Communications via High Altitude Platforms: Technologies and Trials

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Fotini-Niovi Pavlidou
Aristotle University of Thessaloniki

M. Ruggieri
University of Rome Tor Vergata

Ryu Miura
National Institute of Information and Communications Technology

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Communications via High Altitude Platforms: Technologies and Trials

High Altitude Platforms (HAPs) are considered nowadays as a substantial part of the future integrated terrestrial/satellite networks for providing wireless communication services. Airship technology is developing quite satisfactorily and commercial applications are turning into reality. The quasi-stationary aerial platforms operating in the stratosphere preserve many advantages of both terrestrial and satellite systems but also provide special advantages of their own. Mobility on demand, large coverage, payload reconfigurability, capability of frequent take-offs and landings for maintenance and upgrading and very favourable path-loss characteristics (with respect to terrestrial or satellite systems) are the main features which make HAPs attractive for a large class of applications and services.

The platforms are known under different names as High-Altitude Platforms (HAPs), High Altitude Aircraft and Airships (HAAS), High Altitude Aeronautical Platforms (HAAPs), High Altitude Long Endurance Platforms (HALE Platforms), Stratospheric Platforms (SPFs), etc. They are located at 17–22 km above the earth surface and ITU has allocated specifically for HAPs services the spectrum of 600 MHz at 47/48 GHz (shared with satellites) worldwide. HAPs are also authorized to be used in some 3G services (around 2 GHz) and fixed services in 31/28 GHz in some countries. There is also a potential use of the bands in the range 3–18 GHz by HAPs in the fixed and mobile services. These standardization activities confirm the attention paid all over the world to this technology.

One of the most important business sectors open for HAP applications is Telecommunications and Informatics and specific services that could be provided are: very wideband Internet access (e.g. more than 10 Mbps in downlink and uplink), entertainment video and audio, videoconferencing, cellular telephony, broadband LMDS services, access provision to digital networks (i.e. ISDN, Internet), etc. Moreover, HAPs can provide solutions for special geographical regions (islands and impervious areas) or emergency/temporary applications (Olympic Games) supporting multimedia services at satisfactory quality. Concerning the integration into the GSM or UMTS standard, different scenarios can be conceived. One scenario employs HAPs as "back-up" base stations for covering areas partially served by terrestrial base stations. HAPs can also be used for providing a full-service coverage of a wide rural area, where no terrestrial network is active.

Even though active and passive communications platforms date back to the early 60s, there are still many open topics that need to be tackled, as for example:

System architecture: A typical system design should strive for high reliability, low design and operation consumption and light payload Interference analysis. A suitable mixed architecture comprising HAPs and satellites seems to be of great importance currently.

Interference analysis: The frequency bands allocated for HAPs services at 47/48GHz worldwide (In some countries in Asia, Russia, and North and South America the 31/28 GHz band is assigned) are shared with some satellite services, the interference from/to other systems is a good issue to investigate in any future application system.

Antennas: Interference analysis is closely linked with the examination of the effects of the antenna specifications on Carrier to Interference Ratio (CIR). Various types of antennas are currently explored that meet the requirements imposed by the high frequency bands, the movement of the HAP, the minimization of the interference and the reduced weight, size, and power consumption of the mission payload.

Channel and Propagation: Optimisation of the provided services requires designers to take into account propagation information early in the system design. Relevant channel models should be available to assess by simulation the end-to-end quality of service and the system performance.

Modulation and Coding: Taking into consideration the medium-term or long-term channel variations adaptive modulation and coding techniques are to be proposed and evaluated.

Optical Transmission: Free-space optical transmission technology offers data transmission at high data rates with low signal power, and it should be considered as a key technology in future telecommunications systems. Optical transmission can be employed for the inter-platform links, or even for the HAP-satellite link.

The scope of this Special Issue was to provide a thorough study of research and field test activities in this area: to engage in a deep investigation of the different layers of the communications path taking into account all the relevant factors influencing the performance evaluation of the system, and; to examine future perspectives and directions for low cost and efficient communication services.

The papers received were generally of a high quality and covered almost all the critical issues of a HAP system's design. They can be characterized as academic research papers as well as tutorial or trials oriented papers. Out of 17 submissions, finally six papers have been selected for inclusion in this special issue.

In the first paper a novel channel model and a related channel simulator especially tailored for HAP-based communication systems are presented The model is conceived for link-level simulations of point-to-point communication links, wherein both the transmitter and the receiver may be equipped with an array of antennas. Peculiar physical effects of the stratospheric channel are taken into account as well as impairments due to the possible presence of scatterers and relative movement of both transmitting and receiving stations. The structure of the channel simulator is conceived to maintain the computational burden low by exploiting an efficient tapped delay line implementation.

The second paper discusses the conjugation of OFDM techniques with smart antennas for HAP-based communications, stressing the need for integration of the different functional blocks of an OFDM receiver. In fact, in order to face a time varying scenario, adaptive techniques are needed, and only a careful joint design of time and frequency synchronization with beamforming algorithms can guarantee reliable communications. The detailed and integrated receiver design described in the paper is based on the OFDM version of the IEEE 802.16a transmission standard.

In the third paper the authors provide a method to estimate the capacity of a wideband code division multiple access (WCDMA) scheme using High Altitude Platform Stations (HAPS), and demonstrate the results. This proves that the HAPS system is one of the most effective solutions to provide high quality wireless communication services, such as IMT-2000 services. A practical system model is used which describes the HAPS system most appropriately, and this leads to realistic estimation results. The reverse and forward link capacity of the HAPS WCDMA system are estimated and compared to that of a terrestrial system. The estimation results show that the capacity of the HAPS WCDMA system is about 1.2–1.67 times larger than that of the terrestrial system.

In the fourth paper the performance of a radio system, based on HAPS and working at 48 GHz, is evaluated by means of simulation results. The use of FMT is considered as a way of improving the system availability. This particular system has been chosen for three reasons: the aforementioned allocation of the frequency band for this application, the existence of a proposed system with publicly available detailed technical specifications, and the availability of experimental propagation data gathered in a previous research project at that frequency band. The quantitative results presented in this paper are strictly related to that particular system. However, qualitative conclusions can be obtained that may be helpful in any other system.

In the fifth paper the inter-working between HAP and Satellite segments in an integrated QoS architecture is addressed and a new way to manage Integrated Services over a new hybrid wireless platform is proposed. A smart terminal device is considered in order to perform an intelligent switching on the wireless access segment. The switching criteria applied in the HAP/Satellite architecture is based on the available bandwidth and on the admissible data packet end-to-end delay. Performance evaluations of the integrated HAP-Satellite platform have been evaluated in terms of bandwidth utilization and number of admitted calls. The simulations show an improvement of admitted calls, a reduced data packet end-to-end delay and an increased bandwidth utilization.

Finally, in the sixth paper the 10-year program of Korean (KARI) trials to develop a stratospheric airship for telecommunication relays and ground observations at 20 km altitude is fully described throughout the various phases of its development.

KARI finished the design of the system, manufacturing of components and sub-systems, tests of components and sub-systems, and total system check for flight test. The characteristics of the 50 m unmanned airship system are first introduced, with ground and flight test results given in detail.

It is worthy to mention that this special issue provides a look at some of the interesting research topics in the field. As is always the case in special issues, because of limited space we were not able to include all the papers meritorious of publication. We would like to express our thanks to all the authors who submitted their papers and wish success in the extension of their work.

Fotini-Niovi Pavlidou
Aristotle University of Thessaloniki
Thessaloniki 54124
Greece

Marina Ruggieri
University ToR Vergata
Rome
Italy

Mario Gerla
Department of Computer Science
University of California
Los Angeles
CA 90024
USA

Ryu Miura
National Institute of Information
and Communications Technology
3-4 Hikarino-oka, Yokosuka-shi
Kanagawa 239-0847
Japan

Fotini-Niovi Pavlidou received the PhD degree in Electrical Engineering from the Aristotle University of Thessaloniki, Greece, in 1988 and the Diploma in Mechanical-Electrical Engineering in 1979 from the same institution. She is now a Full Professor at the Department of Electrical and Computer Engineering in the same Institution. Her research interests are in the areas of mobile and personal communications, satellite communications, multiple access systems, routing and traffic flow in networks. She is involved in many national and international projects in these areas (Tempus, COST, Telematics, IST) and she chaired the European COST262 Action on "Spread Spectrum Systems and Techniques for Wireless and Wired Communications". She is the delegate of Greece in the COST TC-TIST.

She has served as member of the TPC (in some being the TPC chairperson) of many conferences supported by IEEE/IEE. She is a permanent reviewer for many international journals. She has published about 180 papers in refereed journals and conferences. She is currently chairing the joint IEEE VT&AES Chapter in Greece. She is a senior member of IEEE and a member of Technical Chamber of Greece.

Marina Ruggieri graduated in Electronics Engineering in 1984 at the University of Roma. She was: with FACE-ITT and GTC-ITT (Roanoke, VA) in the High Frequency Division (1985–1986); Research and Teaching Assistant at the University of Roma Tor Vergata (RTV) (1986–1991); Associate Professor in Telecommunications at University of L' Aquila (1991–1994). Since November 2000 she is Full Professor in Telecommunications at the RTV (Department of Electronics Engineering), teaching DSP, Information and Coding. In 1999 she has been appointed member of the Board of Governors of the IEEE AES Society (2000–2002) and re-elected for the period 2003–2005. Her research mainly concerns space communications and navigation systems (in particular satellites) as well as mobile and multimedia networks.

She is the Principal Investigator of: a satellite scientific communications missions (DAVID, WAVE) of ASI; a national research programs (CABIS) on CDMA integrated mobile systems (2000–2002) and on satellite-HAP integrated networks for multimedia applications (SHINES), co-financed by MIUR (2002–2004). She co-ordinates RTV Unit in various European Projects: EU FP6 IP MAGNET (My personal Adaptive lobal NET); EU ASIA LINK EAGER-NetWIC (Euro-Asian Network for Strengthening Graduate Education and Research in Wireless Communications); EU Network NEXWAY; GALILEO JU 1st Call – July 2003: VERT (VEhicular Remote Tolling); and in the ASI program on V-band payloads (TRANSPONDERS).

She is Editor of the *IEEE Transactions on AES* for "Space Systems", Chair of the IEEE AES Space Systems Panel. Since 2002, she is co-chair of Track 2 "Space Missions, Systems, and Architecture" of the AES Conference; she has been re-appointed in the IEEE Judith A. Resnik Award Committee for 2004; she has been member of TPC for PLANS 2004. She is member of the Editorial Board of Wireless Personal Communications – an International Journal (Kluwer). She was awarded the *1990 Piero Fanti International Prize* and she had a nomination for the *Harry M. Mimmo Award* in 1996 and the *Cristoforo Colombo Award* in 2002. She is author of about 180 papers, on international journals/transactions and proceedings of international conferences, book chapters and books. She is an IEEE Senior Member (S'84-M'85-SM'94).

Mario Gerla received the graduate degree in electrical engineering from Politecnico di Milano, Italy, in 1966 and the M.S. and Ph.D. degrees in computer science from the University of California, Los Angeles, (UCLA) in 1970 and 1973, respectively. From 1973 to 1976, he was a Manager at the Network Analysis Corporation, Glen Cove, NY, where he was involved in several computer network design projects for both government and industry, including performance analysis and topological updating of the ARPANET under a contract from DoD. From 1976 to 1977, he was with Tran Telecommunication, Los Angeles, CA, where he participated in the development of an integrated packet and circuit network. Since 1977, he has been on the Faculty of the Department of Computer Science, UCLA. His research interests include the design, performance evaluation, and control of distributed computer communication systems and networks. His current research projects cover the following areas: topology design and bandwidth allocation in ATM networks, design and implementation of optical interconnects for supercomputer applications, design and performance evaluation of air/ground wireless communications for the Aeronautical Telecommunications Network, and network protocol design and implementation for a mobile, integrated services wireless radio network.

Ryu Miura received the B.E., M.E., and PhD degrees in Electrical Engineering from Yokohama National University, Yokohama, Japan, in 1982, 1984, and 2000, respectively. He joined Communications Research Lab (CRL), Ministry of Posts and Telecommunications, Tokyo, Japan in 1984, where he worked for research on mobile satellite communication systems using the Engineering Test Satellite, ETS-V. During 1991–1992, he was a visiting researcher in AUSSAT, Pty. Ltd. (now Optus, Pty. Ltd.), Sydney, Australia. During 1993–1996, he was a senior researcher in ATR Optical and Radio Communications Research Labs, Kyoto, Japan, where he worked for research on digital beamforming antennas for mobile communications. He is now a group leader of Wireless Innovation Systems Group in the Yokosuka Radio Communications Research Center of NICT (National Institute on Information and Communications Technology, reorganized from CRL in April 2004), where he is leading a national R&D project on wireless communication systems using stratospheric platforms. Dr. Miura is a member of IEEE and IEICE.