Tree Theft Controlling System Using Wireless Sensor Node

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Abstract - Smuggling/Theft of Trees has led to an increase risk of Natural Resource getting extinguished. Animals are losing their Natural Habitat, thus causing a total imbalance in Nature. This software helps to control the illegal tree theft and maintain the forest environment. We are using the wireless sensors for detecting the temperature and weather changes. The wireless temperature sensor node senses and transmits the variations in the local temperature to the central computing unit placed within the range. The central base station receives the data and stores it in the file and plotting the variations simultaneously.

Goal in event-driven wireless sensor networks is to transmit the event information to users as soon as possible. To improve the reliable transmission of the single alarm packet, we use a dynamic multi copy scheme similar as conventional multipath routing for continuous flow.

I. INTRODUCTION

The project as mentioned was a unique idea. The other part was the implementation of analogue filters: band pass and band stop. From the studies conducted it was found that the sound of tree cutters was around 200Hz of major frequency content, from the studies of MATLAB. But the sound of woodcutter also falls around 200Hz but with a difference that 30Hz was also there

If there is a content of 200Hz then it must not contain 30 Hz. The present system of tree-cutting alarm is only when the tree is out of range due to the tag embedded in it.

The aim of this paper is to design a low cost wireless temperature data logging system with 8-bit embedded microcontroller and low-power ZigBee RF transceiver. The main functions of the proposed system are:

- Continuous temperature monitoring
- To transmit the data to remote personal computer
- To implement Peer-to-Peer network and multipoint network can be established by configuring each module to operate as a sensing node.

Human presence by sensing heat. This technique is more suitable for protection of Trees in farms where no other Animals are likely to enter other than Human beings and also where the area to be considered for protection is not large. However, this method is inadequate for poaching control in Wild forest as the forests are marked with presence of creatures other than Human-beings.

- Installation of CCTV cameras for covering large area proves very costly and is hard to implement due to limitation of power supply in deep forest areas.
- Also, the latest trend for protection of trees is to tag an RF-ID to trees just like tagging an Animal for knowing the whereabouts of a particular tree. However, this technology doesn't give Real Time Information while the activity is happening. Activity is detected only when the Tree leaves its Initial position.

WSN is a most emerging technology, widely used in many applications which involve monitoring and control. to forest areas, WSN is already deployed for fire detection, rearing! poaching of wild animals. WSN facilitates easy installation and maintenance; they eliminate the use of expensive cables and save cost. It has many advantageous applications in real world and so used in many project.

The main idea presented in this paper is to design a portable wireless sensor node which will be a part of a Wireless Sensor Network. It will be mounted on trunk of each Tree, capable of detecting theft as well as automatically initiate and send alarm signals if any to Central Base Station.

[n [7], the Author and his team has shown use of FFT for Signal processing. They checked frequency of cutting mechanism of trees with Band pass filter.

Hiring Security personals for monitoring the entire area for suspicious Activity is one of the methods to control poaching. However, due to physical limitations in Human it is hard to monitor the entire area continuously, thus the hiring of guards proves unreliable and inadequate.

The device uses MSP430G2553 as the microcontroller which gives powerful processing with low cost. This would ideally fit in the forest areas because of such a large scale implementation possible.

The network load of some event types is usually light due to the infrequency.

Critical events, such as fire detection in a forest or enemy detection in a battlefield, have one thing in common. Only packets carrying event indication are of interest.

The location of the sensors is often known in EWSNs. In event monitoring applications, we concern about not only whether the event happens or not, but also where is the event.

II. SYSTEM MODEL AND PRELIMINARY NOTATIONS

A typical EWSN consists of a number of different sensor nodes equipped with different sensors and a sink Nodes in the radius of an event sense the environment value independently and also collect observation data from its neighborhoods. Then a local event decision is conducted and routed to the sink node to make further action.

A. *Communication Model*

We consider a static event-driven wireless sensor network with N sensor nodes. We use an N*N neighborhood relation matrix PN*N to indicate the direct communication of node pairs. That is Pij = 1 if node i can send a packet to node j; otherwise Pi,j = 0. To allow bidirectional communication between a node pair in our study, PN*N is a symmetric matrix, i.e., Pij = Pj,i. Some notations and symbols use, we consider a static event-driven wireless sensor network with N sensor nodes. Given is an N xN neighborhood relation matrix PN*N that indicates the node pairs for which direct communication is possible. We will assume that PN*N is a symmetric matrix, i.e., if node i can transmit to node j, then j can also transmit to node i. For such node pairs, the (i, j) the entry of the matrix is unity, i.e., Pij = 1 if node i and j can communicate with each other; we will set Pi,j = 0 if nodes i and j cannot communicate. For any node i, we define Ni = j: Pij =1, a which is the set of neighboring nodes of node i.

1) *Forward Set (FS)*

This set is used to indicate those neighbor nodes that are closer to the destination than the source. Mathematically, we let FS i be the set of neighbor nodes that belong to Ni such that node j 6 FS i if

D (i,s) < D(j,s)

D (i,d) > D(j,d)

2) *Backward Set (BS)*

This set is used to indicate those neighbor nodes that are closer to the source than the destination. Mathematically, we let BS i be the set of neighbor nodes that belong to Ni such that node j 6 BS i if

D(i,s) > D(j,s)

D(i,d) < D(j,d)

Where D(i, j) represents the distance between node i and j. ‘s’ and ‘d’ denote the source and destination node respectively. Note that we can easily obtain FS i or BS i by simply scanning the neighbor set of node i.

B. *Composite Event*

A composite event is defined as a set of predefined observation attributes and the corresponding predicates defined on the attributes. Then a composite event E is defined as E = (E1, E2,...,E|M|) (3) where Em, m 6 M is the atomic event, M is the set of components of composite event. is a function of Boolean algebra operators such as “OR” or “AND”. An atomic event Em is a special composite event involving only one observation attribute and its corresponding predicate

Taking fire as a composite event for example, the event fire is a fusion of multiple sensed values of multiple different Attributes, i.e., the occurrence of fire should satisfy some Conditions such as temperature > 100 °C AND smoke> 100mg/L, rather than a simple condition temperature > 100 °C or smoke >100mg/L alone. Any change in either temperature or smoke density that makes temperature > 100 °C or smoke>

100mg/L true is an atomic event. The event that is a combination of several atomic events is a composite event, e.g., the composite event fire is represented as temperature > 100 °C AND smoke >100mg/L.

III. PROTOCOL DESIGN

Our efficient event detection protocol (EEDP) is consist of two procedures, Primary Detection procedure (PDP) and Emergency Routing Procedure (ERP). In PDP, each node collects the environment information with its own equipped sensors and makes local primary decision. And then each node routes the local primary decisions to the sink node in the ERP procedure to make further process.

Primary Detection Procedure 1) Detection: For the composite event E, we use two hypotheses to denote the absence and presence of it. We define xim to be the observation of the mth sensor of node i to make a local atomic binary decision pirn. We useDi to denote the final decision result of node i, the node i with i = 1 generates an alarm packet to destination immediately. In this work we consider the observations xim to be statistically independent, and also identically distributed conditional to the same hypothesis. In a realistic setting we can think that observations xim are related to the sensing of environmental information, if the sensed value exceeds a determined threshold value. Taking fire for example, when the sensed temperature exceeds 100 °C, we could make the decision that the temperature atomic of fire has happened. The independent signal xim is obtained: xim =^{v} wim if H0,(E is absent); f (ri)+wim if H1,(E is present); (4) where wim ~ N(0,o2 w) is the noise that follows a normal distribution with mean 0 and standard deviation ow; ri is the distance between node i and the Pol; and f is a function that monotonically decreases with increasing ri. For each sampled signal xim, node i makes a per sample binary decision pim 6{ 0,1} by the Single DecisionRule (Eq. 5): 1) Single Decision Rule (SDR): pim = D1 if xim >Dim; 0 otherwise. (5) where Dim is the per- sample threshold of node i for the mth atomic event Em. 2) Composite Decision Rule (CDR): Di = D1 if pi 1 AND pi 2 AND ... AND pi |M|=1; 0 otherwise. (6)

Case 1: If the sensor component of atomic event Em does not exist, we set the value of xim to zero, that means xim < i m. And then, the value of pim equals zero according to SDR

Case 2: If the sensor component of atomic event Em does exists, the value of xim must be bigger than zero. Then, the sensor node could make a primary decision according to

SDR. Of cause, we could set a different values for case 1, such as qim =-1. However, in this paper, it is unnecessary as we use “OR” operation receiving different values from other nodes (seen Algorithm1 step 6), only concerning on the values of qim = 1.

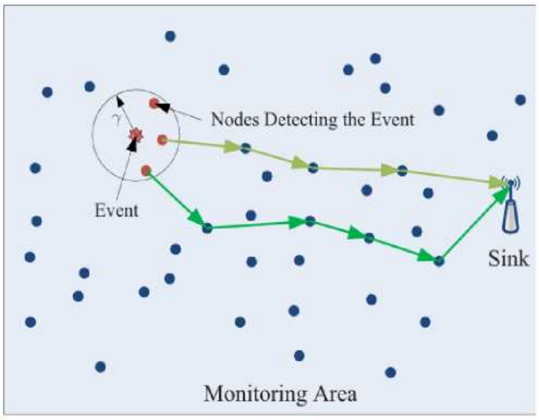


Fig: 1. Example of a typical EWSN

In EWSNs, whether the event occurs or not is more of interest to users rather than the detailed event information. However, an event should not be decided only based on one property of the event like the research mentioned above, but combining with other properties together. Composite event is first proposed in [14] to make accurate event detection. To ensure the quality of surveillance, some applications require that if an event occurs, it needs to be detected by at least k sensors, where k is a user-defined parameter. In [15], authors examine the Timely Energy-efficient k-Watching Event Monitoring (TEKWEM) problem and propose a detection model and a warning delivery model to Monitor the composite events and delivery warnings to users. However, detection set and a (a,P)-Light Approximate Shortest Path Tree should be established which is not suitable in the surroundings with low bandwidth and limited computation ability. A loss tolerant reliable data transport mechanism for dynamic Event Sensing (LTRES) was proposed in [16], which focuses on the reliable event information transmission by appropriate congestion control scheme. A distributed source rate adaptation mechanism is designed, incorporating a lightweight congestion control mechanism with loss rate as the indication of upstream congestion level. By this way, the traffic injected into the network is

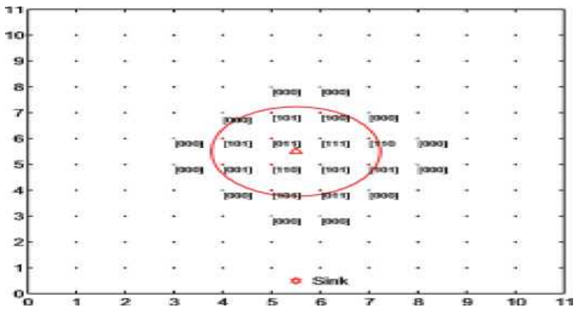


Fig: 2. Example of primary detection result

regulated, so that the reliability requirements can satisfied.

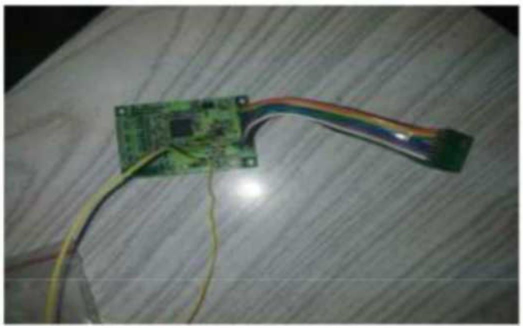


Fig.3: wireless sensor node

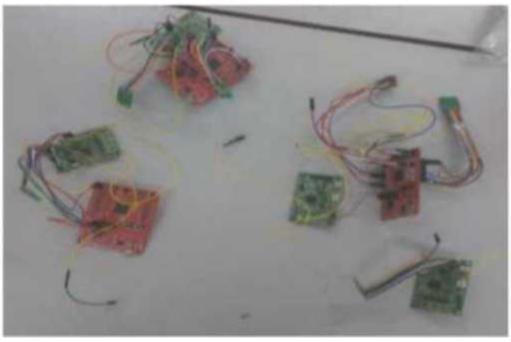
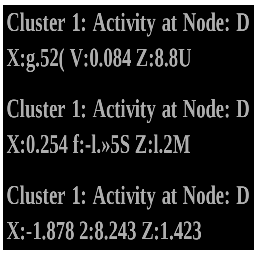


Fig.4: group of wireless sensor nodes



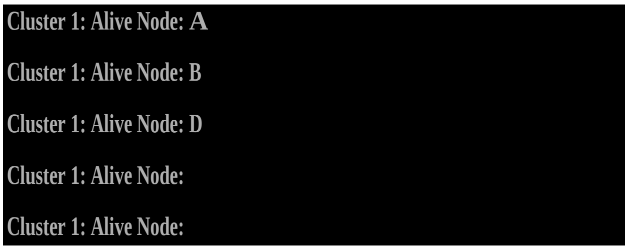


Fig.5: result on the desktop

Obviously, the primary detection procedure and message broadcast will be only conducted among the ESNs. This way has at least two benefits: one is saving energy by limiting the packets forwarding, and the other is to improve the reliability and shorten the delivery latency by reducing the congestion in routing path.

The system was analogue based, be it the active op-amp filter or the magnitude comparator. This made the design very simple and quicker. By carefully selecting the resistors and capacitors we could get the desires response.

The input data format from the sensors is analogous and that from the transceiver is as mentioned to be digital with SPI

protocol. The output was the same as sending signals of pulses to other transceivers and the chronos watch.

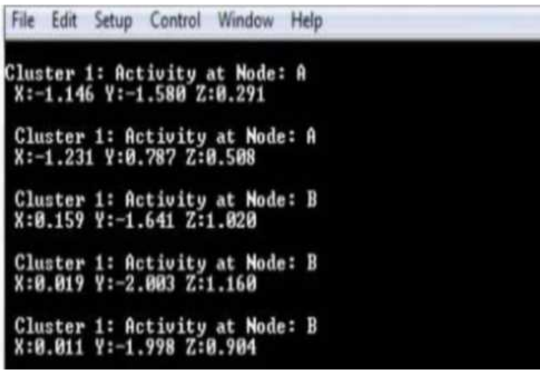


Fig.6: Result display on Tera-Term VT

The project was successfully demonstrated using the filters and sensors of pure analog as per the required conditions. The project didn't use surface mount components as a result of which the circuit could not be embedded in to a tree, rather it was implemented on TI launch pad and ASLV2010 kit.

The project could be extended to use zigbee protocol which would enable best network communication instead of intermediate hubs.

IV. PROPOSED WORK

The temperature is sensed and converted to the digital form by means of Analog to Digital converter (ADC) and is given to the input port of the microcontroller. The microcontroller transmits the data serially through the ZigBee module.

A. *ZigBee/ IEEE802.15.4 module*

Sensor nodes make use of wide range radio frequency band which gives free radio, huge spectrum allocation and global availability. Among the various choices of wireless transmission media like Radio frequency, Optical communication (Laser) and Infrared, Radio Frequency (RF) based communication is the most relevant that fits to most of the Wireless Sensor Network (WSN) applications. WSN uses the communication frequencies between about 433 MHz and

2.4 GHz.

Fig.7: ZigBee Model

The functionality of both transmitter and receiver are combined into a single device known as transceivers used in sensor nodes. The transceiver used here, Texas Instrument's CC2500 is a low-cost 2.4 GHz transceiver designed for very low-power wireless applications.

On receiving end the temperature data is received through another ZigBee module and is transmitted serially through COM1port to the personal computer.

B. *Sensing Module:*

The LM35-DZ a high precision centigrade Temperature sensor from National Semiconductors is used which produces the output voltage proportional to the Celsius Temperature. LM35 has an advantage over linear temperature sensors calibrated in

° Kelvin, as the user is not required to subtract a large constant voltage from its output voltage to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming circuits[10]. It draws only 60pA from its supply. It is rated to operate over 0 ° C to 100 ° C

With the linear scale factor of +10.00mV/C.

C. *ADC and Microcontroller Module:*

ADC0809- 8-bit, Multi-channel ADC is used for conversion with the reference voltage of +5V. The Read write signals, ALE, address selection, Interrupt signals are controlled by 8- bit programmable microcontroller (89C51) through software.

D. *Serial Interfacing Module:*

In our project, the RS-232 is used as a means of implementing hardware SPI (serial peripheral interface) which enabled the communication between cc2500 and AT89c51. The MAX232 is an integrated circuit that converts the signals from an RS-232 serial port to signals suitable for use in TTL compatible digital logic circuits. The MAX232 is a dual driver/receiver and typically converts the RX, TX, CTS and RTS signals. The drivers provide RS-232 voltage level outputs (approx. ± 7.5 V) from a single + 5 V supply via on-chip charge pumps and external capacitors. This makes it useful for implementing

RS-232 in devices that otherwise do not need any voltages outside the 0 V to + 5 V range, as power supply design does not need to be made more complicated just for driving the RS-232 in this case. The receivers reduce RS-232 inputs (which may be as high as ± 25 V), to standard 5 V TTL levels. These receivers have a typical threshold of 1.3 V, and a typical hysteresis of 0.5 V.

V. PEER TO PEER NETWORK

In this work initially the peer to peer communication is implemented between the transmitting node and the Central processing unit. Both the transmitter and receiving end can acts as a transceiver. The transmitting nodes sense the temperature and transmit serially through ZigBee module. The receiving end receives the data from ZigBee module and the received data is fed to the computer through RS232 for further processes.

The MATLAB code running on the computer log the ASCII data as a string with two characters and convert the ASCII to decimal value. Then the actual temperature is calculated from the received temperature equivalent voltage. This temperature variation is logged in the Excel file. The flowchart for MATLAB code is given in Fig.6.Thus every time the temperature data is maintained in the PC connected via ZigBee module and the plotting of the recorded temperature variations is also carried out simultaneously. The temperature log is maintained until the power supply to microcontroller is reset.

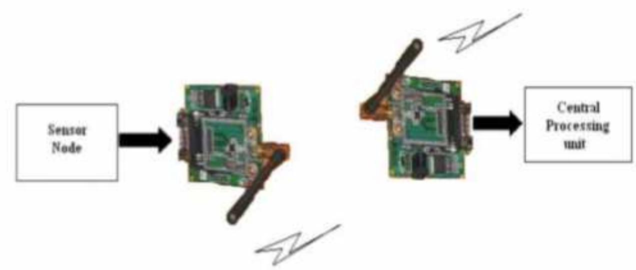


Fig.8: Schematic of peer-to-peer link

The IEEE802.15.4ZigBee protocol is a wireless technology developed as an open global standard to address the unique needs of low-cost, low power, wireless sensors network.

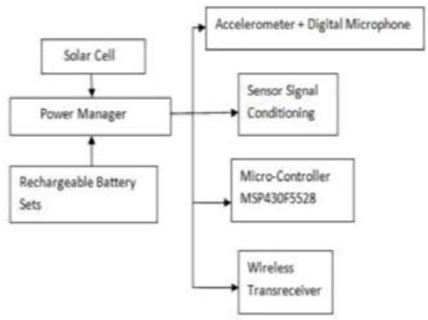


Fig.9: Individual wireless sensor model

One of the inputs, say sound is measured using a cheap capacitor mike. This sensor is ideal for large scale production in case of both the cost factor and the frequency response of the same. There was no attenuation below 1 kHz as desired. The filter section is an active analog filter[1]. The team first designed the band-pass filter with a current source shunted by R, L, C elements. But with the inductor constraints, the team had to port to op-amp. This was simple, the current provided by the inductor (Vo/(s*L)) should be supplied in parallel to the R, C elements. The high precision opamp OPA 4277 was used here and this would just complement the output and the integration of the complemented output is given so as to represent an inductor. The design of R and C values was taken as per the required center frequency to be filtered and the bandwidth made very low by designing the elements for high quality factor.

The same methodology was done for band stop filter for 200Hz. The analog circuit was then drawn in a simulator and checked for accuracy and the frequency response. The input here is found to be taken as analogue from the mike with higher frequencies attenuated by its characteristics. Then the cutter’s frequency would be only passed by the filters to the microcontroller. The cutter’s frequency was earlier found out by recording the sound of a few similar tools and taking the FFT of the signals in MATLAB. The other sensor was a vibration sensor which needed relatively simple circuitry. The output of the sensor just went on to a magnitude comparator made of an op-ampOPA 4277. This had a threshold setup by a potentiometer and the op-amp’s output was given to the MSP.

The next stage is the MSP430, it normally had a software code of detecting from the transceiver RF booster pack[2] that the tree nearby is “OK”. Similarly the same MSP would also send the signal “OK” to the nearby circuit. This was the software’s normal routine. Now when the sensors detect the presence of a cutter, the corresponding MSP would detect the sound of a cutter and send signal “DANGER” which would reach ultimately to the MSP near to the forest guard. This would then send 8 9 signal of danger along with the tree number assigned, to the forest guard’s room. Initially all the transceivers will be paired and send messages to each other of well being “OK”. The communication of the MSP430G2553 with the transceiver is by SPI. This was simple in case of one master and numerous slaves, ideal in this project. The SPI involved a master clock being shared/given to the transceiver and on the rising edges the transceiver and MSP gives off data through two different channels dedicated for the same. The last pin was used to select the slave, which in this case is only one. The input data format from the sensors is analogous and that from the transceiver is as mentioned to be digital with SPI protocol. The output was the same as sending signals of pulses to other transceivers and the chronos watch. The cost mainly centered around the transceiver, whereas all other components were cheap. The quality or type of transceiver used mainly decides the cost of the project. The main constraint was in deciding the shape of the project which would be attached to the tree. The current project was done in the MSP430 launch pad. The circuit can be shaped in form of a nail to attach on to a tree if smt components are used. The system was analogue based, be it the active op-amp filter or the magnitude comparator. This made the design very simple and quicker. By carefully selecting the resistors and capacitors we could get the desires response.

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VI. SOFTWARE IMPLEMENTATION

Fig: 5. Flow chart

VII. PERFORMANCE EVALUATION

A. Simulation Setup :

We have conducted extensive simulations using the ns-2 tool [21] to evaluate our proposed algorithm. The simulation parameters that we have chosen are summarized in Table II, and have been selected so as to be compatible with other studies of WSNs [18]. The simulations we have conducted focus on a EWSN which collects and reports data with a low frequency fc to the sink constantly in normal state. Any abnormal event occurring will trigger node into emergency state and report the state of event with frequency fe > fc. Fig. 5 shows the topology of simulation. The network considered has a total of 100 nodes with a single sink represented by a red hexagon. The node positions are all uniformly distributed randomly within a 200m*200msquare. The communication range is 40 meters, and the sink is located at the bottom center of the square(100,5). The frequency of event message fe is 10pkts/s, while the frequency of periodic traffic is 0.2pkts/s. The number of event source nodes in the range of event is set to 3 depending on different radius of the event influence. Each of the source nodes establish a route path to the sink represented by the red line, black line and green line respectively.

VIII. SIMULATION RESULTS

1) Delivery Ratio:

The packet delivery ratio is defined to be the ratio of data packets received by the sink to those generated by the sources, including the periodical packets. In order to evaluate the performance under different network condition, the loss probability of the channel varies from 0 to 0.1 with a step of 0.02. If EEDP is activated in the network, large amount of packets is limited at the event source area using Algorithm 1. Thus, the whole delivery ratio is improved obviously than traditional routing protocol without EEDP as the less competition. Fig. 6 shows the delivery ratio at different channel conditions. As the channel contention and limited resource of wireless sensor networks, the delivery ratio decreases with the increasing loss probability in the network. In our proposed protocol, the local broadcast algorithm is used to reduce the traffic by restraining the transmission as soon as receiving emergency present message. Thus, the delivery ratio is obviously improved and then the latency is reduced correspondingly as fewer retransmissions and congestion. It is worth noting that, when the loss rate of channel is zero, the delivery ratio is not 100%.

2) Detection Latency: For a traditional protocol, the latency is usually defined as the transmission latency from event source nodes sending event message to destination receiving it. In this paper, detection latency is defined to be the time from the occurrence of an event to the time instant when the destination has detected it. In EEDP, the detection latency comprised of two components, one is the primary decision, another is the transmission delay on the emergency routing procedure. Fig. 7 plots the latency of GPSR without EEDP. The large amount of raw traffic lead

to serious congestion at sink, as the final decision is made at the destination. Thus, the latency of GPSR grows under harsh network. In EEDP, we use the local broadcast to make final decision and the event source nodes suspend to send packets timely. The latency couldbemaintainedunder1.0ms,even under high channel loss probability (Fig. 8), compared with 4ms-12ms without EEDP (Fig. 7). It's worth noting that the difference between total latency and decision latency is the transmission latency on the emergency routing procedure. 3) Energy Efficiency: As introduced above, to ensure the event notification with probability 100%, the event virtual node sends the even alarm periodically until receiving a reply from destination. Thus, we evaluate energy efficiency in terms of the number of event packets transmitted until the sink detecting the event. The comparison of energy efficiency is shown in Fig.9. Without EEDP, traditional methods send the raw packets to sink without any process. Thus, the cost is obviously higher than EEDP, especially under harsh network condition. In EEDP, there is only one alarm packet sent to destination if the link error rate is very low .With the increasing of the channel loss rate, the copies of alarm packet increase as the candidate forwarding due to packet retransmission. In fact, another factor influencing the energy efficiency performance is the sleep scheduling scheme in wireless sensor networks saving energy more efficiently. However, the sleep scheduling will bring large end-to-end latency as the waiting time for next hop waking up. Thus, there is a trade-off between energy efficiency and timeliness. In the future work, we will further investigate the sleep-wake scheduling scheme and detect the event reliably and timely at a reasonable low energy cost.

IX. RESULTS

The circuit was first simulated regarding the filter designs for R and C elements. Then the filter was tested in the lab which ensured its close agreement with simulation results. The analogue circuits were then tested for working under the conditions and found to be correct with the delay of sending the transceiver of danger signal less than 1 second.

X. CONCLUSION

The project was successfully demonstrated using the filters and sensors of pure analog as per the required conditions. The project didn't use surface mount components as a result of which the circuit could not be embedded in to a tree, rather it was implemented on TI launch pad and ASLV2010 kit. The project could be extended to use zigbee protocol which would enable best network communication instead of intermediate hubs. we have proposed an efficient event detection protocol in event-driven wireless sensor networks to detect the event and delivery emergency message reliably and timely. Our algorithm composes composite events, each of which consisting of a few of atomic events. Each sensor node has multiple different sensors and each sensor independently senses the environment to determine one atomic event. Then with the local broadcasting scheme, the sensor node could make a final decision combining with the detect results of its neighbors efficiently. To improve the reliable transmission of the single alarm packet, we use a dynamic multi-copy scheme similar to the conventional multi-path routing for continuous flow and provide a considerable improved performance in term of reliability and timeliness.

FUTURE SCOPE

- Implementation of Multi-node network
- Embedding control algorithm in sensor node or in the central computer
- To implement the network for real-time control applications

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