Mobile Cloud – Combining EPC, SDN and NFV

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About the Speaker

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Scientific work and PhD focus on:

- Evolved Packet Core (EPC)
- Software Defined Networks (SDN)
- Policy Control and Flow Based Charging
- Cross-Layer Composition within NGNs and Fi

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Competence Center Next Generation Network Infrastructures (NGNI)
Agenda

• Introduction and Problem Statement
• Virtualization Trends: SDN and NFV
• Telecommunication Core Network Evolution
• Project OpenSDNCORE
• Concept, Implementation and Validation
• Conclusion and Future Work
Introduction and Problem Statement

• Main trends in today (mobile/fixed) telecommunication networks
  – Heterogeneous and partially RAN deployment (WiFi, 4G, Femto Cells, ...)
  – Limited spectrum and radio capacity (800, 1.800 and 2.600 MHz for LTE in DE)
  – Increasing number of mobile devices (smartphones, tablets, laptops, ...)
  – Always on - quasi permanent connection between the device and the network
  – High bandwidth demands – large variety of apps and multimedia services
  – Cheaper flat-rate tariffs offered by the network operator
  – Strong grows in IP data and 3GPP Diameter protocol signaling

• Key research challenges:
  – Handling the IP data and Diameter signalling traffic grows efficiently, QoS, mobility, security, Network-as-a-Service (NaaS), elasticity and flexibility on the data path, etc.

• Today’s approaches: Access- and core network congestion handling approaches
  – TR 22.805 FS_UPCON Study on “User Plane Congestion Control”
  – TR 22.806 FS_ACDC Study on “Application specific Congestion control for Data Connectivity”
  – TR 23.843 FS_CNO Study on “Core Network Overload solutions”
  – 3GPP Policy Control and Charging (PCC) architecture (TS 23.203)
SDN & NFV Definitions and Concepts

- **Software Defined Networks (SDN)**
  - Definition: ‘Physical separation of the network control plane from the forwarding plane’ (ONF)
  - Open Networking Foundation (ONF)
    - [https://www.opennetworking.org/index.php](https://www.opennetworking.org/index.php)
  - Source: ONF Spec. OpenFlow v1.4.0

- **Network Function Virtualization (NFV)**
  - Definition: ‘Decouple software from dedicated hardware. Modular Virtual Network Functions (VNF) run on COTS hardware.’
  - ETSI Industry Specification Groups (ISG)
  - Source: Network Functions Virtualisation – Update White Paper 2
Core Network Evolution Strategies

- Short term optimizations
- Enhancing capacity through improving system performance
- Overprovisioning: Adding additional redundant components
- 3GPP Access- and core network congestion handling approaches

3GPP Core Network Architecture

- SDN: Separation of data- and control-path
- NFV: Flexibility in controlling architecture components
- Elasticity in data- and control-path
- Smart usage of network resources
- Dynamic Service Chaining

Keeping the current architecture: Performance Enhancements

Evolving the current architecture: Applying virtualization concept
Mobile Core Network Architecture Evolution Path

GPRS
  GGSN
  SGSN
  BSC
  BTS

UMTS
  GGSN
  SGSN
  RNC
  NodeB

HSPA r7
  GGSN
  SGSN
  RNC
  NodeB

HSPA r8
  GGSN
  SGSN
  RNC
  NodeB

SAE/EPS r12
  PGW
  SGW
  MME
  eNB

SAE/EPS + SDN/NFV
  PGW
  SGW
  MME
  eNB

Control Plane
OpenFlow Control Plane
Data Plane
Business Driver: Elastic and Flexible Network Design - Example EPS

- Elastic network design aligned on real-time network load situations
- Enablement and disablement of redundant access- and core-network elements
- Optimized energy consumption of the access- and core-network
- Network Resources as a Service (NRaaS) and on demand

IEEE ICCCN'13
IEEE SDN4FNS'13
Traffic Pattern, Traffic Demands and Line Cards

- Definition of a “Traffic Pattern”
- Definition of a “Traffic Demand” as capacity requirements
- Awareness power consumption [1,2]

Routing Formulation as Mixed Integer Program (MIP)

- **Goal**: Definition of an *optimization schema* that *minimizes the weighted operational costs* arising in each of the *traffic pattern and active network element* that we need to support.
- Fat tree network topology design of physical network model: $G = \{V, E\}$
- Enriching topology model $G$ with meta data
  - Physical line cards per switch/node
  - Physical interconnection as links between line cards (connectivity map)
  - Edge with maximal capacity of each physical link $\{u, v\}$
    - Active links have costs
- Approach: Dantzig-Wolfe reformulation as Mixed Integer Program
OpenEPC Rel. 5: Mirroring the Future Operator Core Network

- OpenEPC includes the main functions of 3GPP Evolved Packet Core (3GPP Release 8→12)
- The principles of standard alignment, configurability and extensibility have been respected in the overall architecture and in the specific components implementation
- OpenEPC Rel. 5 enables the establishment of small operator network testbeds including
  - Core network mobility support (GTP, PMIP)
  - Deep integration with real LTE, 3G, 2G and WiFi
  - AAA for 3GPP and non-3GPP accesses
  - Policy and Charging Control
  - Access network selection
  - Common mobile equipment support

PLEASE NOTE: OpenEPC does not claim 100% standard compliance, but allows for early prototyping
User Plane Realization – SDN with OpenFlow 1.4.0

• For user plane handling, OpenEPC Rel. 5 includes the development of an initial SDN solution
  – Splitting of gateways into Control and multiple Switches
  – Communication via OpenFlow protocol 1.4.0
  – Flexible deployment of control components
  – Flexible data traffic management through elastic network design

• SDN Controller:
  – OpenFlow 1.4.0 protocol support
  – JSON-RPC API for OpenFlow Controller Applications
  – Integration with SGW and PGW control entities

• Integration with OpenSDNCORE Switch (www.opensdncore.org)
  – Support for GTP and GRE encapsulation
  – Metering Tables extensions
OpenSDNCore

- OpenSDNCore is a practical implementation of a future core network based on the latest network evolution paradigms:
  - Software Defined Networks (SDN) – flexible data plane
    - Separation of control and data plane
    - Flexible forwarding mechanisms
    - Aggregated control plane
  - Network Functions Virtualization (NFV) – flexible service plane
    - Self-orchestration of network components
    - Network topology awareness
- Self-adaptable connectivity on different levels and scopes
  - Orchestrator – service life cycle mgmt. and control
  - Control Plane – integrating novel Internet and Telecom principles in a simplified modular manner
  - Data Path – plane data plane forwarding functions
- OpenSDNCore is a non-open source, standards inspired toolkit designed for adaptable deployments
Evaluation of Wharf based OpenFlow Switch Implementation

• Four types of measurements have been performed.
• (1) A none-OpenFlow maximum point-to-point link connection without any involvement of a switch.
• (2) The latest OpenVSwitch kernelspace implementation version 1.9.3.
• (3) The latest OpenFlow reference switch implementation version 1.3 (last commit 08/09/13).
• (4) Our OFS implementation based on the Wharf platform.

Switch: Dell manufactured motherboard (0TP412), an Intel Core2 Quad processor and 4 Gbyte of DDR2 667 MHz RAM. Network connectivity is provided by one Intel 82571EB dual port 1 Gbit/s and one Intel 82575GB quad port 1 Gbit/s NICs plugged into PCI-Express bus. The operating system is Linux Ubuntu 12.04.3 LTS, kernel version 3.8.0-29-generic.
Traffic generators: are ASUSTeK Eee Boxes with an Intel(R) Atom(TM) CPU N270 @1.60GHz CPU
Mobile-Cloud Networking (MCN)

• MCN project high level objectives
  – develop a novel mobile "network" architecture and technologies, using proof-of-concept prototypes, to lead the way from current mobile networks to a fully cloud-based mobile communication system
  – extend cloud computing so as to support on-demand and elastic provisioning of novel mobile services
• Extend the Concept of Cloud Computing Beyond Data Centres Towards the Mobile End-User
• Start November 1st, 2012 for 36 month
• Website: http://mobile-cloud-networking.eu/site/
Summary and Outlook

Summary

• Business Driver: Elastic and Flexible Network Design, Flexible data path, Network as a Service
• Telco Network Evolution – influences of SDN and NFV
• Project OpenSDNCore
• Concept, Implementation and Validation

Outlook

• Service placement / location algorithm
• Validation on large scale physical networks
TUB and FOKUS Publications on SDN, Traffic Engineering and Network Management

References

- OpenEPC, [http://www.openepc.net](http://www.openepc.net)
- OpenIMSCore, [www.openimscore.org](http://www.openimscore.org)
- OpenSDNCore, [www.opensdncore.org](http://www.opensdncore.org)
- NGN to Future Internet Evolution, NGN2FI, [www.ngn2fi.org/](http://www.ngn2fi.org/)
- FP7 IP Project Mobile-Cloud Networking, [https://www.mobile-cloud-networking.eu/](https://www.mobile-cloud-networking.eu/)
4th FOKUS „Future Seamless Communication“ Forum (FFF) Berlin, Germany, November 28-29, 2013

- **Theme:** „Smart Communications Platforms for Seamless Smart City Applications – Fixed and Mobile Next Generation Networks Evolution towards virtualized network control and service platforms and Seamless Cloud-based H2H and M2M Applications“

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  - FFF 2011 was attended by around 200 experts from 30 nations
  - FFF 2012 was attended again by around 200 experts from 30 nations

- See [www.fuseco-forum.org](http://www.fuseco-forum.org)

Workshop 3:
"Evolution of the Operator Networks beyond EPC: SDN and NFV"
Questions ???

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