

Chapter VI

High Altitude Stratospheric Platforms (HASPs)

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ABSTRACT

High Altitude Stratospheric Platforms (HASPs) have gained much of attention from the scientific society and the communication industry in the recent years. Their use in the Next Generation Networks can offer enhanced coverage and facilitate the implementation of several heterogeneous wireless networks schemes. In this chapter, the main aspects of the HASP-related technology are presented. Emphasis is given in the ways the intrinsic characteristics of these platforms can be used effectively in order to compensate for the disadvantages of both the existing terrestrial and satellite solutions. Antennas and coverage planning, capacity and interference, call admission control, handover, mobility management, networking and TCP/IP performance are the main issues addressed. The provided mathematical tools and the state-of-the-art techniques presented here, can be useful to engineers interested in designing and evaluating performance of HASP-aided hybrid networks.

INTRODUCTION

Ubiquitous coverage and integration of different technologies are key characteristics of the Next Generation Networks. High quality wireless services will aim to subscribers of different types, either fixed or mobile, in remote or highly-density areas, with different propagation characteristics and different bandwidth, delay and jitter demands, depending on the type of service. The terrestrial cellular network is a good candidate as a base for the deployment of a platform offering a greater variety of services than the traditional voice/data/video services currently offered by the 3G cellular systems. Nevertheless, the extended high-cost terrestrial infrastructure in terms of base stations and the multipath phenomena especially in urban areas are issues that cannot be neglected. As for the satellite solutions, they suffer from increased delay, huge cost of development and low capacity. Dealing with the so-called 'last mile' problem, i.e. reliable delivery of information between the access point and the end-user, is a matter of concern. High Altitude Stratospheric Platforms (HASPs) seem to be telecommunication components that can alleviate these limitations and be part of effective heterogeneous architectures. HASPs are unmanned airships that fly on the stratosphere at altitudes between 17 and 22 kilometers and offer wireless coverage in areas on the ground. (Djuknic, Friedenfelds & Okunev, 1997) They are equipped with multi-beam smart adaptive antenna arrays that can illuminate certain areas with a variety of ways. They are also known as

High Altitude Platforms (HAPs), High Altitude Aeronautical Platforms (HAAPs) and High Altitude Long Endurance (HALE) platforms. In order to achieve easier integration, HASPs can be based on existing communication standards with some modifications suitable for their operational environment. (Grace et al., 2005)

The use of HASPs is characterized by several advantages. HASPs can replace or fill the gaps in existing ground infrastructures, especially in remote areas with deficient or corrupted base stations. Compared with the terrestrial systems, HASPs offer mainly Line-of-Sight (LOS) links, thus they perform better in terms of propagation and rain attenuation, offering large capacity at the same time. The capacity offered from HASPs is significantly larger in comparison with the satellite systems. They also offer better link budget and lower delay than satellites. In addition, developing and putting in service a stratospheric platform is a more cost effective solution than developing a satellite. The reason is that less sophisticated equipment is used and no launch is required. HASPs are environmentally friendly owing to the use of alternative power resources like fuel-cells and solar power. (Tozer, 2000)

Several applications can be supported by a HASP-aided wireless system. Broadband Wireless Access (BWA), 3G and beyond, navigation/localization, military communications, surveillance and emergency applications are the most important of them. (Tozer & Grace, 2001; Avangina, Dovic, Ghiglione & Mulassano, 2002; Dovic, Lo Presti & Mulassano, 2005) In general, HASPs are not foreseen as stand-alone platforms but as parts of integrated schemes in a NGN environment. (Faletti, Laddomada, Mondin & Sellone, 2006) They can cooperate with the terrestrial cellular networks and with the GEO satellites. They can also form constellations of multiple HASPs using inter-HASP links. (Figure 1) Flexibility is one of the most important features that make HASP technology a strong candidate in future generation wireless networks. A HASP-based network can be connected with other public or private networks via gateway stations. According to where switching takes place, two implementations are possible: bent-pipe platform with on-ground switching and on-board switching. In the multi-platform scenario, HASPs may be interconnected either via ground stations or via inter-platform links. Interworking with other networks includes loose and tight interworking. In loose interworking the HASP is used complementarily to other access networks and it is more independent as there are no common network elements. In tight interworking a HASP is the sub-part of other networks. (Kandus, Svirgelj & Mohorcic, 2005) Although existing techniques and methodologies of wireless communications can be applied in HASPs, there are some intrinsic characteristics that engineers should take into account as they can increase performance and flexibility. In the following sections, the main aspects of the HASP-related technology are presented along with effective solutions in several domains.

COVERAGE PLANNING AND ANTENNAS

HASP can carry communicational payload able to produce several cellular patterns on the ground. (Thornton, Grace, Spillard, Konefal & Tozer, 2001) Actually, HASPs can be considered as very low orbit satellites or very tall cellular masts. Consequently, many elements of the satellite theory are applicable. The geometrical characteristics given in this section are necessary for coverage planning and choosing the appropriate antenna configuration. El-Jabu and Steele (2001) have conducted a thorough study that is summarized next. The maximum area that can be theoretically covered by a satellite is given by

$$S = 2\pi R_e W \quad (1)$$

where R_e is the radius of the earth and W is the depth from the earth's surface. Considering a system of Cartesian coordinates on the same plane with the HASP and the earth's diameter, the distance from the platform to point (x, y) is

$$d = \sqrt{x^2 + (h + R_e - y)^2} \quad (2)$$

where h is the platform's nadir height. The arc describing the distance from the point (x, y) to the reference point $(R_e, 0)$ on the earth surface just below the platform is

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