

# Chapter 15

## Reducing Complexity and Achieving Higher Energy Efficiency in Wireless Sensor Network Communications by Using High Altitude Platforms

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### ABSTRACT

*In this chapter, a novel approach is explored to employ high-altitude platforms (HAPs) to remove the relaying burden and/or de-centralize coordination from wireless sensor networks (WSNs). The approach can reduce the complexity and achieve energy efficiency in communications of WSNs, whereby applications require a large-scale deployment of low-power and low-cost sustainable sensors. The authors review and discuss the main constraints and problems of energy consumptions and coordination in WSNs. The use of HAPs in WSNs provides favorable communication links via predominantly line of sight propagation due to their unique position and achieves benefits of reduced complexity and high energy efficiency, which are crucial for WSN operations.*

### 1. INTRODUCTION

Recent advances in low-power and low-cost wireless sensors are revolutionizing the way we interact with the physical world. These sensors are generally equipped with data processing,

communication and information collection capabilities (Chong & Kumar, 2003). They can detect the variation of ambient conditions in the environment surrounding the sensors and transform them into electric signals. Sensors, which send collected data via radio link to a sink either directly or through other nodes in a multi-hop fashion, can organize themselves in networks.

DOI: 10.4018/978-1-4666-0101-7.ch015

The research field is driven by the desire to expand current communications capability beyond the reach of conventional networks (Technology Review, 2003). A typical sensor network is shown in Figure 1, where a large number of sensor nodes with data processing and communication capabilities send collected data via radio transmitter, to a sink either directly or through other nodes in a multi-hop fashion. The sink in Figure 1 could be either a fixed or mobile node with the capability of connecting sensor networks to the outer existing communication infrastructure, e.g. Internet, cellular and satellite networks.

### Challenges in Wireless Sensor Networks

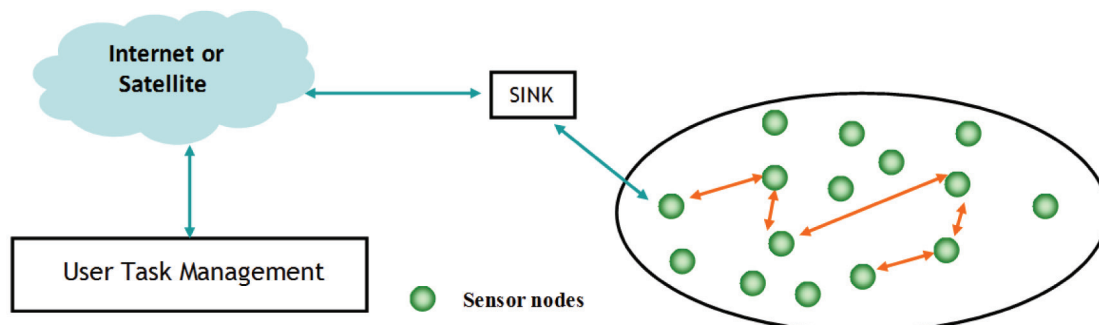
Using wireless sensor networks (WSNs) in environmental monitoring and control applications, such as fire detection, disaster prevention, and control of urban environments, are new trends of applications and have flourished in recent years. In general, these applications, which require a large-scale deployment of sensors over vast geographical areas and deliver a large unpredicted amount of information about the environments, face many challenging issues such as:

- **Energy constraints:** The process of data routing in WSNs can be greatly affected by energy considerations, routing path and

radio link. If sensor networks consist of a large number of sensors (in the order of tens of thousands or higher) over a large area, it may not be energy efficient to gather measured data from sensors to sinks using data aggregation. Sensors are highly expected to work in a considerable long period, e.g. months or years, and be disposable, which gives more constraints to energy consumptions (Cheng, et al., 2008).

- **Dynamic networks:** Basically a WSN consists of sensor node, sink and event. If sensors are randomly deployed in remote geographical regions, inaccessible environments and disaster areas, it may be challenging or unfeasible to deploy powerful sinks or impractical to provide communications to sinks sending data externally. Moreover urgent situation in dynamic environment monitoring applications demands unpredicted reports to the sink in an unexpected period.
- **Propagation environment:** Sensor nodes deployed on the ground have a relative low effective height of antenna and a small distance to the radio horizon. Because dense environment of deployment can cause severe attenuations, non line of sight signal transmission is predominant in most directions. Signal power at a distance  $d$  away from the transmitter may be estimated as

Figure 1. General communication scenarios of a WSN (redrawn from (Akyildiz, et al., 2002))



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