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Monitoring the Shelf Life of Packaged Food by Energy Efficient Wireles Sensor Nodes: A Survey

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Abstract—*Wireless sensor networks have increased its application in industrial field as well as in scientific research very rapidly. By integrating WSN with various bio-chemical sensors, in addition to temperature and moisture sensors, more kinds of information can be involved in the intelligent and interactive packaging communication system. It enhances the functionalities of the package such as protecting the integrity and effectiveness of product, providing safety information details, and being child resistance, senior friendliness. A set of cluster head nodes within a cluster called "cluster head set", instead of only one cluster head like other routing algorithms. Energy efficient WSN states that within the set one node act as cluster head once at a time in rotation basis and aggregate the data from other nodes and send it to the base station. Whereas in other cluster based routing protocols only one cluster head is used within a cluster it is shown that our proposed algorithm is more energy efficient.The aim of the present paper is to review the technical and scientific state of the art of wireless sensor technologies and standards for wireless communications in the food packaging sector. Food losses along the cold chain can be reduced by accurate monitoring of the transport conditions. These technologies are very promising in several fields such as environmental monitoring, precision agriculture, cold chain control or traceability. The paper focuses on WSN (Wireless Sensor Networks) presenting the different systems available, Future trends of wireless communications in intelligent and interactive packaging technology are also discussed here which has been an emerging and global research topic over the years.*

Keyword*: Wireless sensor network (WSN), Food packaging, Cluster head (CH), BaseStation (BS).*

1. INTRODUCTION

Wireless sensor network is an emerging field where lots of research work has been done involving hardware, system design, networking, security factor and distributed algorithms [1].Sensor nodes normally sense the data packet and transfer it to the Base Station (BS) via some intermediate nodes. The sensor nodes are low cost, low power, multi-hop routing capable tiny device. [2].Unlike a centralized system, a sensor network is subjected to a unique set of resource constrains such as finite on-board battery power and limited network communication bandwidth [9]. Nodes can be deployed either randomly or in synchronized manner and they can be either static or mobile [3]. Each node has the capability to communicate and send data packets to other nodes as well as the BS. There are various problem domains in WSN; energy conservation of the sensor nodes is one of the major thrust areas, which in turn deals with enhancing the life time of the whole network. We know each sensor node has limited battery power.

In different applications, the structures of WSN are different, which normally includes signal collection, information processing, data acquisition,data transfer, and power management. Most WSN devices have following hardware components: several sensors, a microcontroller for computation, a small RAM for dynamic data and flash memories which keep the program code and long-lived data, a wireless transceiver, an Analog-to-Digital Converter (ADC), and a power source. Several routing protocols have been proposed to conserve energy of each sensor node to increase the overall life time of sensor network. Here in this paper we have implemented a cluster based routing algorithm which is energy efficient as compared to the other routing algorithms as well as enhances the lifetime of the sensor network.

The food industry is nowadays facing critical changes in response to consumer needs, which in addition to health and safety concerns, demand an ever larger diversity of food products with high quality standards.

The quality of these products might change rapidly, because they are submitted to a variety of risks during production, transport and storage that are responsible for material quality losses. Parties involved need better quality assurance methods to satisfy customer demands and to create a competitive point of difference. Successful supply chain logistics calls for automated and efficient monitoring and control of all operations. The monitoring should allow establishing a better knowledge, detecting weakness, and optimizing the whole process, all things that potentially would have a significant impact on the supply chain.[5,6,7].

2. EXTENDING SENSOR NODES LIFETIME BY EFFICIENT ROUTING TECHNIQUE

In Wireless sensor network , the active nodes called"motes" sense the environmental events which consume significant amount of energy, as sensor nodes have limited battery power, resulting drainage of energy causes dead nodes.. So, to extend the lifetime of sensor nodes, we have implemented a energy efficient cluster based routing algorithm based on multiple cluster head within a cluster instead of one cluster head(CH) in other conventional cluster based routing algorithm, which reduced the consumption of energy significantly.

In this model, assume to divide the whole network in K clusters then we choose k number of nodes as CHs randomly. [3]These CHs send a short range advertisement broadcast message. The nodes receive the advertisements and choose their CHs based on the signal strengths of the adv. messages. The signal strength of adv. Messages is measured by SNR (signal to noise ratio). If the SNR value is high that means signal strength is high, if SNR value is less that means signal strength is low. Each sensor node sends an ACK msg. to its CH. In each iteration, the cluster heads choose a set of nodes as a head set member based on the analysis of signal strengths of the acknowledgments .A head-set consists of a CH and the other member nodes of head set those are in partially active state. The head node, responsible to send messages to the BS, is chosen for one iteration of a round. In each sub-iteration, each member of the headset becomes a CH. Based on uniform rotation, a schedule is created for the head-set members for their frame transmissions; only the active CH transmits a frame to the base station. Also a schedule is created for the data acquisition and data transfer time intervals for the nodes that are not members of the head-set. This schedule is called TDMA schedule which is created by CH and broadcasts it to the other nodes within the cluster. Initially all the nodes set their flag zero (f0). Now after completion of one iteration that means when all the head set members become CH once set their flag one(f1). That means they are in non-eligible state, and cannot participate in election phase to become CH again in that round. So now the remaining nodes within the cluster whose flag value is zero(f0) participate in election phase, chose one node randomly as a CH among them and send adv. Msg. to other nodes whose flag is zero and repeat the same process of election phase to chose another head set.

Once clusters, head-sets, and TDMA-based schedules are formed, data transmission begins. The non-cluster head nodes collect the sensed data and transmit the data to the CH, in their allotted time slots based on TDMA schedule. The CH node must keep its radio turned ON to receive the data from the nodes in the cluster. The other members of the head-set keeps their radio OFF and do not send any messages but they can sense the events and store the data in its memory for later use. After, some pre-determined time interval, the next member of head set becomes a CH and the current CH becomes an inactive head-set member. After each iteration, all the head-set members have become CH for once. Finally, at the end of a round, all the nodes have become non-eligible members.

3. TDMA SCHEDULE

All the nodes within network has fixed data transfer rate when it transmits data to the CH (short distance transmission), and CH node also has fixed data transfer rate when it transmits data to the BS(long distance transmission).[3]When one node transmits data to its CH other nodes OFF their radio to conserve energy. When node finishes its transmission other nodes ON their radio and transmits data to corresponding CH. Each node has its own transmission time to send data so, that time other nodes off their radio, by which nodes conserve their energy in a systematic way. If more than one node sends data at one time it may cause collision that should not be occurred, so node maintains TDMA schedule to transfer data.

In the Fig.1 x axis , y axis and z axis represent whole diameter of the network, no of cluster and remaining energy of each sensor node, here it shows that consumption of energy is decreased with the increase of head set size and residual energy of sensor node would not decrease rapidly. Simulation is done using MATLAB.

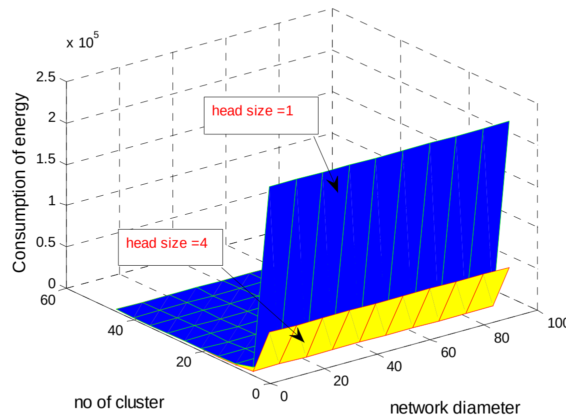

Fig. 1: Energy consumption reduces as headset size increases.

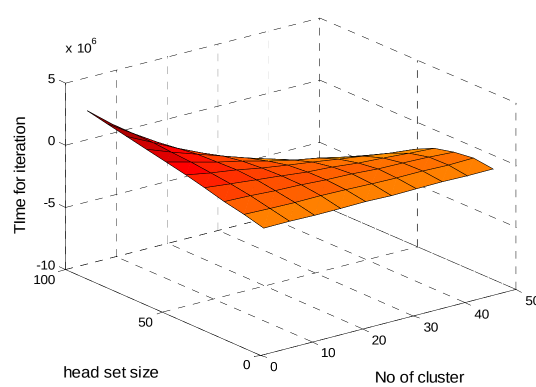

Fig. 2: Time for one iteration with respect to head set size and number of cluster

increases for same number of cluster, but when number of cluster increases , iteration time decreases, because more number of cluster means less number of nodes in head set which significantly reduce iteration time. So, head set size and cluster number should be chosen carefully to extend network life time.

4. IMPLEMENTATION OF ENERGY EFFICIENT SENSOR NODES IN FOOD PACKGING TECHNOLOGY

In this paper, we have shown, this power aware clustering technique which significantly increase the lifetime of sensor nodes which has been deputed in food packaging technology by placing each sensor nodes in different packets to monitoring the environmental events to preserve the vegetables and fruits.

5. TRACING OF AGRICULTURAL PRODUCT THROUGH IMPROVED WSN

Perishable food products such as vegetables, fruit, meat or fish require refrigerated transports. Therefore, temperature is the most important factor when prolonging the practical shelf life of perishable food products. Studying and analyzing temperature gradients inside refrigeration rooms, containers, and trucks is a primary concern of the industry. [8]The supply chain management of fresh foods requires fast decisions because goods are forwarded within hours after arrival at the distribution center. Appropriate planning calls for more information than that which could be provided by standard RFID tracking and tracing. Quality problems should be detected as quickly as possible, and alarms should be triggered when temperature gradients cross a threshold. [9]Even if direct access to the means of transport is not possible, online notifications offer new opportunities for improved transport planning.

6. FRESH FOOD TRACKING THROUGH POWER EFFICIENT WIRELESS SENSOR NODES

According to the report from Billerud AB for fresh food services, ten percentages of all the fruit and vegetables delivered in Europe are damaged and destroyed on the way to the consumer, and the losses reach to ten billion every year [8]. It's really a long and tough journey for fruits and vegetables from growers to consumers, which may experience harvest, packaging, delivery, transportation, storage, and sale, etc. Mechanical damage, temperature and humidity all have significant impact on the life time of the fresh foods.

If the fruit and vegetables are treated in a suitable way, the life time will be prolonged to avoid the waste and save thecost. To achieve the target, the status of the fresh foods should be monitored timely. Fig. 1 shows a WSN based system deployed in one truck. When the sensor network, provide a suitable coverage and accuracy, the wireless sensors attached on the packages of fresh foods are used to measure the tri-axis acceleration, environment temperature, humidity, gas concentration of carbon dioxide, oxygen, and ethylene, etc. The data from sensors are collected by the master nodes. On one hand, the driver can take actions according to these sensing data, such as lowering the temperature, increasing the relative humidity through the truck system, or driving the truck more steadily to avoid the mechanical damage. On the other hand, the sensing data are also sent to the supervisors through the wide area network, such as Global System for Mobile Communications (GSM), General Packet Radio Service (GPRS), and Worldwide Interoperability for Microwave Access (WiMAX), etc. The supervisors can also adjust the conditions remotely. There corded information is very important and useful to improve the transportation scheme to further protect the fresh food. In order to enhance the mobility, deployment and capability of wireless sensors for networked services, an enhanced dual-layer wide area WSN system has been developed and applied in fresh food tracking application [11, 12]. During the fresh food transportation, the sensor nodes of the system provide a set of useful and efficient measurements on the environmental conditions. In this WSN system, all sensor nodes are mobile, remotely controllable and wide area deployable for networked services because of the dual-layer dual-directional wireless communication capability and the removal of fix-installed gateway. The system architecture and the implementation of sensor nodes and sensor network are described in detail in [10]. A case study, a transportation of fresh melon fruit in 20 days from Brazil to Sweden, is performed to verify the feasibility. Considering the large volume data generated by continuously sensing for each sensor node, the efficient compression approach is necessary to lower the data rate between the sensor nodes. A novel compression scheme is proposed to compress the acceleration data. The experimental results show that a high compression ratio with the acceptable distortion could be achieved. It confirms an effectiveness of the compression scheme for a WSN application for resource and cost saving.

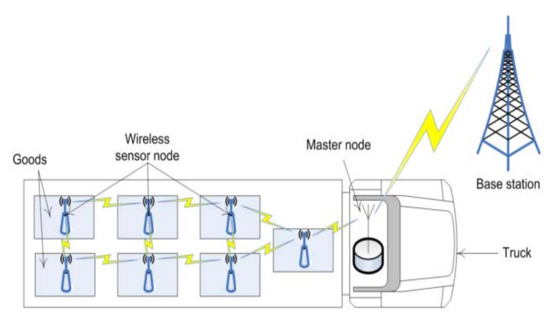

Fig. 3: Fresh food tracking system in one truck.

7. CONCLUSION

In this paper, we have proposed a scheme that wireless sensor technology can be used productively to preserve the food, vegetables in food technology by applying energy efficient cluster based routing technique which extend the life time of sensor nodes. The sensor nodes have been placed in each packet which senses the temperature within the packets of foods. This routing technique also distributes the overall load within the network to enhance the performance of each sensor nodes. In this method, the mobile sensor nodes have been effectively deployed in food packing technology foe fresh food tracking application.

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