Architectural proposal for Federated Satellite/Terrestrial Software Networks in the 5G Context

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Structure of Presentation

- Introduction / Concept
- Use Cases and Requirements
- Architectural Proposal
- Technical Evaluation/Experimentation end
- Economic Assessment
- Roadmap and Recommendations
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Architectural Proposal
Technical Evaluation/Experimentation end
Economic Assessment
Roadmap and Recommendations
The CloudSat project at a glance

Programme

• ESA ARTES Future Preparations (form. ARTES 1)

Overall objective

• To study and assess the interplay of cloud networking/virtualization technologies with satellite telecommunications, highlighting opportunities, issues and perspectives.

Duration

• 15 months (September 2014 – November 2015)

Team

• Space Hellas S.A. – Prime Contractor (GR)
• Thales Alenia Space France (FR)
• Telefonica I+D (ES)
• NCSR “Demokritos” (GR)
Federated Satellite/Terrestrial Software Networks

- Network abstraction, slicing and federation via softwarisation techniques (SDN/NFV)
- In-network Virtual Network Functions (VNFs)
- Over heterogeneous terrestrial and satellite infrastructure

- **Main Goal**: Inclusion of the satellite component, with its inherent benefits (global coverage, high bandwidth etc.) in 5G software-based networks.
- **Main Challenge**: Application of software network technologies (SDN/NFV) to satellite networks
The CloudSat approach

Definition of functional architectures representing integrated satellite/terrestrial cloud networks and their interfaces; assessment of the proposed architectures from a technical and economic point of view.
SDN/NFV applicability to satcom
SDN/NFV in satcom: SWOT analysis consolidation

**Key strengths**
- New services to customers
- CAPEX/OPEX reduction
- Smoother integration for 5G
- Evolutionary deployment possible

**Key weaknesses**
- Stability and security issues for virtualised services critical for satcom
- SDN not suitable for PHY/MAC configuration
- SDN/NFV capabilities at payload and terminal require considerable resources

**Key opportunities**
- SDN and NFV markets rapidly growing (>50% CAGR by 2023)
- SDN and NFV technologies are evolving and supported by wide community initiatives

**Key threats**
- SDN and NFV proven in testbeds but not yet deployed in production networks
- SDN and NFV landscape is still evolving; TRL still low
Use Cases for Satellite SDN/NFV

- Elastic Bandwidth-on-Demand
- Hybrid media distribution network as-a-Service
- Virtual CDN as-a-Service
- Federated Terrestrial-Satellite VPN
- Satellite Virtual Network Operator (SVNO)
- Programmable Payloads and flexible ISLs
- Dynamic backhauling with edge processing
- Customer functions virtualisation

Primary application domains: content distribution, broadband access, M2M/IoT, real-time communications
UC#1: Hybrid Media Distribution Network as-a-Service
UC#2: Dynamic backhauling with edge processing
UC#3: Customer Functions Virtualisation
Key architectural concepts and components

- **Discrete satellite and terrestrial domains**, maintaining administrative independency
- **Federated management entity** for joint management of satellite and terrestrial
- **NFVI-PoPs** (in-network clouds) for accommodating VNFs
- **Two-tier hierarchical management structure** to support heterogeneous infrastructure segments within the domain (e.g. cloud and transport networks, SDN and non-SDN networks etc.)
- **Service interface to customers** (via front-end portal) for both GUI and programmatic access
CloudSat reference architecture
Single-operator variant
Proof-of-Concept implementation

- Satellite Emulator
  - OpenSAND
- NFV Infrastructure
  - Openstack Liberty
- SDN Programmable Network
  - OpenFlow 1.3 switch
  - OpenDaylight Lithium
- Federated Management
  - Programming Scripts
  - APIs of:
    » OpenStack
    » OpenDaylight
Testbed topology

Openstack Compute Cluster

OpenSAND Gateway

OpenFlow Virtual Switch

OpenSAND Satellite Emulator

OpenSAND Satellite Terminal

User Terminal (hybrid access)

Cloud/NFV Controller (OpenStack)

Orchestrator module

SDN Controller (OpenDaylight)

Application Server

Openflow Switch

Openflow Switch

Wi-Fi

Terrestrial Network Segment

Satellite Network Segment

Management/Orchestration Segment
Indicative UC: Customer Functions Virtualisation

- VNF1: Firewall
- VNF2: TCP accelerator
- VNF3: Web cache
Findings of Cost Benefit Analysis

• The introduction of NFV/SDN in SATCOM industry may bring

  • CAPEX cost reduction
    » GEO 18.78%
    » MEO 29.03%
    » LEO 41.10%

  • Increased Revenues due to the NFV-based value-added services
    » Use-case #1 Discounted Payback: 2 Years 5 Months
    » Use-case #2 Discounted Payback: 3 Years 7 Months
    » Use-case #3 Discounted Payback: 2 Years 10 Months
Future works recommendation/roadmaps

TERRESTRIAL domain

*Increase of maturity of the technologies and their operational usage*

**Payloads**

- **Actions Target:** Development/prototyping of on-board HW and OS architecture to be "SDN/NFV ready"

**Ground**

- **Actions Target:** Enabling SDN/NFV loose integration

SATCOM domain

**Actions target:**

- Full support of standard virtualization interfaces
- Convergence of space segment/ground segment control (vHTS, MEO/LEO, megaConstellations)

**Actions Target:**

- Extension towards PHY/MAC layer virtualization ?
- Terrestrial/satellite integration (e.g. 5G)
- Standards evolution

**Technical developments**
- Identify key services/functions
- Identify/develop the new APIs
- NMS + BSS/OSS evolution
- Get technical feedback from service providers

**Confirm/develop satcom business cases**
- Dynamic/virtual provisionning of services
- Virtual satcom operators and providers
SDN/NFV extensions for better integration with satcom

- SDN support for **satcom-specific fields** (e.g. MPEG-2TS / ATM / ULE / GSE fields in DVB architectures)
- **Limitation of controller<>fabric communication overhead** (to allow remote SDN control over satellite)
- SDN extensions for **PHY and MAC control** (resource management)
- Extension of the Cloud-RAN concept for **multi-GW configurations**
- Adaptation of NFV management and execution platforms to accommodate **resource constrains** (payload, terminal)
- Integration with **satcom OSS/BSS**
Candidate targets for tracking & contribution

SDOs

- ONF
- ETSI
- ITU

Open-source initiatives

- OpenStack
- OPNFV
- OpenDaylight
Follow-up activities

• **Close observation of virtualization technologies** and developments by the different parties.

• **Engagement of stakeholders;** Feedback from satcom Service Providers and Customers is of utter importance

• **Prototyping and testing** of different kinds of SDN / NFV-enabled solutions and platforms.

• TRL elevation via **H2020 (&5G) and ESA projects**
Thank you for your attention!