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Energy Consumption by Piezoelectric effect in Wireless Sensor Networks

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Abstract—This paper describes the concept of sensor networks which has been made viable by the effect of piezoelectric materials and microelectro-mechanical systems technology, wireless communications and digital electronics. First, the sensing tasks and the potential sensor networks applications are explored, and a review of factors influencing the design of sensor networks is provided. The piezoelectric effect is explained briefly in this paper.

Index Terms— Sensor Networks, Piezoelectric effect, piezoelectric sensors, Energy Consumption, Power saving, Energy Effiecient, Threshold voltage in sensor networks.

1 INTRODUCTION

Wireless Sensor Network is an emerging technology which can increase the efficiency of production by deploying rechargeable batteries that yields long term,maintenance free wireless monitoring solution.Automated monitoring and control solutions were held back by limitations of conventional wired networks.The features of wireless sensor network includes high reliability,self forming and self-healing,fast and easy deployment,very long battery life,security,low cost,global inter-operability and vendor independence. he challenge of excessive power consumption of these nodes, that have to act as both tags and readers, is addressed. For example, progress has been good in getting the electronics to consume less electricity, by both improved signalling protocols and improved circuitry.As for batteries, lithium thionyl chloride single-use versions have twenty year life in certain circumstances but, for many applications, energy harvesting supplying rechargeable batteries is more attractive.
A typical sensor network consists of a large number of low cost,low power distributed devices called nodes deployed in the environment being sensed and controlled.Each node consists of processor,memory,wireless antenna,battery and the sensor itself.Regarding the powersupply device,a battery is used in most of the cases,playing a vital role in determining the sensor nodes lifetime.Due to the fact that sensor nodes are energy constrained,great part of the Wireless Sensor networks protocols aim at minimizing the energy required for communication.

2 WHY SENSOR NETWORKS ?

The physical properties like electronic sensors,biosensors and chemical sensors are measured by using rechargeable batteries in sensor networks.The task of sensor is to convert the electrical signal in to a physical phenomenon.Sensor networks consist of a large number of very small nodes that are deployed in some geographical area. The purpose of the network is to sense the environment and report what happens in the area it is deployed in. Sensor networks consist of very small devices that could be deployed in some areas. Each node is equipped with a sensor in order to perform monitoring, tracking, or surveillance and reports its finding to some central node. Most of the time the batteries in the nodes are not rechargeable, the networks operates as long as the power supply is O.K. when the power is off, the network ceases to operate. Wireless Sensor Networks (WSNs) have emerged as a new information-gathering paradigm based on the collaborative efforts of large number of sensors. For real-time WSN applications such as monitoring where decision, control and update processes are based on the received data, reliable packet delivery is an important issue. An elegant reliability solution should benefit by constructing an energy-efficient topology, in order to be effective within this resource-constraint networking domain.Thus low power is of utmost important in sensor networks.

3 FIELDS OF APPLICATIONS IN WIRELESS SENSOR NETWORKS

There are variety of applications of wireless sensor networks.They are

- Civil structure monitoring.
- Environmental control.
- Health monitoring by wireless networks.
- Preventing accidents by some system/device monitoring.
- House alarms monitoring.
- Child tracking and monitoring system.

4 ENERGY SAVING IN WIRELESS SENSOR NETWORKS

The motes are deployed with battery but recharging of battery is difficult and lifetime of battery is not prolonged.Therefore the lifetime of the network is maximized through minimizing the energy is an important issue in wireless sensor networks.We know that the sensors are not easily replaced or recharged due to adhoc deployment in dangerous environment.For developing sensors,we are implemented using micro electro-mechanical systems and highly integrated digital electronics.

There are numerous of MAC protocols are there for energy saving in Wireless sensor networks.In that sensor –MAC provides power savings and reduces inactive time of the sensors,U-MAC provides the performance on energy consumption,µ-MAC preserving the message latency and reliability,DEE-MAC also reduces energy consumption.SPARE-MAC saves energy but Z-MAC is used mainly for neighbor discovery.Energy is the one of the crucial resources in Wireless sensor networks.Energy saving in Wireless Sensor nerwork is done by deploying the sensor nodes in wireless networks. Some evaluation metrics.

1. **Time until the first node dies:** This metric indicates the duration for which the sensor network is fully functional.
2. **Time until a β fraction of nodes die:** The suitability of this measure is application dependent. Across applications, choosing β=0.5 seems to be appropriate.Unless specified otherwise, we use this metric to mean the lifetime of the network.
3. **Total number of messages received:** Total number of messages received until a β fraction of the nodes die indicates the amount of information collected until that time. This measure is an indicator of the total amount of information collected during its lifetime.
4. **Energy spent per round:** The total amount of energy spent in routing messages in a round is a short-term measure designed to provide an idea of the energy efficiency of any proposed method in a particular round.

Several approaches have to be exploited, even simultaneously, to reduce the power consumption in wireless sensor networks. At a very general level, we identify two main enabling techniques namely: duty cycling and data-driven approaches. Duty cycling is mainly focused on the networking subsystem. The most effective energy-conserving operation is putting the radio transceiver in the (low-power) sleep mode whenever communication is not required. Ideally, the radio should be switched off as soon as there is no more data to send/receive and should be resumed as soon as a new data packet becomes ready. In this way, nodes alternate between active and sleep periods depending on network activity. Duty cycle is defined as the fraction of time nodes which are active during their lifetime. More importantly, the energy efficiency of WSN is guaranteed by the distributed sensor awakening and dynamic routing.The strict energy constraints of sensor nodes result in great challenges for energy efficiency.

4 PIEZOELECTRIC EFFECT IN WIRELESS SENSOR NETWORKS

In general a piezoelectric sensor is a device that uses piezoelectric effect to measure pressure, acceleration, strain or force by converting them to an electrical charge.Many creatures use an interesting application of piezoelectricity. Bones act as force sensors. Once loaded, bones produce charges proportional to the resulting internal torsion or displacement. Those charges stimulate and drive the build up of new bone material. This leads to the strengthening of structures where the internal displacements are the greatest. With time, this allows weaker structures to increase their strength and stability as material is laid down proportional to the forces affecting the bone.The rise of piezoelectric technology is directly related to a set of inherent advantages. The high modulus of elasticity of many piezoelectric materials is comparable to that of many metals and goes up to 105 N/mm2. Even though piezoelectric sensors are electromechanical systems that react on compression, the sensing elements show almost zero deflection. This is the reason why piezoelectric sensors are so rugged, have an extremely high natural frequency and an excellent linearity over a wide amplitude range. Additionally, piezoelectric technology is insensitive to electromagnetic fields and radiation, enabling measurements under harsh conditions. Some materials used (especially galliumphosphate or tourmaline) have an extreme stability over temperature enabling sensors to have a working range of 1000°C.

Principle	**Sensitivity (V/µ*)**	**Threshold (µ*)**	**Span to threshold ratio**
Piezoelectric	**5.0**	**0.00001**	100.000.000
Piezoresistive	0.0001	0.0001	2.500.000
Inductive	0.001	**0**.0005	2.000.000
Capacitive	0.005	0.0001	750.000

Table 1: Comparison of sensing principles
Comparison of different sensing principles according to Gautschi. Numbers give only a tendency for the general characteristics.

Energy harvesting devices convert the ambient energy surrounding the wireless sensors into electrical energy to extend the lifetime or reach unlimited lifespan of wireless sensors. Mechanical vibrations, existing almost everywhere, have been investigated as a promising energy source for wireless sensors in many applications. Piezoelectric generators are the primary method for converting the vibration energy into electrical energy. Most piezoelectric vibration energy harvesters studied so far are based on simple cantilever-based design with resonant frequency matching the environmental resonant frequency.

However, the energy conversion efficiency of this type of vibration energy harvester drops dramatically if the environmental frequency and the frequency of the energy harvester are mismatched.

6 Conclusion

In this paper we have proposed an energy efficient usage of multiple, mobile base stations to increase the lifetime of wireless sensor networks.Therefore by exploiting piezoelectric materials we must harvest ambient strain energy for energy storage in capicitors and rechargeable batteries.By combining smart energy saving electronics with advanced thin film battery chemistries that permit infinite recharge cycles, these systems could provide a long term, maintenance free, wireless monitoring solution.

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