Preface

Nowadays, satellites are used for a variety of purposes, including sensors and data collection, weather, maritime navigation and timing, Earth observation, and communications. In particular, satellite transmissions have an important role in telephone communications, television broadcasting, computer communications as well as navigation.

The use of satellites for communications was a brilliant idea of Arthur C. Clarke who wrote a famous article in October 1945 in the Wireless World journal, entitled "Extra Terrestrial Relays - Can Rocket Stations Give Worldwide Coverage?" that described the use of *manned* satellites in orbits at 35,800 km altitude, thus having synchronous motion with respect to a point on the Earth. This article was the basis for the use of *GEOstationary* (GEO) satellites for telecommunications. Subsequently, he also proved the usefulness of satellites as compared to transatlantic telephone cables.

Satellite communications deserve the special merit to allow connecting people at great distances by using the same (homogeneous) communication system and technology. Other very significant advantages of the satellite approach are: (*i*) easy fruition of both broadcast and multicast high bit-rate multimedia services; (*ii*) provision of backup communication services for users on a global scale (this feature is very important for emergency scenarios and disaster relief activities); (*iii*) provision of services in areas that could not be reached by terrestrial infrastructures; (*iv*) support of high-mobility users.

Three broad areas where satellites can be employed are: fixed satellite service, broadcast satellite service, and mobile satellite service. Particularly relevant is the significant global success of broadcast satellite services for both analogue and digital audio/TV by exploiting the inherent wide coverage area of GEO satellites. At the beginning of the 21^{st} century more than 70 million European homes watch TV programs through direct satellite reception or through cable distribution systems.

New satellite system architectures are being envisaged to be fully IP-based and support digital video broadcasting and return channel protocols, such as DVB-S, DVB-S2 and DVB-RCS. Trends in telecommunications indicate that four growing market areas are messaging and navigation services, mobility services, video delivery services, and interactive multimedia services. In addition to this, interesting areas for investigation with big potential markets are: the extension of the DVB-S2/-RCS standard for mobile usage, satellite IP networks interconnected with terrestrial wireless systems, and the convergence of satellite communications and remote sensing for Earth observation.

Satellite resources (i.e., radio spectrum and transmission power) are costly and satellite communications impose special constraints with respect to terrestrial systems in terms of path loss, propagation delay, fading, etc. These are critical factors for supporting user service level agreements and *Quality of Service* (QoS).

The ISO/OSI reference model and the Internet protocol suite are based on a layered protocol stack. Protocols are designed such that a higher-layer protocol only makes use of the services provided by the lower layer and is not concerned with the details of how the service is being provided; protocols at the different layers are independently designed. However, there is tight interdependence between layers in IP-based next-generation satellite communication systems. For instance, transport layer protocols need to take into account large propagation delays, link impairments, and bandwidth asymmetry. In addition to this, error correction schemes are implemented at physical, link and (in some cases) transport layers, thus entailing some inefficiencies and redundancies. Hence, strict modularity and layer independence of the layered protocol model may lead to a non-optimal performance.

Satellite resources are costly and must be efficiently utilized in order to provide suitable revenue to operators. Users, however, do not care about the platform technology adopted and employed resource management scheme, but need QoS provision. Unfortunately, resource utilization efficiency and QoS support are conflicting needs: typically, the best utilization is achieved in the presence of a congested system, where QoS can difficulty be guaranteed. A new possible approach addressing both these issues is represented by the *cross-layer design* of the air interface, where the interdependency of protocols at different layers is exploited with the aim to perform a joint optimization or a dynamic adaptation. The innovation of this approach relies on the fact that it introduces direct interactions event between non-adjacent protocol layers with the aim to improve system performance.

The main aim of this book is to address the novel research area of cross-layer air interface design for satellite systems and provide a complete description of available methods, showing the possible efficiency improvements. A particular interest has been addressed here to the protocol stack defined by the ETSI TC-SES/BSM (*Satellite Earth Stations and Systems / Broadband Satellite Multimedia*) working group for IP-based satellite networks. In this framework, a protocol stack architecture has been identified, where lower layers depend on satellite system implementation (*satellite-dependent layers*) and higher layers are those typical of the Internet protocol stack (*satellite-independent layers*). These two blocks of stacked protocols are interconnected through the SI-SAP (*Satellite-Independent - Service Access Point*) interface that has acquired a crucial importance for the definition of cross-layer interactions and signaling.

This book has been conceived in the framework of the SatNEx Network of Excellence (www.satnex.org, project IST-507052, 2004–2006) that has made possible a tight cooperation of many European partners. Since the beginning (January 2004), SatNEx devoted the sub-work-package 2430, namely joint activity 2430 (ja2430), to the investigation of cross-layer issues that were soon considered as an original research field. Such activity attracted the interest of more than 14 SatNEx partners. In particular, research groups at the following European Universities or research Institutions contributed to ja2430:

- AUTh - Aristotle University of Thessaloniki, Greece
- CNIT - Consorzio Nazionale Interuniversitario per le Telecomunicazioni, Italy
- DLR - Deutsches Zentrum für Luft- und Raumfahrt e.V., Germany
- FhI - Fraunhofer Institute for Open Communication Systems, Germany
- ISTI - National Research Council (CNR), ISTI Institute, Italy
- RWTH - Rheinisch-Westfälische Technische Hochschule Aachen, COMNETS, Germany
- TéSA - France
- TUG - Graz University of Technology, Austria
- UAB - Universidad Autónoma de Barcelona, Spain
- UC3M - Universidad Carlos III de Madrid, Spain
- UoA - University of Aberdeen, UK
- UniS - University of Surrey, Centre for Communication Systems Research, UK
- UToV - University of Rome "Tor Vergata", Department of Electronic Engineering, Italy
- UVI - Universidad de Vigo, Departamento de Ingeniería Telemática, Spain.

I had the pleasure to coordinate the ja2430 activities, organizing 4 periodical meetings (plus *ad hoc* meetings dedicated to the coordination of this book activity), where objectives (organized according to *Focus Topics*, FTs), common scenarios and strategies were identified. In particular, the FTs below were defined, thus contributing to the different parts of this book:

- FT 1: QoS for multimedia traffic
- FT 2: Radio resource management
- FT 3: Protocol integration.

The main objective of ja2430 has been the study of novel radio resource management schemes able to support multimedia traffic with QoS guarantee in future satellite communication systems. Our aim has been to propose modifications to the ISO/OSI standard protocol stack by considering interactions and even new interfaces among non-adjacent protocol layers. Such approach can be particularly important in order to optimize the performance (i.e., efficiency) of resource management protocols.

After more than one year of SatNEx ja2430 activities, it was decided in September 2005 to organize the results obtained in a book. With the end of SatNEx activities in March 2006, the work of this book continued in SatNEx II (IST-027393, 2006–2009) in the two new sub-work-packages deriving from ja2430, that is ja2330 (entitled: "Radio Resource Allocation and Adaptation") and ja2230 (entitled: "Cross-Layer Protocol Design").

The activity carried out for this book has been a very good opportunity for the SatNEx community to integrate the competencies of different partners considering all the parts of the system design (i.e., propagation issues, resource management techniques, link design, QoS, transport protocols, etc.) and especially because SatNEx is unique in that its expertise covers both broadband (fixed) and mobile satellite systems. This has been an ideal condition for the study of mechanisms that involve interactions among several protocol layers.

Besides Part I of this book that is aimed to introduce satellite communications (Chapter 1), resource management techniques (Chapter 2), QoS issues (Chapter 3) and cross-layer design methods (Chapter 4), the two following parts are conceived according to the ETSI SES/BSM protocol stack, thus distinguishing cross-layer issues involving satellite-dependent layers (Part II, Chapters 5, 6 and 7) from those of satellite-independent layers (Part III, Chapters 8, 9 and 10).

Before concluding this preface, I would like to say that I feel honored to have coordinated this book work first in the framework of ja2430 and then in ja2230&ja2330. I take this opportunity to thank SatNEx for the economical support received and all the SatNEx Colleagues who have provided a continuous support to this initiative. Finally, a very special thank is for my Collaborator, Dr. Ing. Paolo Chini, for his significant support in helping me during these years of hard work on the book. Many thanks also to my Collaborator, Dr. Ing. Ivano Alocci, for his kind support.

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