NETWORKS AND TELECOMMUNICATIONS SERIES

Satellite and Terrestrial Hybrid Networks

Pascal Berthou, Cédric Baudoin
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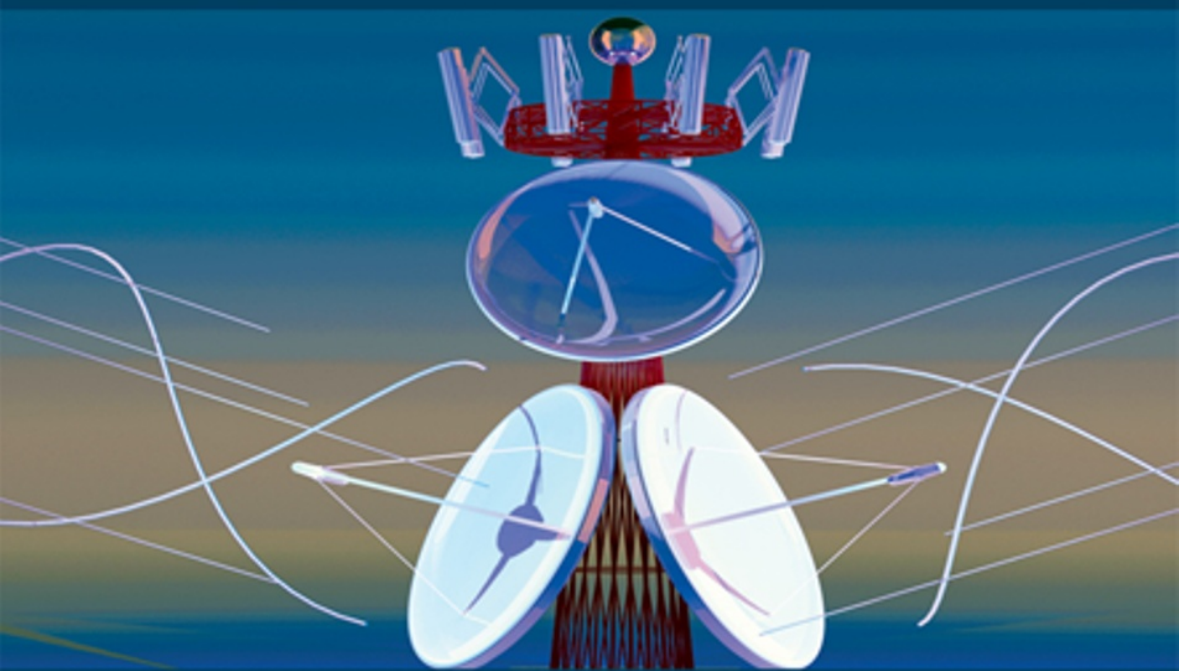

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Contents

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Many thanks to them,

Pascal BERTHOU

Foreword

Once the concept of integrated service appeared with integrated services digital networks (ISDN), the growing adoption of Internet-based technologies into our daily lives has given rise to the concept of "convergence". This is the idea of the progressive merging of information technology, telecommunications and audiovisual technologies into a new and continuously more integrated industry, making the access to the information system more intuitive and easy to use.

Indeed, it appears that the emergence of the digitization and bundling of information was the driving force behind various types of convergence. These range from different uses to diversified points of access, channeling services and networks towards a virtualization of physical infrastructures. Today, digital information flows exchanged via telecommunication infrastructures have become such that it is no longer possible to distinguish an exchange of digital information from a telephone conversation or a message containing audiovisual multimedia content.

This shockwave, which continues to increase the flexibility of the various layers of the information and communication systems, inevitably leads to changes in the structure of economic models, causing significant alterations in the value chain between telecommunications, audiovisual and information industries.

The world of satellite communications has not been spared the effects of this upheaval, and to respond to these changes, stakeholders in the "satcom" sector have been examining the interconnection of satellite radio communications with new information and communication technologies.

This is the subject which this book will address, providing a highly didactic study of the various technical challenges involved in achieving the most transparent integration possible on the different fronts of fixed, mobile and broadcast services with satellite positioning as a core network as well as an access and local network.

The infrastructure for satellite telecommunication has needed to evolve in order to carry various types of traffic and be compatible with frequently updated service offers in an increasingly competitive context. Obviously, the aspect of telecommunication regarding the "quality of service" – looking to offer users the best quality of experience – occupies a special place in this book, and is accompanied by the various technical obstacles to overcome. These include the impacts on the processes for transporting information and communication to mobiles or the new generation of satellite access and diffusion architecture.

This book clearly highlights the various essential aspects to connect satellite communications with the system of new generation terrestrial networks. It provides a detailed insight of a wide range of problems raised by this quest for integration and in doing so represents a unique source of information for those who need to understand the technical challenges which satellite communication networks need to overcome.

The authors, all members of the Internet generation, have spent years actively contributing, through their research, to producing solutions to these technical problems which have influenced the development of the technologies they describe.

Patrick GÉLARD
July 2015

List of Acronyms

2G	second generation (GPRS and EDGE)
3G	third generation (UMTS, HSDPA, HSDPA+ and LTE)
3GPP	third generation partnership project
4G	fourth generation (LTE-advanced)
AAA	authentication, authorization and accounting
ACK	acknowledgement
ACM	adaptive coding modulation
ACQ	(DVB-RCS) acquisition
ADSL	asymmetric digital subscriber line
AF	assured forwarding
AF	(IMS) application function
ANI	application-to-network interface
AP	access point
API	application programming interface
AR	access router
ARC	active resource controller
ASPs	application service providers
AVBDC	(DVB-RCS) absolute volume based dynamic assignment
BA	binding acknowledgement
BACK	binding acknowledgment
BB	bandwidth broker
BBM	break-before-make
BDP	bandwidth delay product

BE	best effort
BER	bit error rate
BSM	broadband satellite multimedia
BU	binding update
C-BGF	core border gateway function
CCSDS	Consultative Committee on Space Data Systems
C2P	connection control protocol
CMT	(DVB-RCS) correction message table
CN	correspondent node
CNES	Centre National d'Études Spatiales
CoA	care-of–address
COPS	common open policy service
COPS-DRA	common open policy service – DiffServ resource allocation
COPS-PR	common open policy service – policy provisioning
CoT(i)	care-of-test (init)
CPE	customer premises equipment
CPM	continuous phase modulation
CR	capacity request
CRA	(DVB-RCS) continuous rate assignment
CSC	(DVB-RCS) common signaling channel
CSCF	(IMS) call/session control functions (P-proxy; S-server; I-interrogating)
CSS	cascading style sheets
CTCP	compound TCP
CWND	congestion window
DAD	duplicate address detection
DAMA	demand assignment multiple access
DCCP	datagram congestion control protocol
DIAMETER	double RADIUS
DNS	domain name server
DSCP	differentiated services code point
DSM-CC	(MPEG2) digital storage media – command and control
DULM	data unit labeling method
DVB-RCS	digital video broadcasting – return channel via satellite
DVB-S	digital video broadcasting – satellite
DVB-S/RCS	digital video broadcasting via satellite/return channel via satellite

ECN	explicit congestion notification
EF	expedited forwarding
E-LSP	EXP-inferred-PSC LSP
eNodeB	evolved node B (LTE)
EPC	evolved packet core (LTE)
ES	(MPEG2) elementary stream
ESA	European Space Agency
ETSI-TISPAN	ETSI-Telecommunications and Internet converged Services and Protocols for Advanced Networking
FBACK	(FMIP) fast binding acknowledgment
FBU	(FMIP) fast binding update
FCA	(DVB-RCS) free capacity assignment
FCT	(DVB-RCS) frame composition table
FEC	forwarding equivalence class
FMIP	fast handover mobile IP
FSS	fixed satellite service
FTP	file transfert protocol
GEO	geostationary orbit
GGSN	gateway GPRS support node
GIST	general internet signaling transport
GPRS	general packet radio service (2.5G)
GSE	generic stream encapsulation
GSM	global system for mobile communications
GTP	GPRS tunneling protocol
GW	Gateway
HA	home agent
HACK	(FMIP) handover acknowledge
HDLB	hierarchical dual token bucket
HHO	horizontal hand-over
HHHO	hybrid HHO
HI	hand-over initiate
HLS	(DVB-RCS2) higher layer satellite
HMIP	hierarchical mobile IP
HNP	home network prefix
HoA	home address
HoT(i)	home test (init)

HSS	(IMS) home subscriber server
HTB	hierarchical token bucket
HTTP	hypertext transfer protocol
I-PEPs	interoperable – performance enhancing proxies
IANA	internet assigned numbers authority
ICMP	internet control message protocol
ID	identifier
IEs	information elements
IETF	Internet Engineering Task Force
IMS	IP multimedia subsystem
INAP	interactive network access operator
INT	(MPEG2) IP/MAC notification table
IP	internet protocol
IP-TV	IP television
ISDN	integrated services digital network
ISP	internet service provider
IST	information society technologies
IT	information technology
ITSPs	internet telephone service providers
ITU	international telecommunication union
ITU-T	ITU telecommunication standardization sector
L-LSP	label-only-inferred-PSC LSPs
LAN	local area network
LBU	local binding update
LCoA	(HMIP) on-link care-of–address
LFN	long fat network
LLS	(DVB-RCS2) lower layer satellite
LMA	(PMIP) local mobility anchor
LSP	label switching path
LSR	label switching router
LTE	long-term evolution
MAC	medium access control
MAG	(PMIP) mobile access gateway
MAP	mobility anchor point
MBB	make-before-break
MF-TDMA	multiple frequency-time division multiplexing access

MIB	management information base
MIP	mobile IP
M2M	machine-to-machine
MME	mobility management entity
MMT	(MPEG2) multicast mapping table
MMUSIC	multiparty multimedia session control
MN	mobile node
MPE	multiple protocol encapsulation
MPEG	moving picture experts group
MPEG2-TS	moving picture experts group – transport stream
MPLS	multiprotocol label switching
MSPs	multicast service providers
MSS	mobile satellite service
NACFs	network attachment control functions
NAR	new access router
NAT	network address translation
NCC	network control center
NCoA	new care-of-address
NCR	(DVB-RCS) network clock reference
NE	network element
NFC	near field communication
NGA	next-generation access
NGN	next-generation network
NIT	(MPEG2) network information table
NMC	network management/operation center
NSIS	next step in signaling
NSLP	NSIS signaling layer protocol
NTLP	NSIS transport layer protocol
OBP	on board processing
OS	operating system
OSI	open systems interconnection
OWD	one way delay
PAR	previous access router
PAT	(MPEG2) program association table
PBA	(PMIP) proxy binding acknowledgment
PBNs	policy based networks
PBU	(PMIP) proxy binding update

P-CSCF	see CSCF
PC	personal computer
PCoA	previous care-of-address
PCIM	policy core information model
PCRF	(LTE) policy and charging rules function
PDCP	packet data convergence protocol
PDF	policy decision function
PDN	packet data network
PDP	policy decision point
PEP	performance enhancing proxy
PEP	policy enforcement point
PES	(MPEG2) packet elementary stream
PHB	per hop behavior
PHoA	previous home address
PIB	policy information base
PID	(MPEG2) packet identifier
PMIP	proxy mobile IP
PMT	(MPEG2) program map table
PrRtAdv	proxy router advertisement
PSI	(MPEG2) program and service information
PUSI	(MPEG2) payload unit start indicator
QNF	QOS NSIS forwarder
QNI	QOS NSIS initiator
QNR	QOS NSIS responder
QoS	quality of service
RA	random access
RA	(IPV6) router advertisement
RACFs	resource and admission control functions
RACS	resource and admission control system
RADIUS	remote authentication dial-in user service
RAN	radio access network
RBDC	(DVB-RCS) rate based dynamic assignment
RC	request class
RCoA	(HMIP) regional care-of-address
RCS	return channel via satellite
RCST	return channel satellite terminal

RFC	request for comments
RLE	return link encapsulation
RMF	resource management function
RNC	radio network controller
RO	route optimization
RRT	return routability test
RSVP	resource reservation protocol
RTO	retransmission timeout
RTP	real time protocol
RTSP	real time streaming protocol
RtSolPr	router solicitation for proxy advertisement
RTT	round time trip
RT-ViC	real time video conferencing
SAC	satellite access control
SACK	selective acknowledgment
SAP	session announcement protocol
SCF	service control function
SCPSs	space communications protocol specifications
SCPS-TP	SCPS transport protocol
SCT	(DVB-RCS) superframe composition table
SCTP	stream control transmission protocol
SD	satellite dependent
SDP	session description protocol
SDU	service data unit
SEs	signaling entities
SESs	satellite earth stations
SGSN	serving GPRS support node
SGW	serving gateway
SIP	session initiation protocol
SLA	service level agreement
SLF	(IMS) subscriber location function
SLS	service level specification
SMTP	simple mail transfer protocol
SNACK	selective negative acknowledgment
SNDU	sub network data unit
SNMP	simple network management protocol

SNO	satellite network operator
SNR	signal to noise ration
SO	satellite operator
SOAP	simple object access protocol
SP	service provider
SPT	(DVB-RCS) satellite position table
ST	satellite terminal
SVNO	satellite virtual network operator
SYN	synchronize
SYNC	(DVB-RCS) synchronization
TBTP	(DVB-RCS) terminal time burst time plan
TCP	transmission control protocol
TCT	(DVB-RCS) timeslot composition table
TDM	time division multiplexing
TIM	(DVB-RCS) terminal information message
TM/TC	telemetry/remote control
TSAPs	transport service access points
TS	(MPEG2) transport stream
UAC	user agent client
UAS	user agent server
UDLR	unidirectional link routing
UDP	user datagram protocol
UE	user equipment
ULE	ultra lightweight encapsulation
UMTS	universal mobile telecommunications system
UNA	unsolicited neighbor advertisement
UNI	user-to-network interface
URI	uniform resource identifier
UTO	user timeout option
UTRAN	UMTS terrestrial radio access network
VBDC	(DVB-RCS) volume based dynamic assignment
VCI	(ATM) virtual channel identifier
VCM	variable coding modulation
VHO	vertical handover
VoIP	voice over IP
VPI	(ATM) virtual path identifier

VPN	virtual private network
VPN SPs	VPN service providers
VSNs	virtual satellite networks
VSNO	virtual satellite network operator
WIMAX	worldwide interoperability for microwave access
WAN	wide area network
WLAN	wireless local area network

Introduction

The history of communication satellites began over 40 years ago with the launching of Anik 1 in 1972, which is considered as being the first geostationary commercial communication satellite. Since then, systems have evolved constantly in order to offer more than telephone services or television broadcasting. With the advent of the Internet, the concept of broadband satellite communication rapidly emerged, with the aim of providing a high-speed connection at any point on the planet. Subsequently, in the 1980s, the first mobile services appeared (Mobiles Satellite Services) with Inmarsat. These systems initially offered maritime telephonic communications, and then mobile data services.

Satellite systems have unquestionable qualities: mainly an extensive geographical coverage for a lower infrastructure cost, with fixed or mobile stations, and a capacity for carrying out large-scale broadcasting. Numerous steps forward in coding and antennae now offer higher speeds. However, satellite communication systems are no longer considered as competitive when compared to terrestrial communication systems. The economic model targeted today is a hybrid of terrestrial networks with satellite connections to supplement them in areas where they are inefficient or lack cost-effectiveness: remote areas and large-scale mobility. Furthermore, the satellite is a suitable medium for the coverage of white zones and offers one of the rare methods of communication which can handle large-scale mobility at high speeds (typically required for plane and train services, etc.)

Convergence is one of the key issues for next-generation telecommunication networks (NGNs). It is also one of the foundations of 4G

or 3G long-term evolution (3G-LTE), since it consists of both the convergence of services and fixed-mobile convergence.

This strong trend has given rise to a paradigm shift in order to implement quality of service (QoS) policies in a context where multimedia applications with various demands can be used via different access networks. These QoS policies must, therefore, bring together significantly different QoS management structures depending on the network in question (access or core) while enabling an optimization adapted to each of these networks and services with varied demands. It should be remembered that the current architectures implement a very partial view of QoS from start to finish, and that the solutions implemented at different levels are far from optimal.

This book aims to provide the keys for a successful integration of satellite systems with next-generation terrestrial networks. Digital video broadcasting – return channel via satellite (DVB-S/RCS) family systems (DVB-S/RCS and its evolutions), which are satellite communication systems currently offering the most up-to-date architecture and services – will be used to illustrate the challenges to overcome in order to ensure a successful integration. Of course, the concepts addressed are general and can be applied to other systems, including other rival satellite communication systems.

The presentation of this issue is built around an approach which removes the complexity involved in terrestrial and satellite communication systems. Therefore, this book offers a high-level vision focusing on the components of these systems and their interactions. It is thus aimed at a wide readership, from the designer of the satellite system to the network operator looking to incorporate a satellite option into their portfolio, and from institutional regulators to students wishing to address the issue of terrestrial/satellite hybrid systems.

The various ways of integrating the satellite systems into terrestrial networks will be addressed using several scenarios with different levels of complexity. The management issues related to QoS in terrestrial and satellite networks as well as solutions enabling interoperability will also be addressed. Mobility architectures and their performance will then be tackled. The higher levels will also be addressed with a focus on the role of the transport layer in a hybrid network. All the solutions provided in this book have been developed and tested in a number of European and French research projects. The results were obtained either by measures taken from

existing systems, or by realistic imitation platforms, or by the use of simulators when no other option was possible.

Plan

Chapter 1: Satellite and Terrestrial Hybrid Networks

The success of satellite communication systems mainly lies in their wide coverage and reduced time-to-market. Although niche markets, such as ocean and airspace coverage, will continue to exist, the future of satellite systems looks very different. The integration of satellites into terrestrial systems is now the only way to provide a complete offer of fixed and mobile services, with or without broadcasting. This chapter offers a number of hybrid scenarios. These scenarios, known as “tightly coupled”, “gateway” or “loosely coupled”, will be examined and their impact on the architecture and services will be described.

Chapter 2: Quality of Service on Next-Generation Terrestrial Networks

The QoS guarantee is the cornerstone of the next-generation networks including satellites, in order to remain competitive and profitable. This chapter looks at the essential communication architecture which provides an advanced management of the QoS. Internet engineering task force (IETF) and ITU-NGN approaches will be compared.

Chapter 3: Quality of Service in DVBS/RCS Satellite Networks

DVB-S/RCS is one of the most powerful and flexible satellite communication systems in managing the QoS. This chapter presents the standard DVB-S, its return channel via satellite (RCS) and the recent evolutions of this standard. Particular attention will be given to the QoS architecture promoted by the European Space Agency and the SatLabs group.

Chapter 4: Integration of Satellites into IMS QoS Architecture

The implementation of an integrated QoS architecture, compatible with terrestrial and satellite networks, is a significant challenge. After the presentation of various approaches in Chapter 3, this chapter examines an example of a successful integration in the IP multimedia subsystem (IMS) architecture.