Hindawi Publishing Corporation
EURASIP Journal on Wireless Communications and Networking
Volume 2008, Article ID 934837, 3 pages
doi:10.1155/2008/934837

Editorial

Advanced Communication Techniques and Applications for High-Altitude Platforms

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Received 20 November 2008; Accepted 20 November 2008

We are beginning to witness an exciting era for researchers and developers of advanced future generation multimedia telecommunication systems. High-altitude platform (HAP) systems are among these novel technologies and are starting to attract considerable attention worldwide. Research and development activities include the EU FP6 CAPANINA Project and the COST 297 Action in Europe, along with government-funded projects in Japan, Korea, and USA. Commercial projects are also underway in Switzerland, USA, China, and UK.

High-altitude platforms (HAPs) are airships or planes, operating in the stratosphere, at altitudes of typically 17–22 km (around 75000 ft). At this altitude (which is well above commercial aircraft height), they can maintain a quasi-stationary position and support payloads to deliver a range of services: principally communications, and remote sensing. Communications services including broadband, WiMAX, 3G, and emergency communications, as well as broadcast services, are under consideration. A recent HAP trial in Sweden has successfully tested the usage of a HAP at 24 km altitude, operating in the mm-wave band to send data via Wi-Fi (802.11b) to a coverage area of 60 km in diameter, with the goal of demonstrating the potential of this novel technology.

A HAP can provide the best features of both terrestrial masts (which may be subject to planning restrictions and/or related environmental/health constraints) and satellite systems (which are usually highly expensive). This makes HAP a viable competitor/complement to conventional terrestrial infrastructures and satellite systems. In particular, HAPs permit rapid deployment, and highly efficient use of the radio spectrum (largely through intensive frequency reuse). The relatively close range of HAPs compared to satellites means that data rates can be significantly higher for the same size antennas, and imaging and remote sensing are highly effective, offering low cost and high resolution. A variety of hybrid applications may also be envisaged, such as traffic management, navigation, security management, and so on. There are two fundamental types of platform technology capable of stratospheric flight: manned and unmanned aircraft, and unmanned airships. Other platform technologies at lower altitudes, including manned aircraft and tethered aerostats, and Unmanned Aerial Vehicles (UAVs) may also play a developmental role towards HAPs and their applications.

HAPs differ from other means of communications delivery in the fact that HAP movement and limited mission durations must be taken into consideration in order to ensure that communication services are maintained. Innovative solutions including mechatronic antenna beam steering techniques, smart and MIMO antenna technologies, intra/inter HAP handoff processes, and diversity techniques could play an important role. Multiple bearer systems, using multiband wireless and free space optic technologies, including hybrid terminals can exploit the advantageous propagation environment. Integrated networks containing HAP, terrestrial, and satellite components can be further used to enhance the user experience and exploit the best features of each segment.

In light of the above, it was therefore timely to propose a special issue exploring recent advances in communications and applications linked to HAPs and related systems. The main purposes of this special issue are three-fold:

(i) highlighting the recently emerged technological advances, new trials, and applications related to HAPs,

(ii) reporting on the activities of the European COST 297 Action,

(iii) promoting these novel results to a wider audience.

After a stringent peer-review procedure by experts in the field, thirteen papers were accepted for inclusion in this special issue. The papers cover different aspects of HAP systems and are grouped in the following four categories. The first category provides an overview of HAPs for disaster recovery and emergency telecommunications (the first paper). The second category addresses the coexistence scenarios and interference management (from the second to the sixth paper). The third category covers the propagation effects, trials and demonstrations for HAP systems (from the seventh to the twelfth paper). Finally, the forth category which addresses the techno-economic issues of HAP-based communications is covered by the last paper.

The first paper, "High-altitude platforms for disaster recovery: capabilities, strategies, and techniques for emergency telecommunications," by J. Deaton, presents a very well-reasoned case for using HAPs to provide emergency communications infrastructure following a major disaster. Interesting case studies of past disasters are discussed, for example, New Orleans after Hurricane Katrina. The author shows how HAPs can be used to implement critical elements of a cellular communications system to give the emergency services an access to multiple applications and services in the immediate aftermath of a disaster. The pros and cons of the different architectural configurations of the communications architecture are discussed.

In the second paper, "Downlink coexistence performance assessment and techniques for WiMAX services from high-altitude platform and terrestrial deployments," by Z. Yang et al., the authors investigate the performance and coexistence techniques for worldwide interoperability for microwave access (WiMAX) delivered from high-altitude platforms (HAPs) and terrestrial systems in shared 3.5 GHz frequency bands. The paper shows that it is possible to provide WiMAX services from individual HAPs systems.

In the third paper, "Performance evaluation of WiMAX broadband from high-altitude platform cellular system and terrestrial coexistence capability," by Z. Yang et al., the performance of a WiMAX microwave access link from HAP is investigated, and the coexistence capability with multiple-operator terrestrial WiMAX deployments in the same frequency band is examined. The HAP coverage area is divided into multiple cells served by a multi-antenna payload, and both uplink and downlink performances are analyzed.

The forth paper "Coexistence performance of high-altitude platform and terrestrial system using gigabit communication links to serve specialist users," by Z. Peng and D. Grace, proposes some iterative methods to adjust the pointing direction of aperture antenna in mm-wave bands onboard HAP for the purpose of providing the highest CINR value at specialist users. The system scenario assumes that the specialist user needs a very high speed link up to 3 Gbps for the transmission of uncompressed HDTV pre-broadcast content, sharing the same frequency band with point-to-point terrestrial link. The methods become important particularly when the HAP covers a wide service area like 300 km in diameter.

The fifth paper "WCDMA uplink interference assessment from multiple high-altitude platform configurations," by T. Hult et al., investigates the possibility of multiple HAP coverage of a common cell area using a WCDMA system, focusing on the analysis of the uplink system performance.

In the sixth paper "An evaluation of interference mitigation schemes for HAP systems," by B-J. Ku et al., various performance evaluation results of interference mitigation schemes from HAPS user terminals (HUTs) are presented. The results include performance evaluations using a new interference mitigation approach as well as conventional approaches. An adaptive beamforming scheme (ABS) is introduced as a new scheme for efficient frequency sharing, and the interference mitigation effect on the ABS is examined considering pointing mismatch errors. The authors show that the application of ABS enables frequency sharing between two systems with a smaller power reduction of HUTs in a co-coverage area compared to conventional schemes.

The seventh paper "Penetration loss measurement and modeling for HAP mobile systems in urban environment," by J. Holis and P. Pechac, presents the results of a building penetration loss measurement campaign performed using a remote-controlled airship, and proposes an empirical model for predicting penetration loss in 3G and 4G HAP-based mobile systems.

In the eighth paper, "Building entry loss and delay spread measurements on a simulated HAP-to-indoor link at S-band," by F. Perez-Fontan et al., the results of a measurement campaign emulating the high-altitude platform (HAP)-to-indoor communication channel at S-band are presented. A link was established between a transmitter, carried by a helicopter representing the HAP, and a receiver placed at several locations in different building types. A wideband, directive channel sounder was used to measure building entry loss and time delay spread. Results of the building entry loss are presented as a function of building type, elevation, and building entry angle. Results of delay spread for each building are also provided.

The ninth paper "A WiMAX payload for high-altitude platform experiment trials," by J. Thornton et al., reports the communication system design and results of terrestrial and airborne pretrials for WiMAX payload developed for the Swiss-based HAP programme "StratXX". The terrestrial trial took place to evaluate long-distance LOS performance. The airborne trial that used a helicopter at a low altitude shows the potential for WiMAX service from aerial platform. This paper is valuable as a report of field trial on HAP, the number of which is very limited to date.

The tenth paper "A study of gas and rain propagation effects at 48 GHz for HAP Scenarios," by S. Zvanovec et al., assesses the effects of atmosphere and rainfall on HAP millimeter-wave links through measurements and simulation of these phenomena. The gas attenuation measurements are performed using a Fabry-Perot resonator-based system, while the rain attenuation is analyzed considering both single and double HAP link scenarios.

In the eleventh paper "Posthumous numerical study of DTV broadcast antenna integration with prototype stratospheric airship gondola," by D. Gray et al., the 2004 digital television (DTV) broadcast demonstration using a prototype stratospheric airship is reviewed. The authors found out that random signal loss is experienced at the receiving station directly below the airship, and later they identified a possible cause of this signal loss. Several possible mitigation techniques and alternative antenna designs which would have fitted within the constraints of the 2004 demonstration were then compared.

The twelfth paper "Application of single-mode fiber-coupled receivers in optical satellite to high-altitude platform communications," by F. Fidler and O. Wallner, investigates the phase front distortions induced by atmospheric turbulence on the efficiency with which the laser beam is coupled into a single-mode fiber. The authors analyzed different link scenarios including a geostationary satellite (GEO), a high-altitude platform (HAP), and an optical ground station (OGS).

Finally, the last paper "Is HAPS viable for the next generation telecommunication platform in korea?," by J. Kim et al., presents a techno-economic analysis of the delivery of the 3G telecommunications systems taking into account HAP capacity, and speed of migration from existing means of delivery. This is one of the first papers to consider the techno-economic issues of HAP-based communications, a subject that is of critical importance for operators, entrepreneurs, and investors when considering the future of this technology.

ACKNOWLEDGMENTS

The guest editors would like to thank the authors for their contributions and the reviewers who dedicated their precious time in providing numerous comments, suggestions, and corrections that helped improve the quality of the manuscripts. We would also like to thank the past and present Editors-in-Chief Phil Regalia and Luc Vandendrope for the interest in this special issue and for giving us the opportunity to publish in this journal, and the editorial staff from Hindawi Publishing Corporation for their support throughout the editing process. We acknowledge the contribution of the COST research programme of the European Science Foundation. Indeed, the first four guest editors are members of the European COST 297 Action "HAPCOS—High-Altitude Platforms for Communications and Other Services," and the fifth guest editor is an Associate Member of this action. In addition, eight papers in this special issue were authored by various members of this action. COST 297 commenced in September 2005 for a period of 4 years, and is the largest gathering of research community with interest in HAPs and related systems. The guest editors believe that this special issue will be of great value to the academic and industrial research community and standardization bodies. Finally, we hope that the readers will find the papers in this special issue helpful to their research and future development in this innovative technology.

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