

Design and Implementation of a Carrier Grade Software Defined Telecommunication Switch and Controller

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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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Next-Generation-Networks*

Fraunhofer Institute FOKUS

*Competence Center Next Generation Network
Infrastructures (NGNI)*

Agenda

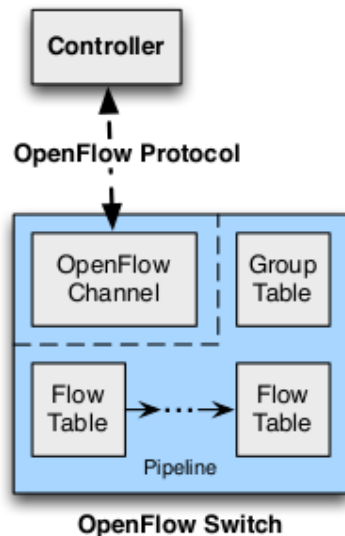
- Introduction and Problem Statement
- Virtualization Trends: SDN and NFV
- Telecommunication Core Network Evolution
- Project OpenEPC
- Concept, Implementation, Validation and Evaluation
- Conclusion and Future Work

Introduction and Problem Statement

- Main trends in today (mobile/fixed) telecommunication networks
 - Heterogeneous and partially RAN deployment (802.11ac, LTE/LTE-A, Small 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 active connectivity 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
 - Inflexible policy and charging models
- 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)

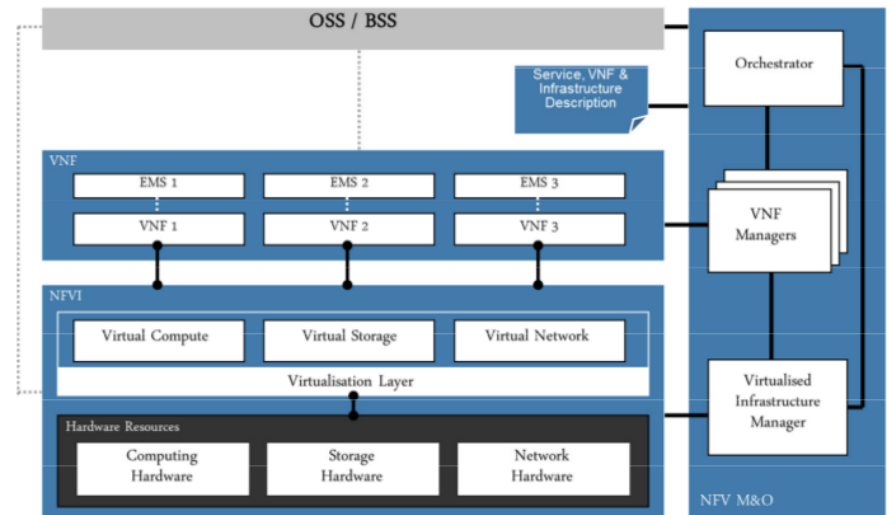
SDN & NFV Definitions and Concepts

- 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>



- 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)
- <http://portal.etsi.org/portal/server.pt/community/NFV/367>



- Source: Network Functions Virtualisation – Update White Paper 2

Core Network Evolution Strategies

3GPP Core
Network
Architecture

Keeping the current
architecture:
Performance
Enhancements

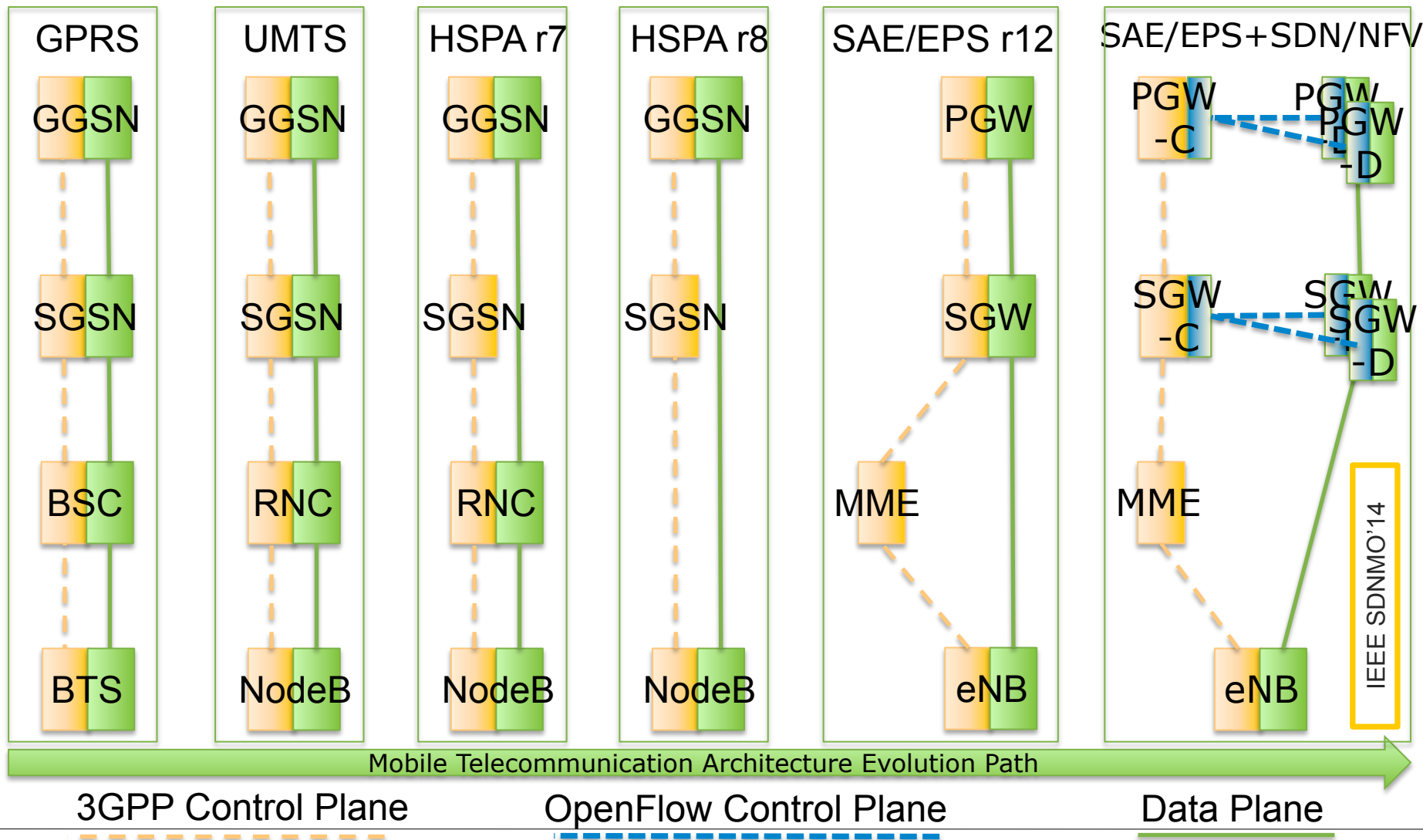
- Short term optimizations
- Enhancing capacity through improving system performance
- Overprovisioning: Adding additional redundant components
- 3GPP Access- and core network congestion handling approaches

Evolving the current
architecture:
Applying virtualization
concepts

- 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

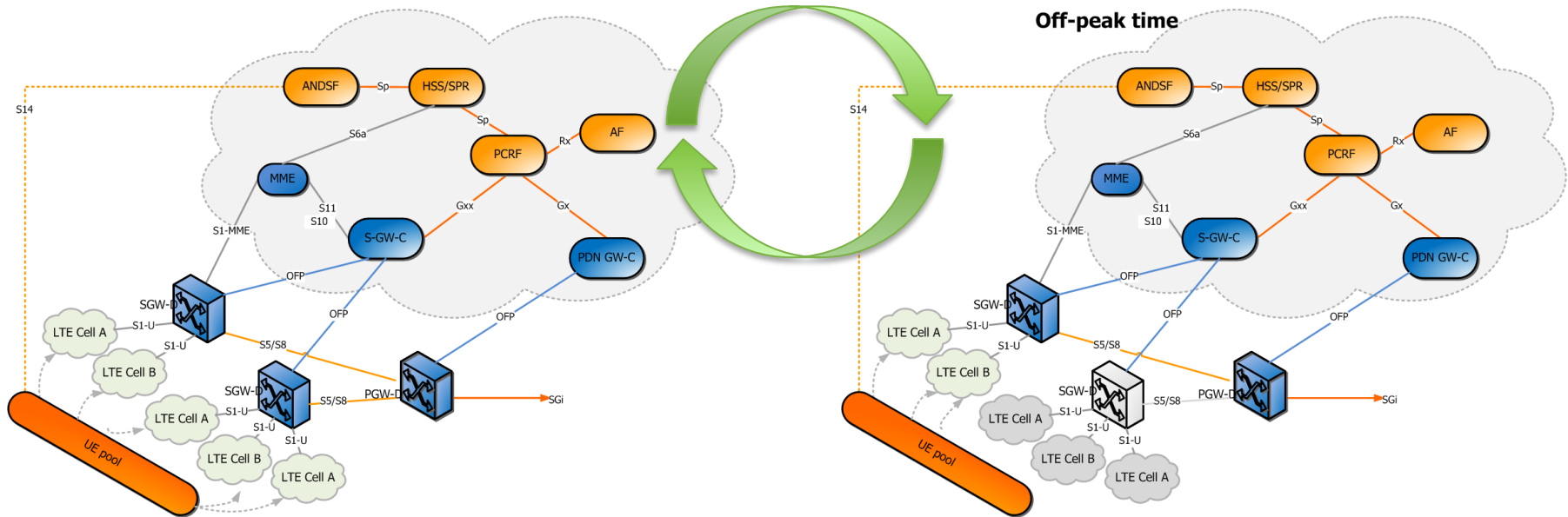
Time

Mobile Core Network Architecture Evolution Path



Business Driver: Elastic and Flexible Network Design - Example EPS

- Other Business Driver: Multi Tenancy, Redundancy, Efficiency, Service Chaining



- 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

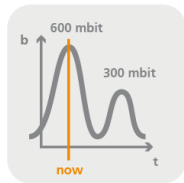
IEEE ICCCN'13

IEEE SDN4FNS'13

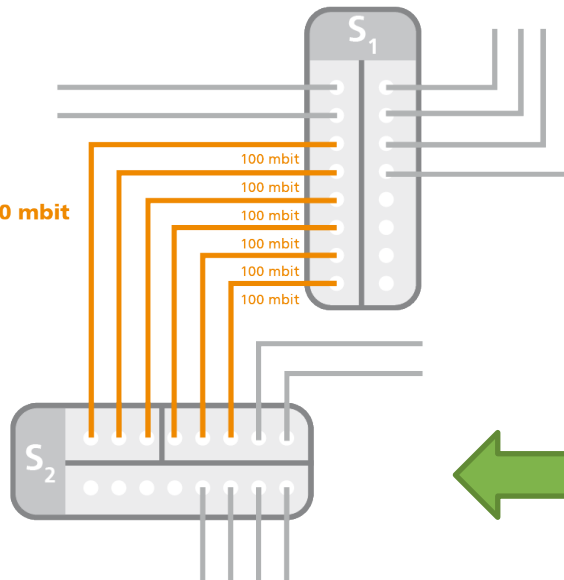
Traffic Pattern, Traffic Demands and Line Cards

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

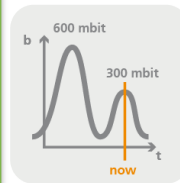
Physical Network



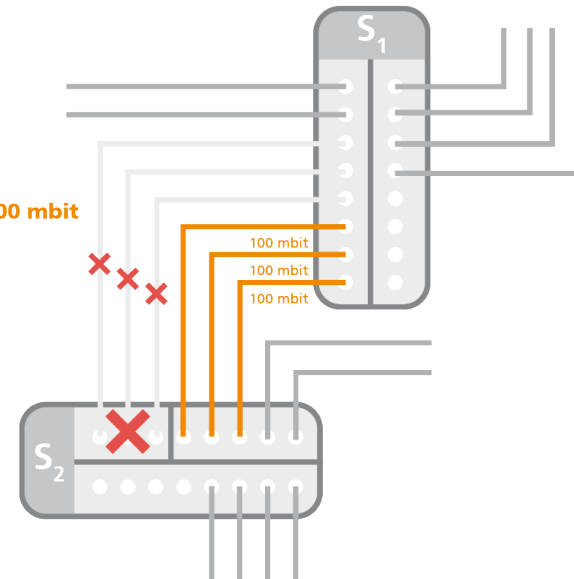
cap=600 mbit



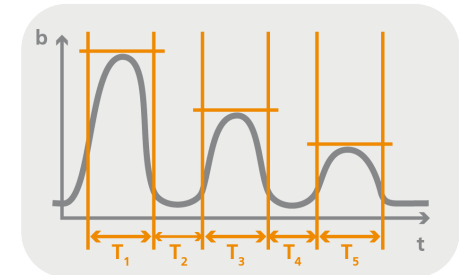
Physical Network



cap=300 mbit



How to choose traffic patterns?



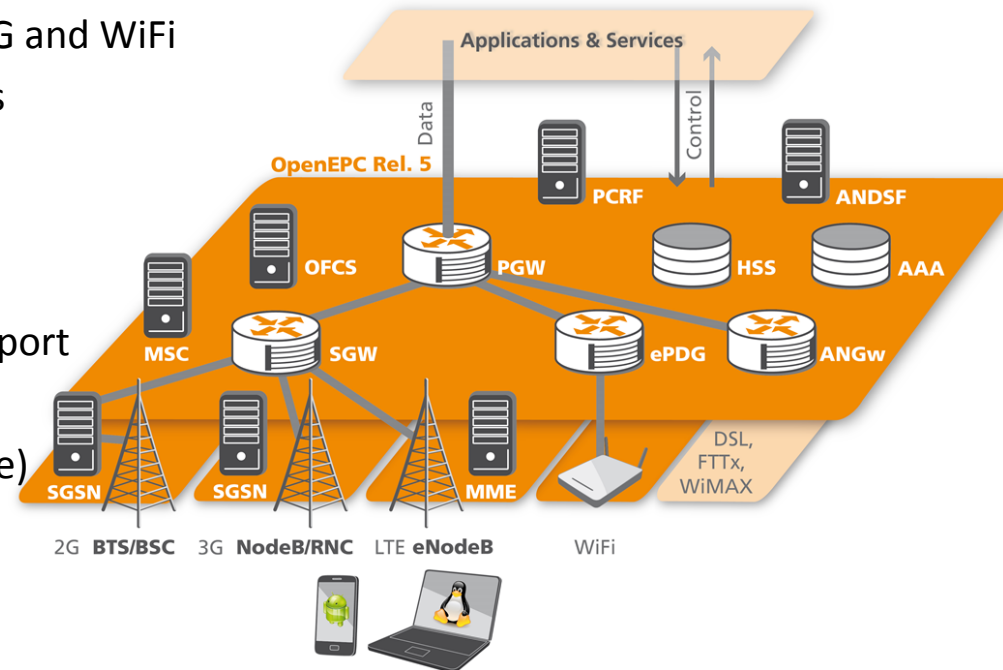
IEEE SDN4FNS'13

OpenEPC Rel. 5: Mirroring the Future Operator Core Network

open epc++
core net *dynamics*

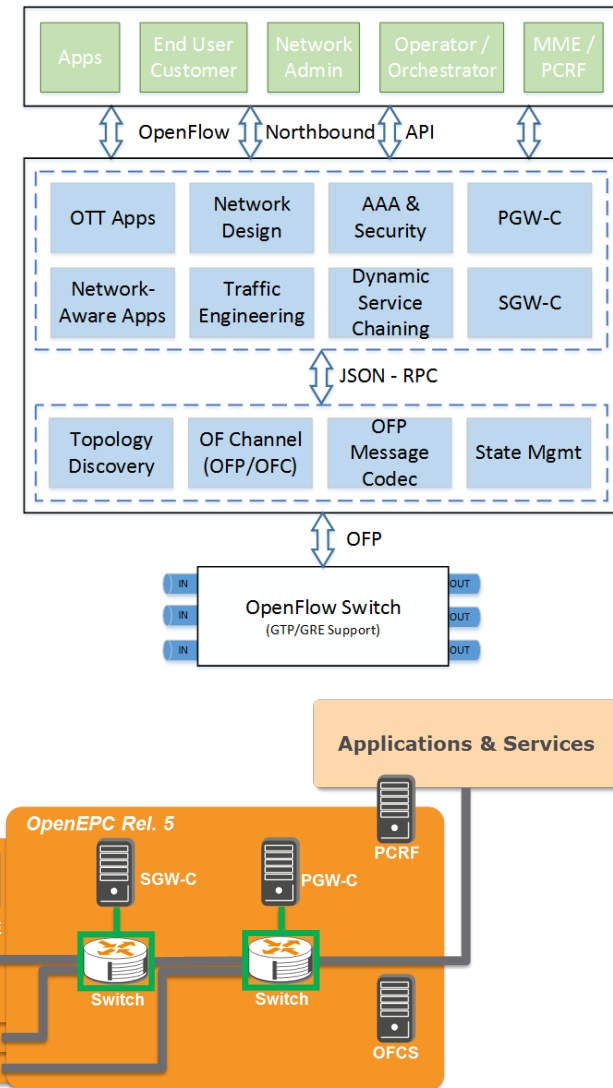
- OpenEPC includes the main functions of 3GPP Evolved Packet Core (3GPP Release 8→12)
- The principles of standard alignment, configurability and extensibility have been respected in the overall architecture and in the specific components implementation
- OpenEPC Rel. 5 enables the establishment of small 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
 - Gateway split for SDN/OpenFlow support
- Support for multimedia services and IP Multimedia Subsystem (OpenIMSCore)

PLEASE NOTE: OpenEPC does not claim 100% standard compliance, but allows for early prototyping



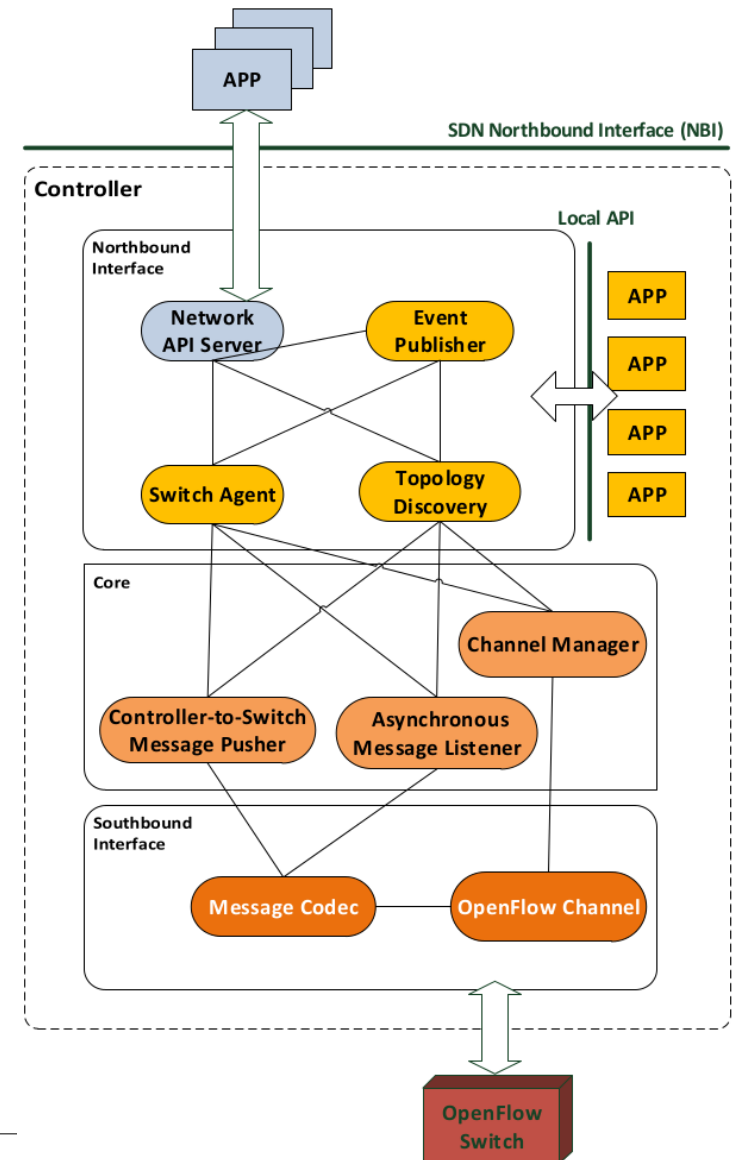
User Plane Realization – SDN with OpenFlow 1.4.0

- 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 (green networks, demand oriented network dimensioning)
- SDN Controller implementation:
 - OpenFlow 1.4.0 protocol support
 - JSON-RPC API for OpenFlow Controller Applications (NBI)
 - Topology Discovery
 - Integration with SGW and PGW control entities
- SDN Switch implementation:
 - Support for GTP and GRE encapsulation
 - Metering Tables extensions
 - Monitoring



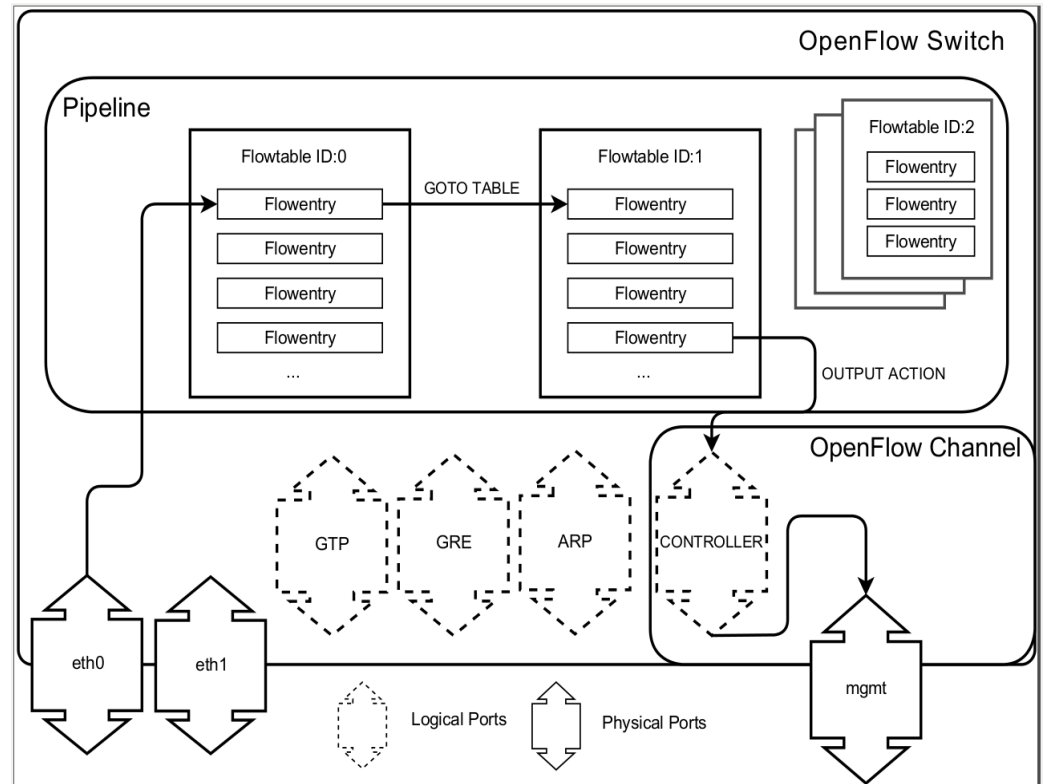
SDN Controller Architecture

- Three OF controller planes
 - JSON RPC northbound interface towards applications
 - Core controller modules
 - Southbound interface towards OF switches
- Interfaces towards
 - API for local applications
 - SDN Northbound Interface (NBI)
- OpenFlow channel in version 1.4.0

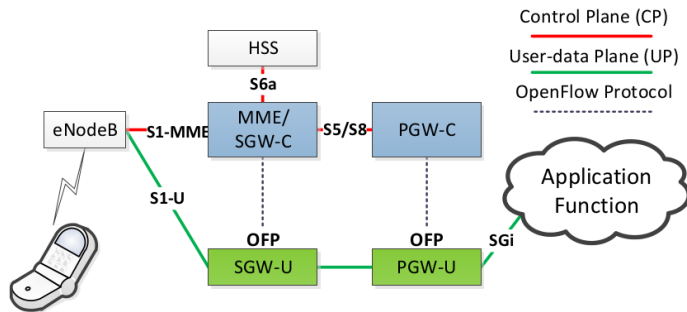


SDN Switch Architecture

- Support of multiple physical and virtual ports
 - Basic switching
 - Protocol en-/de-capsulation
 - OpenFlow channel
- Pipeline processing
 - Flowtable and flowentry
 - Goto-Instructions sets
- Hash based flowtable lookup strategies

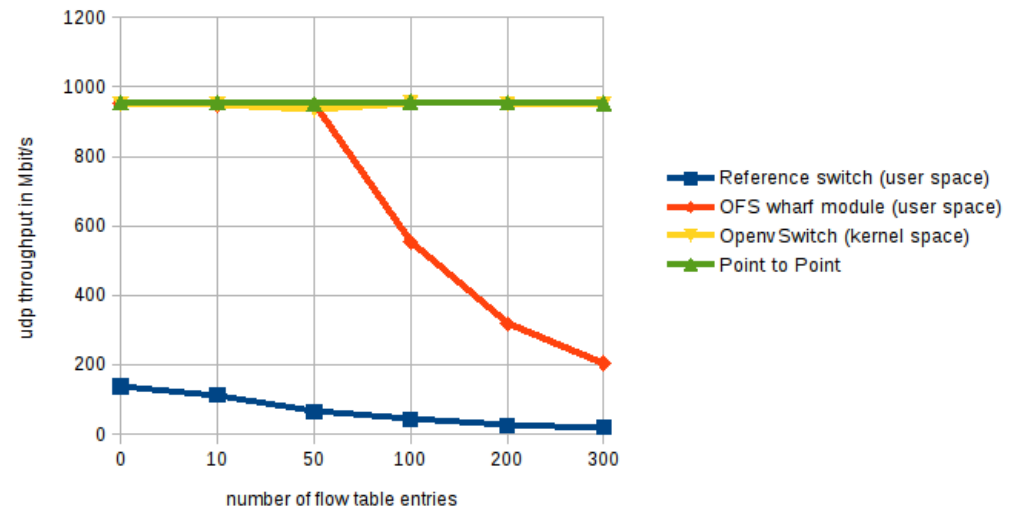


Evaluation of Wharf based OpenFlow Switch Implementation



- 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) Fraunhofer FOKUS OFS implementation based on the Wharf platform.

OpenFlow Switch UDP throughput comparison



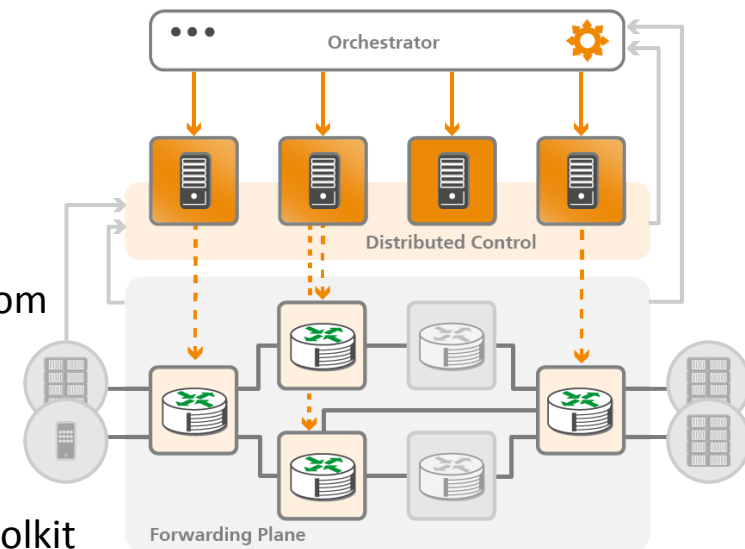
(Each measurement has been performed four times and the mean value is presented in the evaluation above)

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

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

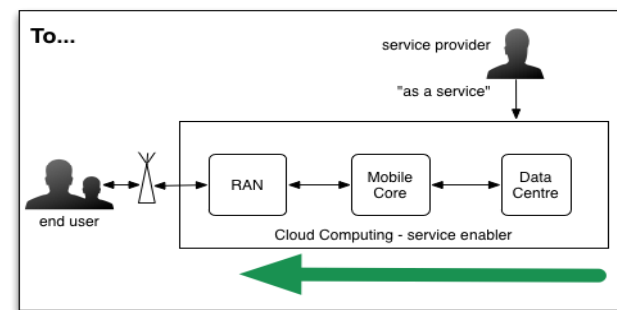
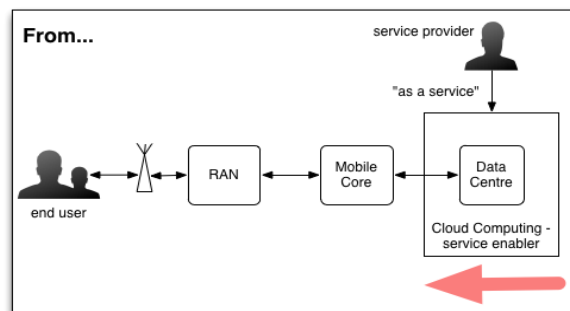
open sdn core



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

- Mueller J., Wierz A., Magedanz T., '**Scalable On-Demand Network Management Module for Software Defined Telecommunication Networks**', accepted for IEEE SDN4FNS'13, Trento, Italy, Nov 11-13, 2013, <http://sites.ieee.org/sdn4fns/>
- Mueller J., Wierz A., Vingarzan V., Magedanz T., '**Elastic Network Design and Adaptive Flow Placement in Software Defined Networks**', accepted at International Conference on Computer Communications and Networks ICCCN 2013, Nassau, Bahamas, July 30 - August 2, 2013, <http://www.icccn.org/icccn13/>
- Mueller J., Magedanz T., '**Towards a Generic Application Aware Network Resource Control Function for Next-Generation-Networks and Beyond**', IEEE ISCIT 2012, International Symposium on Communications and Information Technologies (ISCIT), DOI:10.1109/ISCIT.2012.6381026, ISBN:978-1-4673-1156-4, Page(s): 877 - 882, Gold Coast, Australia, October 2–5, 2012, www.iscit2012.org/
- Mueller J., Magedanz T., '**Generic-Adaptive-Resource-Control (GARC) in Next-Generation-Networks and the Future Internet**', Demonstration, 12th Würzburg Workshop on IP: ITG Workshop "Visions of Future Generation Networks" (EuroView2012), Würzburg, Germany, July 23rd - July 24th 2012, <http://www.g-lab-deep.de/>
- Further publications on SDN and OpenFlow
http://www.openflow.org/wk/index.php/OpenFlow_based_Publications

References

- OpenEPC, <http://www.openepc.net>
- OpenIMSCore, www.openimscore.org
- OpenSDNCore, www.opensdncore.org
- Open5GCore, www.open5gcore.org
- NGN to Future Internet Evolution, NGN2FI, www.ngn2fi.org/
- TU-Berlin – AV, <http://www.av.tu-berlin.de/>
- Fraunhofer FOKUS – NGNI, www.fokus.fraunhofer.de/go/ngni/
- FP7 IP Project Mobile-Cloud Networking, <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“
- **FUSECO FORUM** is the successor of the famous **FOKUS IMS Workshop series** (2004-09)
 - FFF 2010 attracted 150 experts from 21 nations
 - 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

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



Questions ???