Preparation for IPv6 in Satellite Communications

IABG Final Presentation
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Introduction – IABG at a glance

- IABG is a leading technical services company on the European market
- Founded in 1961
- 10 locations spread over Germany
- Headquarter in Ottobrunn near Munich
- About 1000 employees mainly working in different fields of engineering
- For more information see www.iabg.de
Introduction – IABG’s business areas

Automotive

Information & Communications

Transport & Environment

Aeronautics

Space

Defence
Main focus of our work on advanced IP services

- **IPv6**
  - IPv6 transition
  - Interoperability aspects

- **IP Security**
  - Security protocols (IPsec, SSL, TLS, …)
  - Security in WLAN, Hot Spots

- **IP Mobility**
  - Mobile end systems (MIP, HMIP,…)
  - Mobile networks
  - ad-hoc-networks (OLSR, AODV, …)

- **IP over Satellite**
  - IP over DVB, SCPC
  - Secure transmission via IPsec
  - TCP performance optimization

- **IP Multicast**
  - Multicast routing protocols
  - Secure multicast
  - Reliable multicast
Introduction – IABG‘s Teleport

- Local Internet Reseller (LIR) with IPv4 and IPv6 address range
- Peering with terrestrial IPv6 ISPs
- Provision of IPv6 over satellite service to Teleport customers
Introduction – **Key personnel in project**

- Wolfgang Fritsche (project manager)
- Karl Mayer
- Gerhard Gessler
- … and Prof. Peter Kirstein (UCL)
Introduction – Introducing IPv6 in satellite networks

- Identification of satellite specific issues for IPv6
- Specification of satellite architectures for IPv6
- Implementation of missing IPv6 functionality
- IPv6 support for satellite specific components
- Selection of transition mechanisms
- Specification of transition scenarios
- New / modified service models for IPv6 over satellite

Contribution to Standardisation Bodies
- Development of prototypes
- Performance of practical verification tests
- Promotion of potential of “IPv6 over satellite”
- Education of service provider, manufacturer, user, ...

Thinking the future
Introduction – Task overview

**T1**
Identification of satellite specific protocol issues for IPv6
- T1.1: Identification of link layer protocol issues for IPv6
- T1.2: Identification of network layer protocol issues for IPv6
- T1.3: Identification of transport layer protocol issues for IPv6
- T1.4: Identification of network management protocol issues for IPv6

**T2**
Impact of IPv6 on existing and future satellite network architectures and services
- T2.1: Impact of IPv6 on satellite network architectures
- T2.2: Investigation of transition scenarios for satellite networks
- T2.3: Investigation of modified service offerings using IPv6
- T2.4: Detailed transition plan for example satellite network architectures

**T3**
Definition and Preparation of IPv6 demonstrations over satellite
- T3.1: Identification of illustrating IPv6 functionality and applications
- T3.2: Description of possible demonstration scenarios
- T3.3: Selection and specification of the pilot

**T4**
Pilot demonstration of IPv6 over satellite
- T4.1: Integration of pilot
- T4.2: Execution of demonstration

**T5**
Identification of IPv6 roadmap and recommendation

**T6**
Dissemination of project activities and results

**T7**
Project and Quality Management
Agenda

- Introduction
- IPv6 general aspects
- Satellite specific protocol issues
- Modified service offerings
- Transition scenarios
- Demonstrations
- Dissemination
- Lessons learnt and recommendations
- Questions and discussion
IPv6 general aspects – **New features**

- IPv6 header with 128 bit addresses
- Extension headers (RH, DH, AH, ESP, …)
- Mandatory IPsec (in implementations with full IPv6 support)
- **IPv6 Neighbour Discovery (built-in mechanism)**
  - Address Resolution
  - Duplicate Address Detection
  - Neighbour Unreachability Detection
  - Router and Prefix Discovery
- **IPv6 stateless address autoconfiguration**
IPv6 general aspects – IPv6 stateless address autoconfiguration

IPv6 router

Router Advertisement

IPv6 host

Interface config:
- IPv6 link local address
- IPv6 global address
- IPv6 default router list

IPv6 host

Interface config:
- IPv6 link local address
- IPv6 global address
- IPv6 default router list

Link

Interface config:
- IPv6 link local address
- IPv6 global address
- IPv6 default router list

Int

Int

Int
IPv6 general aspects – **Bidirectional links and link multicast**

**IPv6 Neighbour Discovery**
- AR, DAD, NUD
- Router and Prefix Discovery

**IPv6 stateless address autoconfiguration**
IPv6 general aspects – Logical interface

Device 1
- IP layer
  - Logical Interface
    - Serial interface
    - IP → DVB

Device 2
- IP layer
  - Logical Interface
    - DVB → IP
    - Serial interface

DVB-S
SCPC simplex
IPv6 general aspects – UDLR mechanism

Unidirectional Link
e.g. DVB-S

Bidirectional Link
e.g. Ethernet

Encapsulation Overhead

Original IP packet

IP Header | GRE header | MAC header | Original IP packet
Thinking the future

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Satellite specific protocol issues – Link layer protocols

DVB-S link:

DVB-S protocol stack:

- Higher layer (e.g. IPv4 and IPv6)
- MPE
- ULE
- SE
- Others
- MPEG-2 Transport Stream
- DVB-S Physical Layer

MPE:
- IP version signalling?
- Address resolution?

ULE:
- Address resolution?
Satellite specific protocol issues – **Link layer protocols**

- **DVB-RCS link:**
  - IP version signalling in MPE?
  - Address resolution?
  - Unidirectional link or bidirectional link?
  - Connection Control Protocol?

- **SCPC link:**
  - Serial line protocols over SCPC
  - HDLC, Frame Relay, and PPP support IPv6
Satellite specific protocol issues – Network layer protocols

- **Header compression (HC)**
  - Problems with HC as specified in RFC 1144 (does only support IP/TCP traffic)
  - IPv6 support in HC as specified in RFC 2507 and ROHC (RFC 3095)

- **IP Multicast**
  - PIM-DM and PIM-SM (revised version) support IPv6
  - SSM, DVMRP, MOSPF, BGP-4+, and BGMP support IPv6
  - Proprietary multicast relay solutions for networks without multicast support often do not support IPv6 (e.g. OmniCast)

- **IPv6 Multihoming**
  - Large global IPv6 address space
  - Mobile IPv6 and HIP (Host Identity Protocol) support IP address change during ongoing sessions
  - IPv6 Multihoming can be done more efficient
Satellite specific protocol issues – Network layer protocols

- **Host mobility (MIPv4 and MIPv6)**
  - Bidirectional link between CN, HA, and MN required
  - Route optimization (RO) is built-in in MIPv6
  - Return Routability process (security check while RO) is delayed in case of satellite links → handoff time increases

- **Network mobility (NEMO)**
  - No route optimization

- **Mobile Ad Hoc Networks (MANETs)**
  - Topology of network is changing
  - MANET routing protocols support IPv6
Satellite specific protocol issues – Transport layer

- **Enhanced TCP**
  - Enhanced TCP protocols like TCP Tahoe, TCP Reno, TCP Vegas, TCP New Reno and TCP Santa Cruz operate above IPv4 and IPv6

- **PEP**
  - Protocol Enhancing Proxies (PEPs) are standardized in IETF for both, IPv4 and IPv6
  - Some PEPs (TCP splitting) break end-2-end transparency:
    - IPv6 assumes end-2-end transparency
    - IPsec support mandatory in IPv6
    - Hence, IPv6 could be affected more severe
  - PEP devices available mostly do not support IPv6, and hence, TCP over IPv6 traffic mostly cannot be enhanced
Satellite specific protocol issues – PEP without IPv6 support

Router A  PEP  Router B
IPv4
IPv6
IPv4

IPv6
IPv4
IPv4

Router A  PEP  Router B
**IPv6 support required in:**

- SNMP protocol \(\rightarrow\) SNMPv2, SNMPv3
- Agents, managers, applications \(\rightarrow\) e.g. Net-SNMP package
- Management Information Bases (MIBs) \(\rightarrow\) other objects
Satellite specific protocol issues – Network management

- **SNMP support:**
  - DVB-S: Network management is not specified
  - DVB-RCS:
    - SNMP Network Management is optional
    - missing: IPV6-MIB, IPV6-ICMP-MIB

- **IPv6 support in MIBs:**
  - DVB-RCS-MIB: Several objects of type IpAddress (32 bit)
  - Proprietary MIBs use IpAddress type: e.g. Harmonic and SkyStream

- **IPv6 support in management applications:**
  - Input/output fields often support only IPv4
  - Parsers often support IPv4 address format only
Several Authentication, Authorization and Accounting (AAA) protocols have IPv6 support e.g.:
- COPS (Common Open Policy Service)
- Diameter
- Remote Access Dial In User Service (RADIUS)

Bidirectional link requirement:
- COPS: TCP
- RADIUS: UDP
- Diameter: TCP
- Exception: Diameter could be based on SCTP (Session Control Transport Protocol), and SCTP INIT message includes peering IP address of the sender
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Modified service offerings – End-to-end IP addressing

- Issue in IPv4:
  - Not enough global unique IPv4 addresses available
  - Deployment of NAT boxes (Network Address Translation)
  - Deployment of Application Level Gateways (ALGs)

- Problem with NAT boxes and ALGs:
  - Break of end-to-end connectivity (principle of the Internet)
  - NAT and ALG represent a single point of failure
  - Any application with IP address info in the payload requires an ALG
  - ALGs cannot access payload when encrypted (IPsec)
  - NAPT has no information about related sessions (VoIP)
Modified service offerings – **IPsec**

- **ESP** encrypts upper layers (ports, TCP checksum)
- **AH** protects several fields in the IP header and upper layers
Modified service offerings – Voice over IP

**H.323 and NAT**
- Q.931: Call setup, H.245: Control, T.120: Data, RTP: Audio and video
- Several connections with related address information
  - H.245 address and port negotiation via Q.931
  - RTP/RTCP addresses and ports negotiated via H.245
  - H.245 connection can be encrypted → no payload change possible
- Difficult for ALGs to manage related sessions

**SIP and NAT**
- IP addresses and ports at several places in SIP messages
- Example: SIP INVITE message
  - IP addresses and ports in header and in SDP part
Modified service offerings

- **IP mobility**
  - MIPv6 has route optimization integrated
  - NEMO currently only specified for IPv6 as extension to MIPv6
  - NEMO allows for platform mobility support, such as aircrafts, ships, trains, vehicles

- **IPsec**
  - IPsec support mandatory in all nodes with full IPv6 implementations
  - No more NAT deployment → allows large scale deployment (e.g. IPsec over satellite)

- **CGAs**
  - Cryptographically Generated Addresses (only possible with IPv6)
  - Allows for node authentication without key infrastructure (e.g. satellite terminals)

- **IPv6 SAA**
  - IPv6 stateless address autoconfiguration
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Generic IPv6

transition scenarios
Transition scenarios – IPv6 support in satellite devices

- **DVB-S links: Modules/devices do not support IPv6**
  - DVB gateways
  - DVB receivers
  - Exceptions: New emerged devices with ULE support

- **DVB-RCS links: Modules/devices do not support IPv6**
  - DVB-RCS gateway
  - RCS Terminals

- **SCPC links: Modules/devices support IPv6**
  - Serial interfaces of routers
**Transition scenarios – Generic transition methods**

**Dual stack:**

- IPv6 network
- IPv4 network

**Tunneling** (e.g. configured, automatic, 6to4, 6over4):

- IPv6 network
- IPv4 network
- IPv6 network

**Translation** (e.g. NAT-PT, proxies):

- IPv6 network
- IPv4 network
Detailed transition plan for a DVB-S/RCS architecture
Thinking the future

Transition scenarios – DVB-S/RCS architecture with transparent satellite

Forward link (DVB-S)

Network 1

IP->DVB

DVB modulator

Satellite

DVB-RCS-IP

DVB-RCS demodulator

Network 2

IP->DVB-RCS

DVB-RCS modulator

DVB->IP

R1

I1A

Satellite

R2

I2B

Return link (DVB-RCS)

I1B

I2A
Transition scenarios – **DVB-S/RCS architecture with transparent satellite**

IPv6 network → DVB-RCS-IP → DVB-RCS demodulator → IPv6 network

IPv6 network → DVB-RCS-IP → DVB-RCS modulator → IPv6 network

IPv4 network
Thinking the future

Transition scenarios – DVB-S/RCS architecture with on-board switching
**Transition scenarios – DVB-S/RCS architecture with on-board switching**
**Transition scenarios – DVB-S/RCS architecture with on-board switching**

- **IPv6 network**
- **IPv6 over IPv4**
- **Native IPv6**

- **Separate IPv6 over IPv4 tunnel between all RCSTs**
- **Loss of IP multicast**

**IPv6**

- Terminal 1
- Terminal 2
- Terminal 3

**RCS**

**SAT**
Transition scenarios: DVB-S/RCS network status

Modifications required:
- IOS of Cisco routers
- Management applications
- Applications (Oracle 10g)

Replacement required:
- ISP with IPv6 support
- Traffic shaper
- DVB GW (e.g. ODG)
- RCS Terminals
- Database disk cluster

Transition costs:
- Software upgrades
- New devices
- Training for personnel
Transition scenarios: DVB-S/RCS network with IPv6 in IPv4 tunneling

Deployment case:
- Customers have IPv6 networks (more addresses)
- Customer wants to be connected to IPv6 Internet

Transition steps:
- Tunnel to IPv6 ISP or direct connection to IPv6 ISP
- Insert IPv6-capable router at branches
- IPv6 over IPv4 tunnels between R1 and router at branches
Detailed transition plan for a DVB-S/SCPC architecture
Thinking the future

Transition scenarios – Architectural overview

Unidirectional links
Thinking the future

Transition scenarios – Long-term solution for receiving side

- **New components**
- **Modified components**

- Upgrade router to OS with IPv6 support
- Replace OS on DVB-S receiver with one with IPv6 support
- Use IPv4 and IPv6 capable DVB-S receiving card
Thinking the future

Transition scenarios – Long-term solution for hub

- Use ISPs with IPv6 support
- Use ULE DVB-S gateway
- Replace OS on DVB-S receiver with one with IPv6 support
- Use IPv4 and IPv6 capable DVB-S receiving card
- Upgrade router OS
- Upgrade OSs of web server, monitoring systems, ... plus applications
Transition scenarios – Use of tunnelling as short-term solution
Transition scenarios – Use of tunnelling as short-term solution

- Use ISPs with IPv6 support (native or tunnelled)
- Establish IPv6 over IPv6 tunnel on DVB-S link
- Upgrade router OS on tunnel end points
Transition scenarios – Cost factors for a Teleport

- IPv6 training for Teleport personnel (depends on service)
  - Operational staff: 2 weeks
  - Sales people: 1 week
  - Hotline people: 2 days

- IPv6 training for customers: Depends on their experience / intended service

- Costs for new equipment and upgrades
  - DVB-S sender equipment:
    - ODG: 6 DVB carriers per device
    - 6WIND or dpi4506: One DVB carrier per device
  - Receiver device: PC with Pent@Value card 1500,- €
Thinking the future

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Demonstration of advanced IPv6 services on IABG’s Teleport
Demonstrations – overview

- Hub station
  - CN
  - HA
  - IPsec1
  - 6W
  - IP-DVB
  - DVB modulator
  - SAT
  - IP-DVB
  - DVB-S link (PID1)
  - DVB-S link (PID2)
  - Ethernet link 1 (representing DVB-RCS link 1)
  - Ethernet link 2 (representing DVB-RCS link 2)

- Branch station 1
  - RX-PC1
  - AP1
  - IPsec2
  - DVB->IP

- Branch station 2
  - RX-PC2
  - AP2
  - DVB->IP

Roaming connection

CN’
IPv6 audio (RAT) and video (VIC) conferencing worked fine via satellite.

Mobile IPv6 and IPsec worked fine via satellite (even together).

The Mobile IPv6 handoff time has been increased by the satellite link in the middle (from around 3s to around 5s).

RAT and VIC both worked via an IPsec secured satellite link.

VIC also has been successfully demonstrated together with Mobile IPv6 over satellite.

RAT didn't run on the Linux kernel version required by Mobile IPv6.
Demonstration with the SILK project
Prof. Peter Kirstein (UCL)

Chair of the SILK Executive Board
Demonstrations – **SILK demonstration at a glance**

- **Intention**
  - Demonstrate IPv6 over satellite functionality
  - Establish a longer trial for collection of more detailed results
  - Involve a real, large user community
  - Gain experience in a real operational environment
  - Generate awareness / educate on IPv6 over satellite

- **Contributions from ESA project**
  - Satellite capacity (2 Mbit/s on DVB-S, 600 kbit/s on SCPC) for a 3 months trial
  - Equipment for setting up a native IPv6 service over DVB-S (modulator, ULE encapsulator, ULE receiver cards)
  - Support during the integration phase
  - Guidance / training of the SILK community

- **Involved SILK countries: Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan and Uzbekistan**
Demonstrations – Enhancing the SILK network architecture

IPv4 / IPv6 network

GEANT

IPv4 / IPv6

SCPC modulator

DVB-S1

SCPC1

DVB-S2

IPv6 DVB-S receiver

IPv4 / IPv6 research network

IPv6 DVB-S receiver

IPv6 DVB-S receiver

IPv4 / IPv6 research network

IPv6 DVB-S receiver

IPv4 / IPv6 research network
Demonstrations – IPv6 integration phases for SILK (1/2)

Phase 1

- Procurement / loan of required HW + SW
- Test and configuration of ULE equipment at IABG
- Assembly of installation guidelines (may need to be translated to Russian by SILK)
- Shipment of components to SILK partners
- Upgrade of SILK 7200 routers
- Connection of DESY to GEANT

Phase 2

- Installation at DESY plus local tests
- Installation of ULE at SILK sites with phone support if required
- Installation of local test beds / systems at SILK sites
- Final test
Demonstrations – View of the SILK hub site
Phase 3
- 3 months duration (currently ongoing)
- Test / use / demonstration of IPv6 over satellite capability by SILK partners, e.g. use for audio / video conferencing (will be demonstrated after break)

Phase 4
- ½ month duration
- Dismantling of equipment at DESY and return to ESA or continuation in some other form
Thinking the future

Demonstrations – Monitored Round-Trip-Delay

Average Round-Trip-Delay

Measurement every 60 Minutes (24h/7d)
13.08.2004 - 17.09.2004

IABG Final Presentation
Demonstrations – Monitored Jitter

Measurement every 60 Minutes (24h/7d)
13.08.2004 - 17.09.2004

Azerbaijan
Georgia
Kazakhstan
Uzbekistan
Demonstrations – Lessons learnt from this trial

- IPv6 runs quite stable in SILK
- Integration with existing IPv4 service had been possible without any problems
- Training of administrator staff and user community is absolutely required (mainly on ULE and IPv6 in general)
- Cross-trapping service between EurasiaSat-1 East and West beam is difficult to negotiate with satellite operator
- Support of 8PSK for DVB-S sender and receiver would have been appreciated
- Lack of sufficient management possibilities / separation of IPv4 and IPv6 management is a burden
- Valuable experience has been collected due to involvement of a real, large user community
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- Dissemination
- Lessons learnt and recommendations
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Dissemination – Example activities

- Fora and Task Forces
  - IPv6 Forum
  - European and national IPv6 Task Forces
  - IPv6 cluster

- Conferences
  - ESA IP networking over satellite workshop
  - 6NET IPv6 spring conference
  - German IPv6 summit
  - Asian Pacific Advanced Networking (APAN) conference

- Manufacturer
  - Mentat
  - Skystream

- Projects
  - SILK
  - INSC

- Press
  - Heise News ticker
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Lessons learnt and recommendations

Lessons learnt
Lessons learnt

- Satellite specific protocol issues
  - MPE encapsulation lacks native IPv6 support
  - IPv6 stateless address autoconfiguration won’t work on many satellite architectures (UDLR could help here)
  - Proprietary functionality like PEP often lacks IPv6 support
  - Mandatory IPsec support could conflict with some PEP scenarios
  - Management functionality for most satellite equipment often lacks IPv6 support

- Modified service offerings
  - Mandatory IPsec support allow for encryption of satellite link from hub to terminal (less conflicting with PEPs)
  - Larger deployment of VoIP over satellite in Asia / Middle East
Lessons learnt – continued

Transition scenarios
- Introduction of IPv6 should be done in a dual-stack way
- Non IPv6 ready parts (e.g. DVB-S links) should be tunnelled
- Finally missing IPv6 functionality should be added by manufacturer

Demonstration
- Setting up ODG based ULE encapsulator worked straightforward
- Setting up Pent@Value based ULE receiver is sensitive to Linux system configuration
- Pent@Value solution doesn’t support 8PSK (however, ULE is now part of Linux kernel and should therefore work with more DVB-S receiving cards)
- Once configured, ODG and Pent@Value receiver run stable
- Advanced IPv6 functionality like security and mobility support runs smoothly over satellite (increased handoff delay)
Recommendations
Add missing functionality to satellite products

- ULE support for DVB-S sender and receiver, alternatively extension of MPE to support IPv6
- IPv6 support for management systems
- IPv6 support for PEPs
Recommendations – Standardisation

- IETF ipdvb WG
  - Finally standardize ULE
  - Work on more dynamic address resolution mechanisms (for IPv4 and IPv6)

- ETSI DVB
  - Clarify the distinction of IPv4 and IPv6 packets carried in MPE without using LLC/SNAP

- ETSI DVB-RCS
  - Push / investigate the combination of forward and return link into one logical interface
  - Add full IPv6 support to DVB-RCS MIB
It’s time to start with “IPv6 over Satellite” deployment

- Deployment in R&D projects
  - ESA „IPv6 over Satellite“
  - EC „SATIP6“
  - NATO „INSC“

- Deployment in „pre-commercial“ projects
  - SILK project
  - WIDE project

- Offering of commercial services
  - Service offering on Teleports
**Dissemination is important to …**

- Generate Awareness
- Push for missing standardisation work
- Push for missing product functionality
- Educate users
- Bring together manufacturer, service provider and user
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Are there any questions?
For any further questions please contact …

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