in response to a beacon packet sent from the main node, each node activation, turn on the sensor, collect and process data based on intelligent algorithms (SA) and then turn on the transceiver to send the processed data to the queue, then return to standby mode.

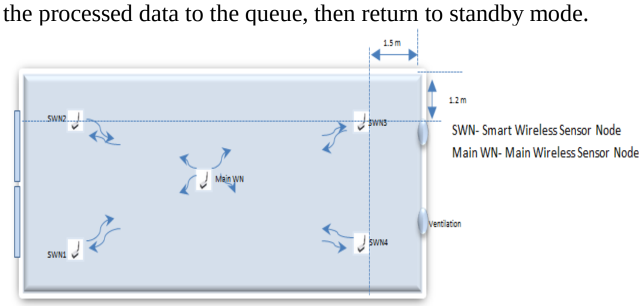

Fig. 2: Distribution of Smart Sensor Nodes in the Greenhouse.

3.1. Achieve smart WSN

The terminal sensor node will be integrated with a smart algorithm that analyzes and processes data received from the sensor, acting as an initial brain in the wireless sensor network. The inclusion of such intelligent nodes in wireless sensor networks reduces the load handling of data on the main node of the network and thus improves the inclusion of network behavior and interaction to simulate high accuracy of human behavior. This method can be easily implemented across all storage area networks (WSAN) based on the smart algorithm features listed in the following section. It is a robust language with a large set of functions and integrated operators that can be used to write any complex program, therefore, it's used for programming algorithms. Figure 3 shows the main function of the embedded algorithm (SA) included in the program, which ends with the transmission process.

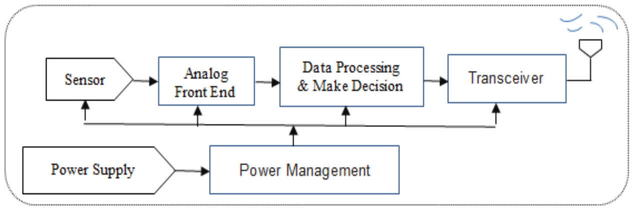

Fig. 3: Wireless Sensor Node Based Smart Algorithm Block Diagram.

The proposed smart wireless node algorithm collects data, calculates the average, applies the comparison, and determines whether the data will be sent to the main node.
Data will be collected and evaluated every minute to obtain a more accurate reading average. The intelligent algorithm was used to reduce the number of data packets sent to the master node. A temperature of 10 temperature and humidity readings are obtained separately and the difference between them and the previous reading average is determined. Depending on the nature of Iraq's dry hot weather throughout the year so the threshold level of $0.5\ c^{o}$ was set to temperature and 1% of moisture.
The sent packet contains a new reading for the result of the comparison (included in the proposed algorithm); this will reduce total power consumption by reducing transmission time due to number of packet sent.
A smart algorithm where proposed to get an accurate read over the time period and only value the data in the queue for transmission. The power consumption of the proposed sensor node will be less, so the lifetime of the node is longer.
The sensor data acquisition department periodically collects data every single minute. The processing unit task of the node is to collect the data, find its average, and compare it with the previous reading. The value data will only be passed to the report block buffer, where it is compared to the previous value rate and based on the comparison result (greater than or less than 0.5), the transfer of the sensor data is passed to the main node.

4. Experimental setup and results

The intelligent node integrated into the proposed network was created within a GH sample, in which many types of salad vegetables were grown in the middle IRAQ. The wireless sensor network within the greenhouse has been built to collect and process temperature and humidity data to give optimal solutions for network operation based on the inclusion of a smart algorithm in sensor data processing. Due to the short distance and the existence of a line of sight between the sensor nodes and the main node, the quality of the connection is high and all the nodes operate with a transmission of packets higher than 95%.
When the transmit power is set to 0dBm on several intelligent nodes, the packet loss rate was less than 10%. so; the smart nodes have been spatially distributed in an equitable way to obtain very low packet losses and thanks to the use of guaranteed slots that

guarantee a high reliability of communication which results in a packet loss of less than 2%. In order to improve the health and productivity of agricultural crops, it is preferable to use high-resolution sensors. Therefore, the SHT75 sensor was used to measure the temperature and humidity in the greenhouse, which provide a tolerance of 1.8% HR and 0.3 ° C.

To study the research proposal, the experiment was conducted during July 2018, where temperature and humidity readings were recorded for a week in Baghdad and as shown in Table 1. Temperature changes were observed within one hour. For example, temperatures were changed from 29 C° to 31C° from 6 - 7 AM. The sensor node is programmed in two ways, the first programming by sending data every minute to the main sensor node and for one hour, which means sending 60 packets consisting of 2 bytes per hour. While the second method, in which the sensor node was programmed with the smart algorithm suggested in this research. Figure 4 shows the operation sequence of a smart sensor node based on SA, where the rate of ten readings of the sensor is compared every minute with the previous reading, if the current reading rate is greater or smaller than the previous reading rate by 0.5, it indicates a change in the read value of the sensor and it is sent in a package consisting of 2 bytes to the main Node.

Table 1: The Temperature and Humidity Readings in Baghdad on 20 July 2018

Time	Temperature	Humidity
6:00	29	33
7:00	31	26
8:00	33	23
9:00	36	20
10:00	38.5	17
11:00	42.5	13.5
12:00	44	12
13:00	44.3	10.5
14:00	44.7	10
15:00	45	9
16:00	44.6	9
17:00	44.3	9
18:00	44	9

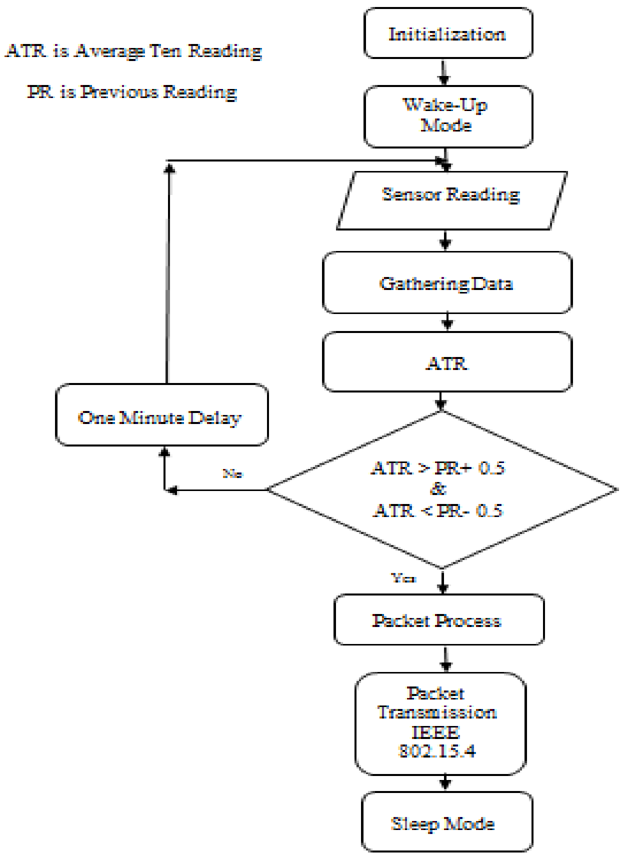

Fig. 4: Operation Sequence of Smart Sensor Node.

The transmitter module will only be activated when a difference of 0.5 is obtained from the previous reading. It was noted that the temperature had changed within one hour (6-7) am only four times. Therefore number of packets sent during this hour is only 4 packets, including the recording of the previously measured temperature difference as follows (29.5, 30, 30.5, 31) c^{o}. The required transmit power is the total power consumed by transmission of n-byte packet, listening to the channel, and activating the wireless transceiver modes, as shown in Figure 5 and Table 2.[17]

Table 2: The Required Current for Transmission of A N Byte Packet For 802.15.4/Zigbee Operations.[17]

Operation	State	Average Current (mA)	Duration (ms)
Transmission of a packet of n bytes with sensed data	Transmission of a n-byte packet	27 mA	0.99 + (8 × n)/250
	Listening of the channel: CSMA wait, CCA, Reception of ACK	25.6 mA	2.1 ms
	Activation and programming of the radio transceiver	6.7 mA	1.3 ms

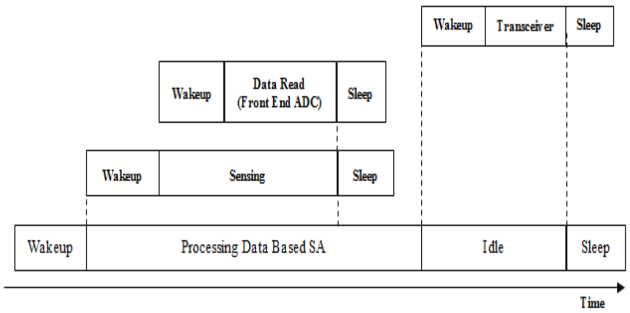

Fig. 5: Smart Node Operation Cycle.

In order to facilitate the comparison of the required power between the sensor node inspection methods, the power of transmission of 2-byte packet is calculated as follows:

$$I_{tt} = I_t \times n \quad (1)$$

Where I_{tt} is the current consumes during the transmission process, I_t is the current required to send one packet (2 bytes), and n is number of transmitter times. So, the current consumed during transmitting 2- bytes and for 60 minutes in the first method is about 1800 mAh while 120 mAh when using the smart algorithm. Therefore, we can enumerate the advantages of the sensor node which uses the smart algorithm to read the sensor data compared to conventional methods with the following:

- Number of packets sent is less.
- The total consumed power of the Node is less.
- High accuracy readings.
- The possibility of increasing the number of sensor nodes that using smart algorithm in the wireless sensor network, due to reduced information sent (reduce load) to the main sensor node to handle.

Figure 6 shows the average temperature and humidity reading of the intelligent sensor nodes connected to the GH. The relative humidity indicated by the results shows that the increase in the room temperature will affect the reduction of the relative humidity, while the inclination towards a colder situation increases the relative humidity. The SA application is able to update the values of barriers based on crop type. A comparison is made between the previous and current measurement values of the sensors using flat math commands. This makes the SA inside the wireless sensor node a successful approach to achieve the realization of the new era of wireless sensor network.

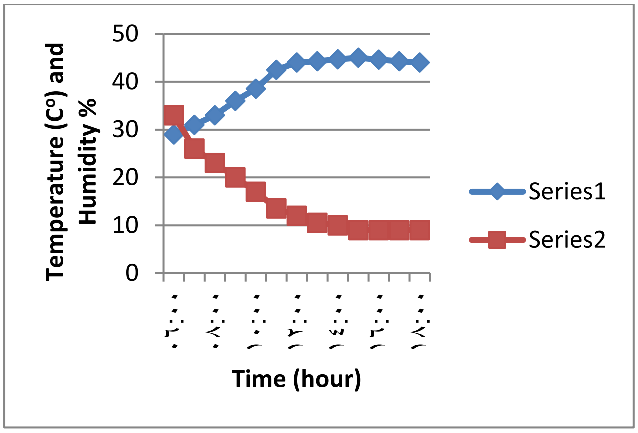

Fig. 6: The Average Temperature and Humidity Reading of the Smart Sensor Nodes Connected to the GH.

The overall performance of the system containing the contract with the smart algorithm shows high results for both the temperature and humidity control process. The effect of these parameters fluctuates slightly in the mean value, while in some weather conditions such as dusty or rainy weather this effect will appear as leaps in the graph.

The concept based on the events applied by GH to the control through the sensor nodes SA provides:

- Event-based control system reduces energy costs.
- Event-based transmission reduces the total number of packet transmissions with very high system performance by 93%.

5. Conclusions

This research paper shows a new design of smart sensor node based on smart algorithm. Intelligent detection and measurements algorithm embedded with the sensor nodes which is the terminal nodes proves the new trend of using cognitive wireless sensor nodes within wide application. Performance was accurate, durable, and reliable during the network trial period. Control parameters can be easily extended to obtain a fully independent greenhouse control system using intelligent sensors. The SA within sensor nodes systems prototype provide real time data monitoring, low cost, small size and little bit inference with labor. Smart sensor nodes can operate at low power between beacons intervals and prolong the life of the system. The measurement of energy efficiency of a sensor node or wireless sensor network for a predefined period is based on the sleep / wake up mode. The main node adjusted the heat and the humidity based on the updating reading transmitted from terminal smart sensor node. The use of intelligent Artificial represented by an intelligent algorithm and its integration with sensor nodes networks provides the essential step of a complete autonomous control system that uses a wireless sensor network for the field of greenhouse applications.

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