Chapter 65
Emerging Trends of Space-Based Wireless Sensor Network and Its Applications

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ABSTRACT

There is a great demand in space and earth observations applications. Traditional satellite missions have complex design architecture involving high cost in design, operation, launch and maintenance. Thus single large satellite is replaced by multiple, small satellites with distributed network, collaboratively performing the same functionality of large satellite. This has been motivated researchers to explore the application of terrestrial Wireless Sensor Network (WSN) to space. The main objective of using space based WSN is to have full power of remote sensing capabilities at all the relevant time horizons and geographical scales with high performance and low cost. It also strives for an optimal solution that gratifies the standards, sizes, air interfaces, network architecture, access schemes, fault tolerance, operating system, hardware components of on-board diagnostics etc. This chapter discusses the characteristics and challenges of Space-Based Wireless Sensor Network (SWSN).

INTRODUCTION

Sky is the Limit, but for us it's the beginning.

The growing demand in space research and recent satellite technology has enhanced the future of space applications. Some applications are earth observation, telecommunication, military, scientific research, interplanetary exploration, etc. A significant breakthrough in terrestrial WSN in harsh environment has motivated to extend WSN to underwater application (Headrick, & Freitag, 2009; Heidemann, Ye, Wills, Syed, & Li, 2006) and space application (Gungor, Lu, & Hancke, 2010).The recent technological ad-

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vances in Micro- Electro-Mechanical System (MEMS), advances in miniaturization and manufacturing of low cost electronics components have driven interest in replacing large single satellite with multiple, small, low cost satellites to achieve the same goal of large satellite, with better performance (Arslan, Yang, Haridas, Morales, El-Rayis, Erdogan, & Stoica, 2009; Barnhart, Vladimirova, & Sweeting, 2007). Small satellites like satellite on chip, PCB sat of 300gms have demonstrated low cost miniaturisation of sub-kilogram technologies enabling sensor network architecture with increased power efficiency of 3.4% (Barnhart, Vladimirova, & Sweeting, 2007). Small satellite is referred to as sensor node and used interchangeably. The group of these small satellites collaboratively perform a task forming a distributed network. The distributed structure of satellite forms a sensor web known as Space based Wireless Sensor Network (SWSN). SWSN are similar to the terrestrial WSN. However, there exist significant challenges in hardware design, deployment, network architecture, topology formation and control, communication (inter-satellite, intra-satellite and to earth station), protocol stack, data gathering, aggregation and collision avoidance from debris and other nodes in the network. These technological adaptations of SWSN with emerging system architecture of distributed network of small satellites reduce impact of system/ network breakdown due to functional fault of single large satellite under various atmospheric conditions. The SWSN with small satellites is quite challenging due to unique space environment.

The impacts of environmental conditions on small satellite are complex orbital mechanisms under non ideal perturbations, atmospheric conditions, vacuum, debris, radiation and launch mechanism. Realization of such networks is still a challenge and many researchers are working towards it. Aim of the chapter is to address the application of WSN in space and challenges to realize SWSN.

WHY SWSN?

In the year 1960, the first satellite TIROS-1(a US meteorological satellite) was launched for earth observation. Currently there are 1100 active satellites (including government and private launchers) and 2600 satellites that are non-functional. Figure 1 shows illuminated small light as the satellites in the orbit. The federal communications commission in space found that non functional satellites weighing up to 6 tons and size of a small school bus. These non-functional satellites can cause collision with the active satellites. These are called as *space debris*. However rules says to burn the unused satellites within 25 year either by dropping them back to earth for Low Earth Orbit (LEO) satellites or lift them up, such that they don't collide with the active satellite in orbit in case of Geostationary Earth Orbit (GEO) satellites (Cornara, Beech, Belló-Mora, & Martinez de Aragon, 1999). The design and implementation of successful satellite network is a complex and iterative process involving a huge cost. The above mentioned statistics brings a great demand for efficient satellite network in space. The current space environment demands for faster, better and cheaper satellites with high performance and reliability.

The growing demand in various satellite based applications is the motivation for launching large number of satellites in space. Large satellites weigh more than 100 kilograms (kg). These satellite missions would generally be a billion dollar programs and any small fault would lead to the entire mission failure causing huge loss and also increases the space debris. This has motivated the current researches to have a paradigm shift from single large satellite to large number of small satellites. These small satellites collaboratively work to achieve the objective of large satellite mission KISS (keep it small and simple).