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An Improved QOS-Oriented High Efficiency Resource Allocation Scheme in Wireless Multimedia Sensor Network using Exhausting Search Method

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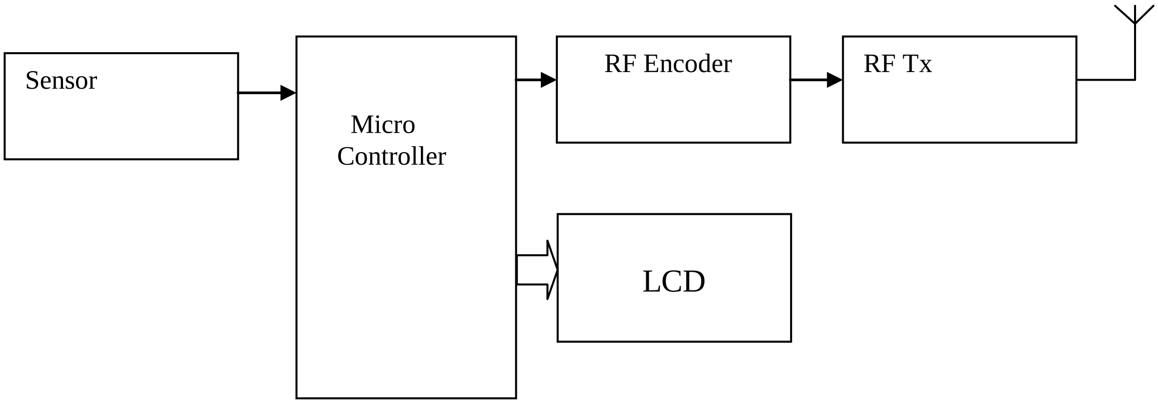
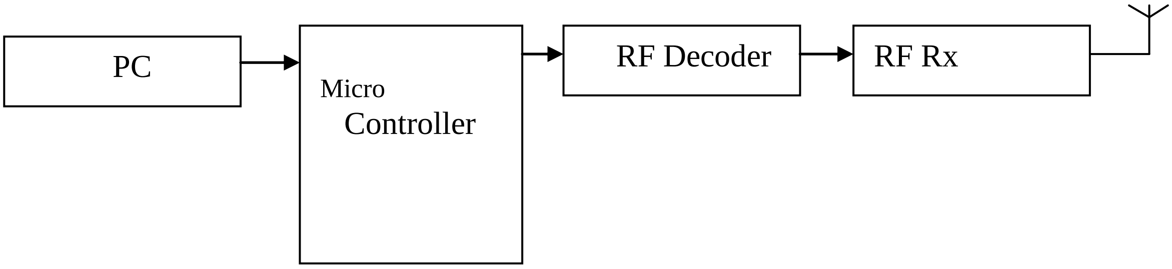
ABSTRACT: Recent advances in wireless communications technology and micro electromechanical systems have enabled the development of low cost, low power, network-enabled, and multifunctional micro sensors. Due to their ease of deployment, reliability, scalability, flexibility, and self-organization, the existing and potential applications of wireless sensor networks (WSNs) span a wide spectrum in various domains, the environmental and technical requirements of which may differ significantly. The major bottle neck in WSN based data collection is the limited power back up. Due to some hostile environments periodic charging of wireless nodes is also not possible. The purpose of deploying a WSN is to collect relevant data for processing and reporting. In particular, based on data reporting, WSNs can be classified as time-driven, event-driven or data driven.

In this paper, a hybrid data-gathering protocol that dynamically switches between the event-driven data-reporting and data-driven data-reporting schemes is proposed. The novel aspect of this approach is that sensor nodes that seem to detect an event of interest in the near future, as well as those nodes detecting the event, become engaged in the adaptive transmission based data-reporting process. This capability enables data from neighboring areas to be gathered proactively without requiring observer intervention. As such, the proposed protocol accurately analyzes the environment being monitored using only moderate resource consumption. The method makes a tradeoff between the energy consumption and data accuracy. The two algorithms named PED for dynamic switching and PAD for area coverage are proposed and the effectiveness of the algorithm in a wireless scenario is analyzed. The implementation of the project is done with PIC micro controller based sensor nodes enabled with 2.4GHz RF modules.

A. Block Diagram:





I INTRODUCTION

A. WIRELESS SENSOR NODES

A typical Wireless Sensor Network Node is composed of four layers, each one fulfilling a specific functionality of the node. These four layers are communication, processing, power supply and sensing/actuation (Figure.1.1)

The benefits of modularity are a low redesign effort and the possibility of interchanging between different layers depending on the requirements of the application. This makes the node very versatile and adaptable. Modularity reduces redesign, as each module is not started from scratch, and cost when the work environment changes. The concept is to have different implementations of each layer to be stacked together in order to create a node adapted to the requirements of the application (Figure.1.2).

A physical node has been constructed to test the modularity concept. The heart of the node is the processing layer. In this first prototype, a mixed design composed of an ADuC831 µC from Analog Devices and a XC3S200 Spartan III FPGA from Xilinx has been chosen, in order to give as much flexibility as possible to the node. In simple applications only one of the devices (the µC or the FPGA) could be used (Figure.1.2). The µC deals with communication control and signals coming from analog sensors (the µC has a 227 kSPS ADC integrated) or simpledigital sensors.

II LITERATURE REVIEW

APTEEN: A Hybrid Protocol for Efficient Routing and ComprehensiveInformation retrieval in wireless sensor networks has been proposed [1].In this worka hybrid routing protocol (APTEEN) is proposed, which allows for comprehensive information retrieval. The nodes in such a network not only react to time-critical situations, but also give an overall picture of the network at periodic intervals in a very energy efficient manner. Such a network enables the user to request past, present and future data from the network in the form of historical, one-time and persistent queries respectively. The performance of these protocols are evaluated and observed that these protocols are ob-served to outperform existing protocols in terms of energy consumption and longevity of the network.

Hybrid protocol APTEEN which combines the best features of both proactive and reactive networks and to provide periodic data collection as well as near real-time warnings about critical events. We have also demonstrated implementation of a query which is versatile enough to respond to a variety of queries. Even though, our query model is suitable for a net- work with evenly distributed nodes, it can be extended further to sensor networks with uneven node distributions.

In APTEEN every sensor node in the network participates in a proactive data-reporting process regardless of its relevance to an event of interest, which leads to energy wastage. The same may lead to higher band width requirement, which in turn will increase the deployment cost. In the proposed method Nodes that detect an event of interest or those nodes that are likely to detect the event in the near future become engaged in a proactive data reporting through spatio-temporal correlation of data.

An Efficient Hybrid Data Gathering Scheme in Wireless Sensor Networks have been proposed in [2]. In this work for time-sensitive applications requiring frequent data gathering from a remote wireless sensor network, it is a challenging task to design an efficient routing scheme that can minimize delay and also offer good performance in energy efficiency and network lifetime. A new data gathering scheme is proposed, which is a combination of clustering and shortest hop pairing of the sensor nodes. The cluster heads and the super leader are rotated every round for ensuring an evenly distributed energy consumption among all the nodes. The proposed scheme is implemented in nesC and performed simulations in TOSSIM. Successful packet transmission rates have also been studied using the interference-model. Compared with the existing popular schemes such as PEGASIS, BINARY, LBEERA and SHORT, this scheme offers the best “energy × delay” performance and has the capability to achieve a very good balance among different performance metrics. This algorithm overcomes the losses incurred from all other data gathering schemes proposed in literature. HDS makes a good harmony among network lifetime, energy costs and network throughput. It not only reduces the network lifetime but also guarantees the best energy-delay product. The coding of HDS in NesC deserves a special mention as it proves the scheme to be feasible on real hardware platforms. Also the radio interference model used for simulation purposes helped us to study the problem from the perspective of a more realistic physical layer.

III METHODOLOGY

A. INTRODUCTION

The essential elements of the hybrid data-gathering protocol proposed in this ***work*** are that: 1) it switches dynamically between the event-driven data-reporting scheme and the time driven data-reporting scheme, and 2) sensor nodes that will detect the events in the near future, which typically are in close proximity to those nodes detecting the events, are also engaged in the time-driven data-reporting process.

The key protocol characteristics: Under normal conditions, sensor nodes respond only when the measured temperature is above 100°C. However, once sensor nodes realize that the abnormal phenomenon is not transient (e.g., at tp and tx), they switch to the time-driven data-reporting scheme and continuously disseminate temperature data to an observer. Furthermore, they notify other nodes of their changes so that neighboring nodes continuously disseminate data as well. Similarly, when the temperature goes below 100 °C (e.g., at tq and ty), the nodes switch back to the event-driven data-reporting scheme.

B . TIME DRIVEN DATA GATHERING

Time - driven programming is a computer programming paradigm, where the control flow of the computer program is driven by a clock and is often used in Real-time computing. A program is divided into a set of tasks (i.e., processes or threads), which has a periodic activation pattern. The activation pattern for all tasks is stored in a dispatch table, were the Least-Common-Multiple (LCM) of all period-times determines the length of the dispatch table. The scheduler of the program dispatches all tasks according to the dispatch table, on which end a new instance of the dispatch table is initiated.

The programming paradigm is mostly used for safety critical programs, since the behavior of the program is highly deterministic. No external events are allowed to affect the control-flow of the program, the same pattern (i.e., described by the dispatch table) will be repeated time after time. However, idle time of the processor is also highly deterministic, allowing for the scheduling of other non-critical tasks through slack stealing techniques during these idle periods.

C. EVENT DRIVEN DATA GATHERING

In computer programming, event-driven programming (EDP) or event-based programming is a programming paradigm in which the flow of the program is determined by eventse.g., sensor outputs (Figure.3.1) or user actions (mouse clicks, key presses) or messages from other programs or threads.

Event-driven programming can also be defined as an application architecture technique in which the application has a main loop which is clearly divided down to two sections:

- the first is event selection (or event detection)
- the second is event handling.

In embedded systems the same may be achieved using interrupts instead of a constantly running main loop; in that case the former portion of the architecture resides completely in computer hardware.

Event-driven programs can be written in any language, although the task is easier in languages that provide high - level abstractions, such as closures. Some integrated development environments, such as Microsoft Visual Studio, provide code generation assistants that automate the most repetitive tasks required for event handling.

D. HYBRID DATA GATHERING

In this work, we propose a hybrid data-gathering protocol that dynamically switches between the time-driven data-reporting scheme and the event-driven data-reporting scheme. The proposed protocol behaves as event-driven, meaning that an event of interest triggers data dissemination by sensor nodes. However, from the point at which an event occurs to the point at which the event becomes invalid, the sensor nodes detecting the event continuously send data to an observer, thereby enabling accurate analysis of the environment.

The novel aspect of our approach is that not only the sensor nodes that are detecting an event of interest but also those nodes that will potentially detect the event in the near future become engaged in the time-driven data-reporting process (Figure.3.2).

This capability enables data from potentially relevant areas to be proactively gathered without requiring observer intervention. As such, the proposed protocol accurately analyzes the environment being monitored using only moderate consumption of valuable resources.

E. BLOCK DIAGRAM:

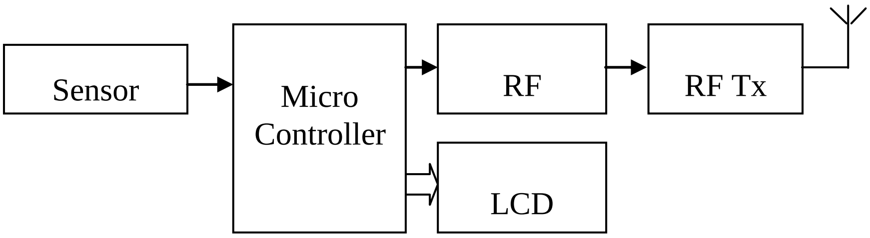


FIGURE.3.3. SOURCE NODE

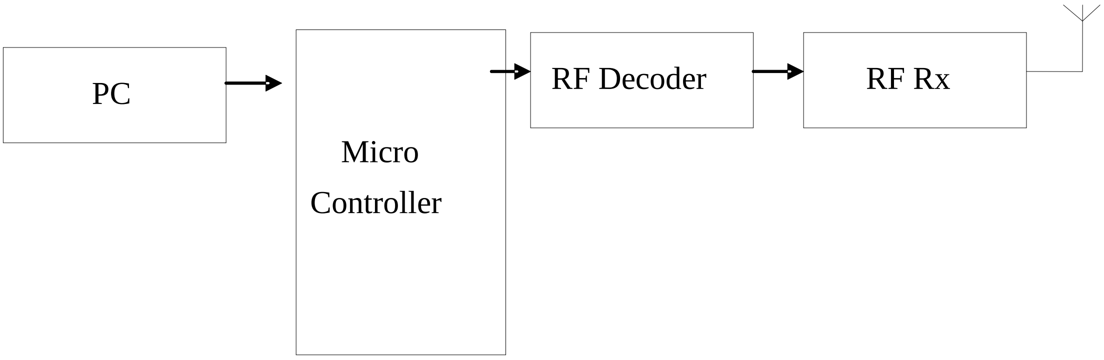


FIGURE.3.4. SINK NODE

F . PED ALGORITHM

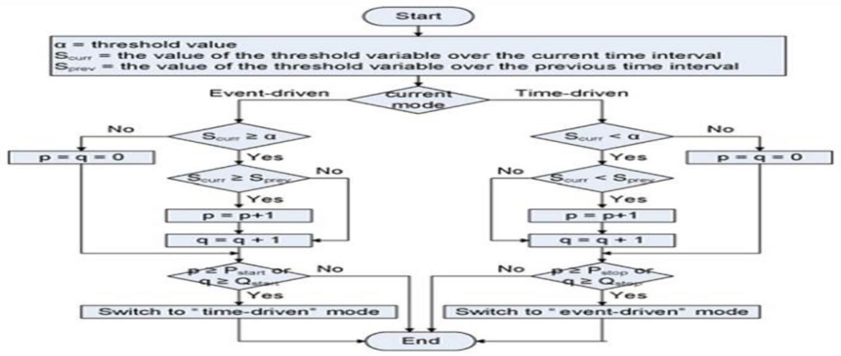


FIGURE.3.5. PED ALGORITHM

As depicted in Figure.3.5, the PED algorithm is given a threshold value, a threshold variable, and two counter-variables controlling the aggressiveness level for changes in data-reporting schemes. The threshold value determines the occurrence of an event of interest. That is, when the value of the sensed attribute is beyond the threshold value, a sensor node must report it to a base station. The threshold variable is the average of the values of the sensed attribute over a time interval. The two counter-variables, *p* and *q*, are defined as follows:

1) *p*: the number of consecutive time intervals with increasing (for starting the time- driven data-reporting scheme) or decreasing (for stopping the time-driven data- reporting scheme) slope of the threshold variable;
2) *q*: the number of consecutive time intervals that the threshold variable is above (for starting the time-driven data-reporting scheme) or below (for stopping the time-driven data-reporting scheme) the threshold value, regardless of slope. Two pairs of constants, *P*start and *Q*start, and *P*stop and *Q*stop, are parameters of the algorithm such that *P*start ≤ *Q*start and *P*stop ≤ *Q*stop.

The PED algorithm works as follows. Suppose that the current data-reporting scheme of a sensor node is event-driven. A sensor node periodically computes the average of the sensed attribute over a recent time window and updates the two counter-variables, *p* and *q*, accordingly. If (*p* ≥ *P*start) or (*q* ≥ *Q*start), a sensor node switches to the time-driven datareporting scheme and reports the sensed attribute continuously over time. To eliminate the risk of a transient response, the two counter-variables are reset when the average value of the sensed attribute goes below the threshold value. Similarly, when the time-driven data-reporting scheme is used, the tests on *P*stop and *Q*stop are executed to determine when to switch back to the event-driven data-reporting scheme. Note that the failure of tests on both *P*start and *Q*start does not affect the normal behavior of the sensor networks. That is, the data capturing an event are still propagated all the way to a base station

Continuous data dissemination ends (p=3. q=3)

Continuous data dissemination starts (p=2. q=5)

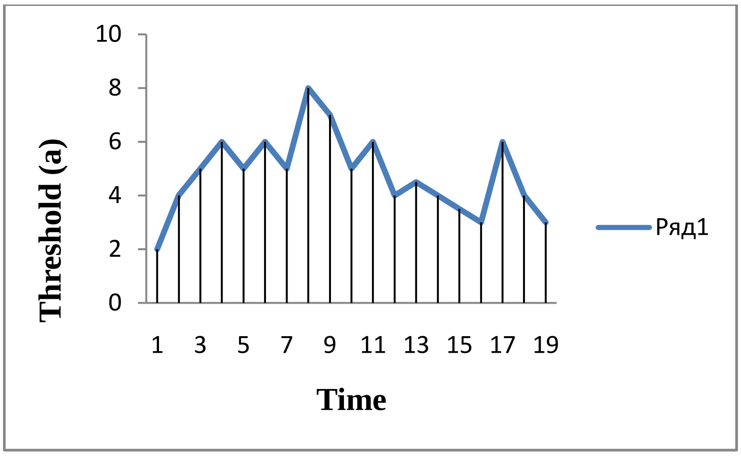


FIGURE.3.6. ILLUSTRATION OF THE PED ALGORITHM

As *P* (e.g., *P*start and *P*stop) requires that the value of the sensed attribute be monotonically increasing (or decreasing) for *P* consecutive time epochs, the use of *P* enables a rapid response to a change in an attribute, and prevents a response to a transient change due to, e.g., sensor malfunctioning. If the test on *P* fails, the test on *Q* (e.g., *Q*start and *Q*stop) is applied, which is more forgiving (e.g., the requirement that the slope is monotonically increasing or decreasing is relaxed). Therefore, *Q* permits some fluctuation of measurements and is more conservative. Overall, smaller values of *P* and *Q* lead to more aggressive action. Figure.3.6 illustrates the operation of the PED algorithm with *P*start = 3, *Q*start = 5 and *P*stop = 3, *Q*stop = 5. At t7, the two counter-variables, *p* and *q*, become 2 and 5, respectively. Therefore, continuous data dissemination starts because $q \geq Q$start . Similarly, at t16, both *p* and *q* become 3. Consequently,continuous data dissemination ends because $p \geq P$stop.

The followings are the transmission cost and receiving costs for a k-bit message in a distance d is as follows,

F .TRANSMITTING

$E_{Tx}(K,d)= E_{Tx-elec}(k)+ETx_{-amp}(k,d)$
$E_{Tx}(k,d)= E_{elec}*k+\varepsilon_{amp} * k* d^2$

G .RECEIVING

$E_{Rx}(k)=E_{Rx-elec}(k)$
$E_{Rx}(k)=E_{elec}*k$

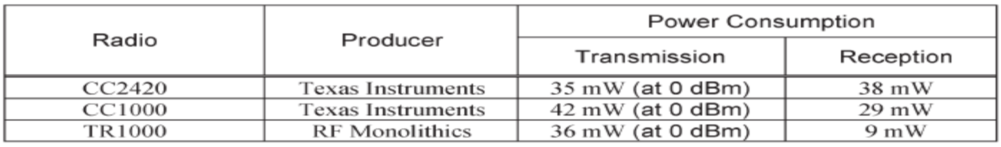
Where, E_{elec} = 50nj/bit(which is the energy dissipated by the radio to run the tx and rx) ,
ε_{amp} = 100pj/bit/m^2.

So the total consumed energy of each cluster can be calculated by,

$$\sum ERx + \sum ETx$$

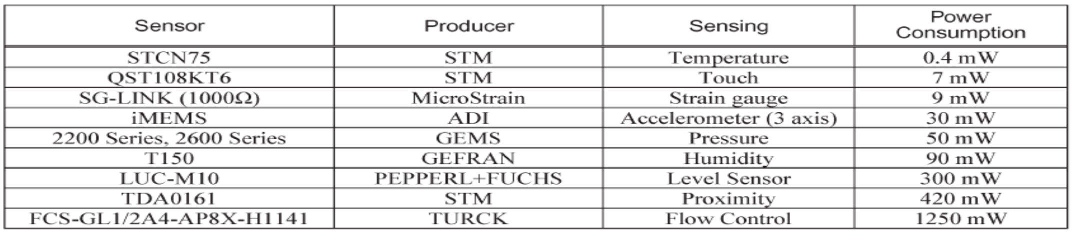
The following table shows the power consumption parameter of some common radios which are being used frequently and some off-shelf sensors.

TABLE I
POWER CONSUMPTION FOR SOME COMMON RADIOS [6]



Radio	Producer	Power Consumption	
		Transmission	Reception
CC2420	Texas Instruments	35 mW (at 0 dBm)	38 mW
CC1000	Texas Instruments	42 mW (at 0 dBm)	29 mW
TR1000	RF Monolithics	36 mW (at 0 dBm)	9 mW

TABLE II
POWER CONSUMPTION FOR SOME OFF-THE-SHELF SENSORS



Sensor	Producer	Sensing	Power Consumption
STCN75	STM	Temperature	0.4 mW
QST108KT6	STM	Touch	7 mW
SG-LINK (1000Ω)	MicroStrain	Strain gauge	9 mW
iMEMS	ADI	Accelerometer (3 axis)	30 mW
2200 Series, 2600 Series	GEMS	Pressure	50 mW
T150	GEFRAN	Humidity	90 mW
LUC-M10	PEPPERL+FUCHS	Level Sensor	300 mW
TDA0161	STM	Proximity	420 mW
FCS-GL1/2A4-AP8X-H1141	TURCK	Flow Control	1250 mW

I . PAD ALGORITHM

Once a sensor node switches to the time-driven data reporting scheme, it broadcasts its change to engage neighboring sensor nodes in the continuous data dissemination. The range of the neighborhood is determined by the PAD algorithm, which is based on two configurable parameters: time-to-live (TTL) and valid time (VT).
Sensor nodes engaged in continuos data
dissemination due to A-> (B,C,D,E)

TTL represents the number of hops within which sensor nodes must switch to the time-driven data-reporting scheme. The use of TTL in the PAD algorithm is similar to that in computer network technology, where TTL specifies the number of hops that a message can travel to before it should be discarded.

When a sensor node receives a broadcast message containing a TTL value that is greater than zero, it switches to the time-driven data-reporting scheme and rebroadcasts a TTL value decremented by one. This process continues until the TTL value becomes zero (Figure3.7).

This approach is based on the argument that the nearer a sensor node is located to the sensor nodes that detect an event, the more likely it is that the sensor node will be relevant to that event in the near future since sensor nodes are formed according to proximity.

For instance, the current temperature measured by sensor nodes located close to the fire may not be high enough to trigger an event, but it would be much higher than those of nodes tens of miles away from the fire. Therefore, the possibility that the closely located sensor nodes will detect an event in the near future increases.

VT is the other important parameter of the PAD algorithm, and it specifies how long a sensor node should use the time-driven data-reporting scheme regardless of the result of its PED algorithm. Note that VT is used only for those sensor nodes that are switched to the time-driven data-reporting scheme by TTL. The necessity of VT arises from the fact that sensor nodes in the vicinity of the area where an event occurs may not yet detect the event. Therefore, without VT, they could immediately switch back to the event-driven data reporting scheme, losing the chance to acquire important information in advance.

We believe that our approach behaves well in multiple event-detection environments, in which sensor nodes are capable of sensing different attributes through simple modification of the PAD algorithm. For instance, a sensor node executes the PED algorithm for each sensed attribute and broadcasts its switching to the time-driven data-reporting scheme to neighboring nodes accordingly. By sending not only TTL and VT but also the type of attribute that caused the switching, the sensor node allows neighboring nodes to determine what type of data they need to collect in a time-driven manner.

The following equation will give the delay period of each and every node,

$$\text{Delay} = KH\,(h^{2\,-}(2h-1)r)$$

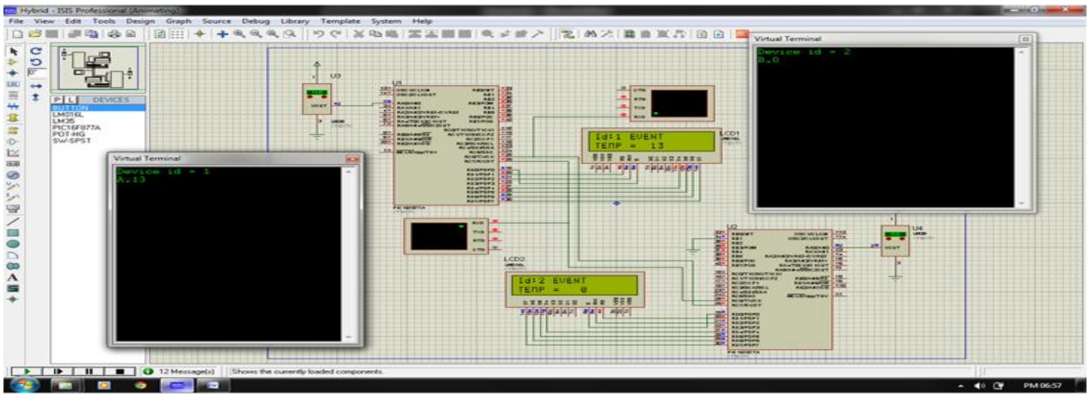
where, h is the length in number of hops away from the front end, r is a random number such that $0 < r \leq 1$, and H is a constant reflecting estimated delay per hop. To incorporate potential effects from queuing and processing delays, K is used as a compensation constant. Normally, K and H are combined and used as adjustable parameters.

The following table shows some important radio parameters of a sensor in our proposed system..

TABLE III
RADIO PARAMETERS

Parameter	Value
Radio	CC1000
Frame size	36 bytes
Bit rate	19.2 Kbps
Transmit Power (0 dBm)	42 mW
Receive Power	29 mW
Idle Power	29 mW
Sleeping Power	0.6 µW

IV RESULTS AND DISCUSSIONS



```
Device id - 1
A,13
```

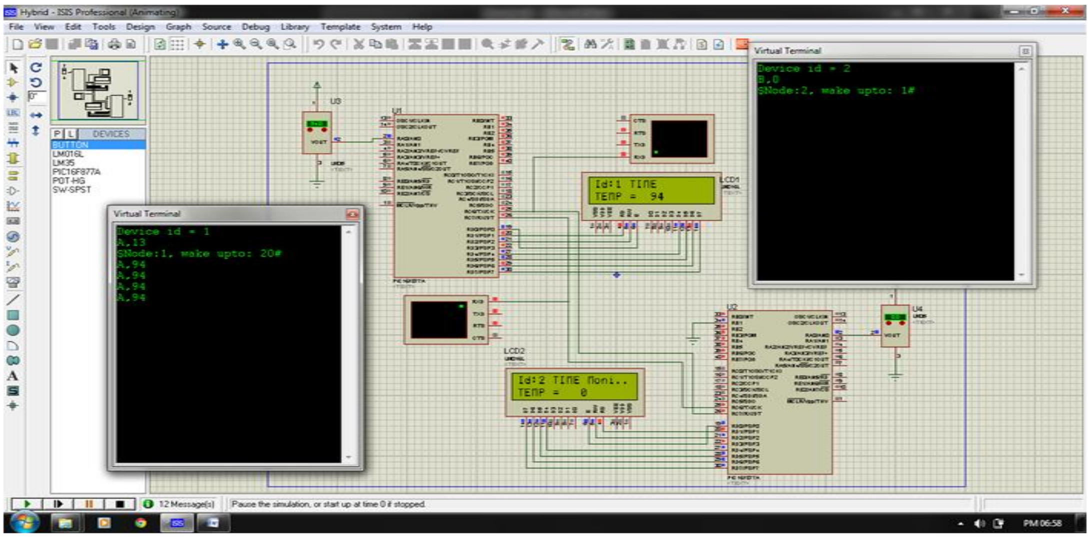
```
Id:1 EVENT
TEMP =  13
```

```
Device id - 2
B,0
```

```
Id:2 EVENT
TEMP =   0
```

FIGURE.4.1. NODE1 AND NODE2 BOTH IN EVENT DRIVEN MODE (INITIALLY)

The hybrid data gathering system, designed for long term data collection has been simulated on a 8 bit microcontroller based platform. An LM35 based temperature sensing system is interfaced with the microcontroller. An XBEE based radio is connected to the communication peripherals of the microcontroller. The fore mentioned system forms the wireless sensor node for the data gathering purpose. The system simulated on Proteus platform with different input patterns. The system effectively addresses the energy issues and data accuracy requirements with appropriate switching between event driven and time driven modes.

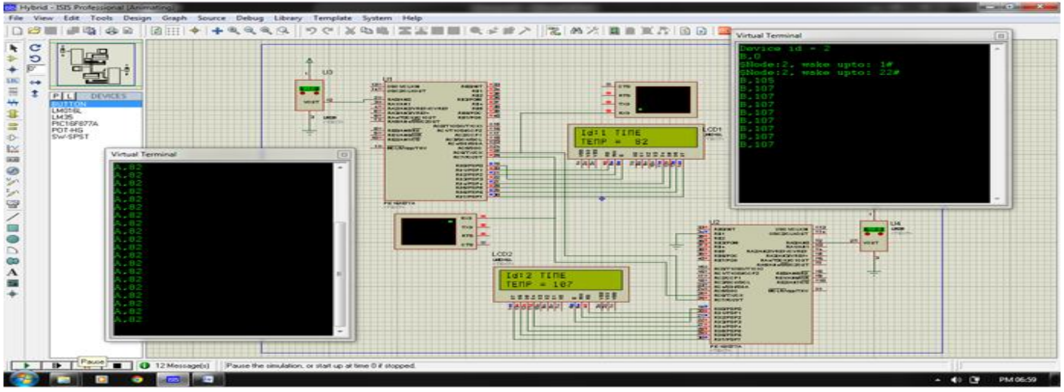


```
Device id = 1
A,13
SNode:1, wake upto: 20#
A,94
A,94
A,94
A,94
```

```
Device id = 2
B,0
SNode:2, wake upto: 1#
```

FIGURE.4.2. NODE1 SWITCHED TO TIME-DRIVEN MODE WAKING-UP NEIGHBORING NODES

The switching between time driven data gathering and event driven data gathering is efficiently handled by Parameter based Event Detection (PED) algorithm. The switching from event driven to time driven is made on the occasion when the input is above the threshold value and the input is increasing consecutively for three time epoch. The switching from time driven to event driven is made when the input is below the threshold value and it is decreasing consecutively for two time epoch.



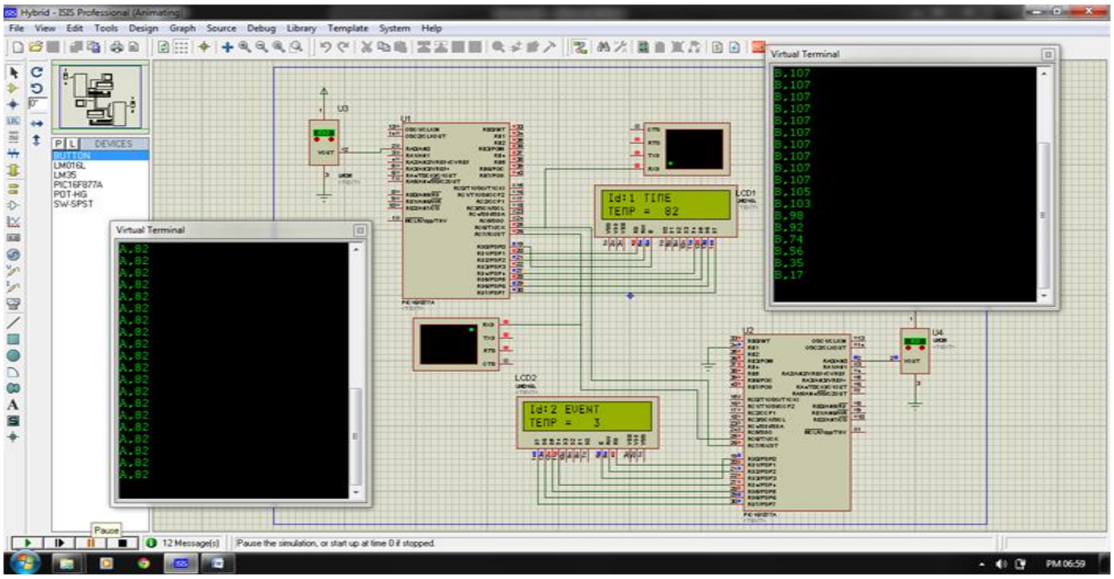
```
A,82
A,82
A,82
A,82
A,82
A,82
A,82
A,82
A,82
A,82
A,82
A,82
A,82
A,82
A,82
A,82
A,82
A,82
A,82
A,82
```

```
Device id = 2
B,0
SNode:2, wake upto: 1#
SNode:2, wake upto: 22#
B,105
B,107
B,107
B,107
B,107
B,107
B,107
B,107
B,107
```

FIGURE.4.3. NODE2 SWITCHED TO TIME-DRIVEN MODE

During time driven data gathering data is transmitted on a constant time span of 500 ms. This mode has achieved high level of data accuracy along with maintaining the data pattern over the duration. But this system suffers from redundant data transmission and bandwidth wastage during normal times.

Here is where, event driven data gathering comes into picture which communicates the information only when the input is changing significantly.



```
Id:1 TIME
TEMP =  82
```

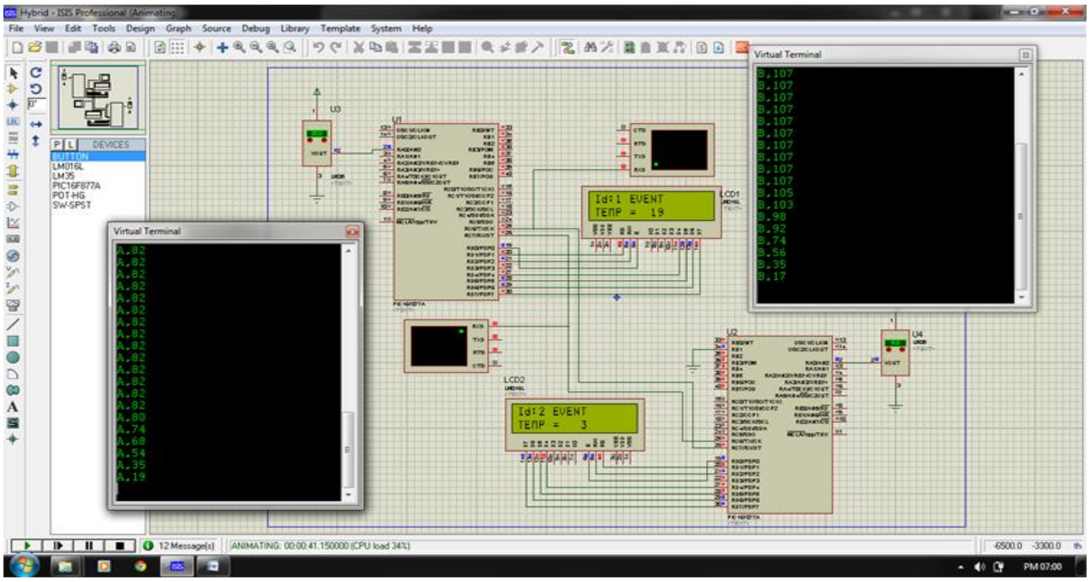
```
Id:2 EVENT
TEMP =   3
```

```
A,82
A,82
A,82
A,82
A,82
A,82
A,82
A,82
A,82
A,82
A,82
A,82
A,82
A,82
A,82
A,82
A,82
A,82
A,82
A,82
```

```
B,107
B,107
B,107
B,107
B,107
B,107
B,107
B,107
B,107
B,107
B,105
B,103
B,98
B,92
B,74
B,56
B,35
B,17
```

```
12 Message(s)    Pause the simulation, or start up at time 0 if stopped.
```

FIGURE.4.4. NODE1 REMAINING IN TIME-DRIVEN MODE, NODE2 RETURNED TO EVENT-DRIVEN MODE



```
Id:1 EVENT
TEMP =  19
```

```
Id:2 EVENT
TEMP =   3
```

```
A,82
A,82
A,82
A,82
A,82
A,82
A,82
A,82
A,82
A,82
A,82
A,82
A,82
A,82
A,80
A,74
A,68
A,54
A,35
A,19
```

```
B,107
B,107
B,107
B,107
B,107
B,107
B,107
B,107
B,107
B,107
B,105
B,103
B,98
B,92
B,74
B,56
B,35
B,17
```

```
12 Message(s)    ANIMATING: 00:00:41.150000 (CPU load 34%)
```

FIGURE.4.5. NODE 1 RETURNED TO EVENT-DRIVEN MODE

The system while addressing the intensity issues of input also addresses the direction of intensification of inputs. When the node is changing from event driven to time driven it wakes up the neighboring sleeping nodes. The coverage area of the wakeup call is governed by the Parameter based Area Detection (PAD) algorithm, which considers the rate of change of input intensity as primary decision factor.

V CONCLUSION

Energy efficient data collection scheme for resource constrained wireless sensor nodes has been simulated successfully and the output results are verified. The results are in line with the expected output. The project has been checked with both software and hardware testing tools. In this work the algorithms for mode switching and area detection are chosen are proved to be more appropriate for the intended application. The project is having enough avenues for future enhancement. The project is a logical model that fulfills all the functional and non functional requirements of a new era wireless sensor network. The project with minimal configuration changes can be directly applicable for multiple real time applications. Thus the project contributes a significant step forward in the field of energy conservation in wireless monitoring systems, and further paves a road path towards faster developments in the same field. The project is further adaptive towards continuous performance and peripheral up gradations. This work can be applied to variety of industrial and commercial applications. The results are encouraging and helps in designing a complete long term data collection system.

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