Introduction

Recent advancement in the semiconductor industry has enabled the development of small, inexpensive, low-powered devices known as sensor nodes. These sensors are endowed with data sensing, data processing and communication components that convert them in multi-functional, flexible platforms.

A wireless sensor network (WSN) is composed of many of these tiny sensor nodes that collaborate to accomplish a common task and are densely deployed in the area to be monitored. A broad variety of applications ranging from geophysical monitoring (seismic activity) to precision agriculture (soil management), habitat and environmental monitoring, military systems and business processes (supply chain management) are supposed to be implemented on WSN.

Unlike traditional wireless networks and ad hoc networks, WSN feature dense node deployment, unreliable sensor nodes, frequent topology change, and severe power, computation and memory constraints. These unique characteristics pose many new challenges to practical realization of WSNs, such as energy conservation, self-organization, fault tolerance, etc. In particular, sensor nodes are usually battery-powered and should operate without attendance for a relatively long period of time. In most scenarios, it is very difficult and even impossible to change or recharge batteries. For this reason, energy efficiency is of primary importance for the operational lifetime of a sensor network.

The wireless medium is used for communication in WSN. However, the wireless nature of the channel forces to deal with undesired phenomena as path losses, channel fading, interferences, and noise disturbances, which cause packets losses, transmission errors and serious delays in the data reception. Therefore, the effect of the wireless channel must be considered when designing energy efficient WSN.

Previous considerations showed the necessity of suitably addressing the energy consumption problem. Many efforts have been made in this direction, and many researchers in the scientific community are currently involved in some specific aspects as:

- Energy-efficient network protocols: most existing network protocols and algorithms for traditional wireless ad hoc networks cannot effectively address the power constraint and other constraints of sensor networks. To realize the vision of sensor networks, it is imperative to develop various energy-efficient network protocols in order to efficiently use the limited power in each sensor node and prolong the lifetime of the network.

- Power control: a suitable tuning of the nodes' transmission power helps to reduce the overall network consumption by transmitting at lower power levels when possible.

- Topology control: this technique consists of letting a subset of the nodes to sleep, while others are active. Topology control reduces the redundancy present in the network as well as the interferences, as lesser number of nodes are active in any given neighborhood, which helps to reduce the Multiple Access Interference (MAI) and consequently, the necessary transmission power.

- Distributed and adaptive source coding: as a result of the high deployment density, nodes sense highly correlated data containing both spatial and temporal redundancy. Thus, given the high correlation present in the data, is important to implement suitable protocols and source coding techniques that exploit this particular characteristic to reduce the overall transmitted information (i.e. to lower the energy consumption). Nevertheless, algorithms must remain simple enough to be able to fit the scarce memory and the low capacity of the sensors' processing unit.

- Energy-efficient source+channel coding: as previously remarked, the dense deployment of the sensors (few meters is the typical distance between nodes) causes serious problems in the communication since nearby nodes can overwhelm the received signal of the desired sensor node forcing to increase the transmission power. CDMA is a promising multiple access scheme for sensor and ad hoc networks due to its interference averaging properties [10]. However, the performance of CDMA systems is limited by MAI. In the past decade numerous methods have been developed to reduce MAI, most of which focus on the design of effective correlation receivers. However, they also introduce an increase in complexity, which is an undesired effect for WSN. Instead of merely designing receivers to suppress interferences, these techniques try to smartly represent the output of the source with a special codebook so that MAI is greatly reduced.

In our work we address the last two issues of the previous list. In Chapter 1 we study a distributed and adaptive source coding algorithm with which we exploit the existing redundancy in the sensed data in the network to locally process the measured data so that we reduce the actual information that needs to be sent over the wireless channel (and so, the power consumed); in Chapter 2 we introduce a source+channel coding scheme, and we state and solve a constrained power minimization algorithm. We also carry out a theoretical study of the system performance in terms of power consumption and bit error probability, considering the presence of the wireless channel; in Chapter 3 we step forward and we present a more complex source+channel coding scheme; novel expressions for the power consumption and bit error probability are derived; in Chapter 4 we report the results of implementing the distributed source coding algorithm studied in Chapter 1 in a real WSN; Finally, in Chapter 5, we conclude our work with the presentation of the conclusions and the outline for the future work.