Scalable On-Demand Network Management Module for Software Defined Telecommunication Networks

Julius Mueller (TU Berlin / Fraunhofer FOKUS)
Julius.mueller@tu-berlin.de
www.av.tu-berlin.de/jm

Andreas Wierz (TU Berlin / RWTH Aachen)
andreas.wierz@oms.rwth-aachen.de

Thomas Magendaz (TU Berlin / Fraunhofer FOKUS)
Thomas.Magedanz@fokus.fraunhofer.de
www.fokus.fraunhofer.de/go/ngni

About the Speaker

Dipl. Inform. *Julius Mueller*

Chair Next Generation Networks

Kaiserin-Augusta-Allee 31
10589 Berlin, Germany

Phone: +49 30 3463 7170
julius.mueller [at] tu-berlin.de

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

Technical University Berlin

Institute for Telecommunication Systems

Chair Architekturen der Vermittlungsknoten / Next-Generation-Networks

Fraunhofer Institute FOKUS

Competence *Center Next Generation Network Infrastructures (NGNI)*

Agenda

- Introduction and Problem Statement
- Background: Telco Network Evolution
- On-Demand Network Management Algorithms and Specifications
    - Elastic Network Design
    - Adaptive Flow Placement
- Implementation and Integration
- Conclusion and Future Work

Fraunhofer
FOKUS

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
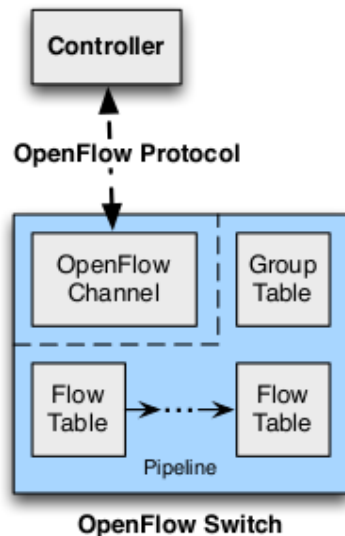
- Source: ONF Spec. OpenFlow v1.4.0

- Network Function Virtualization (NFV)
- Definition: 'Decouple software from specific 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
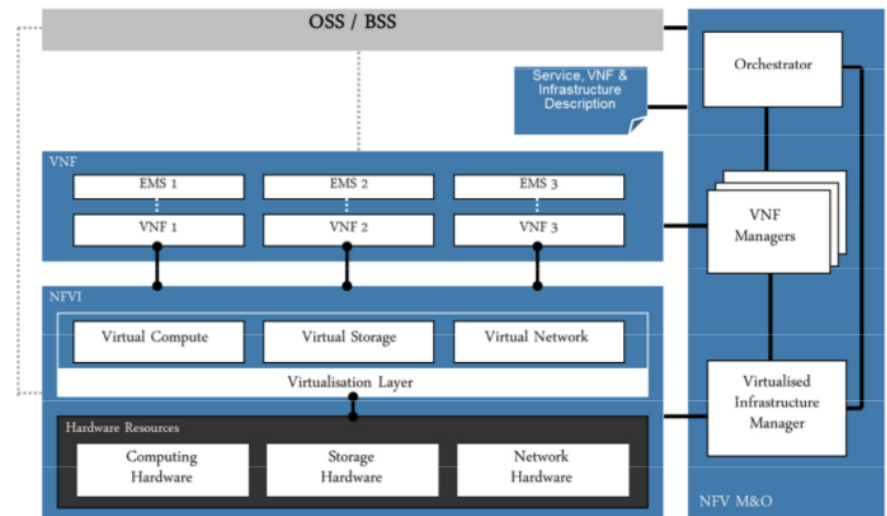
- Source: Network Functions Virtualisation – Update White Paper 2

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 concept

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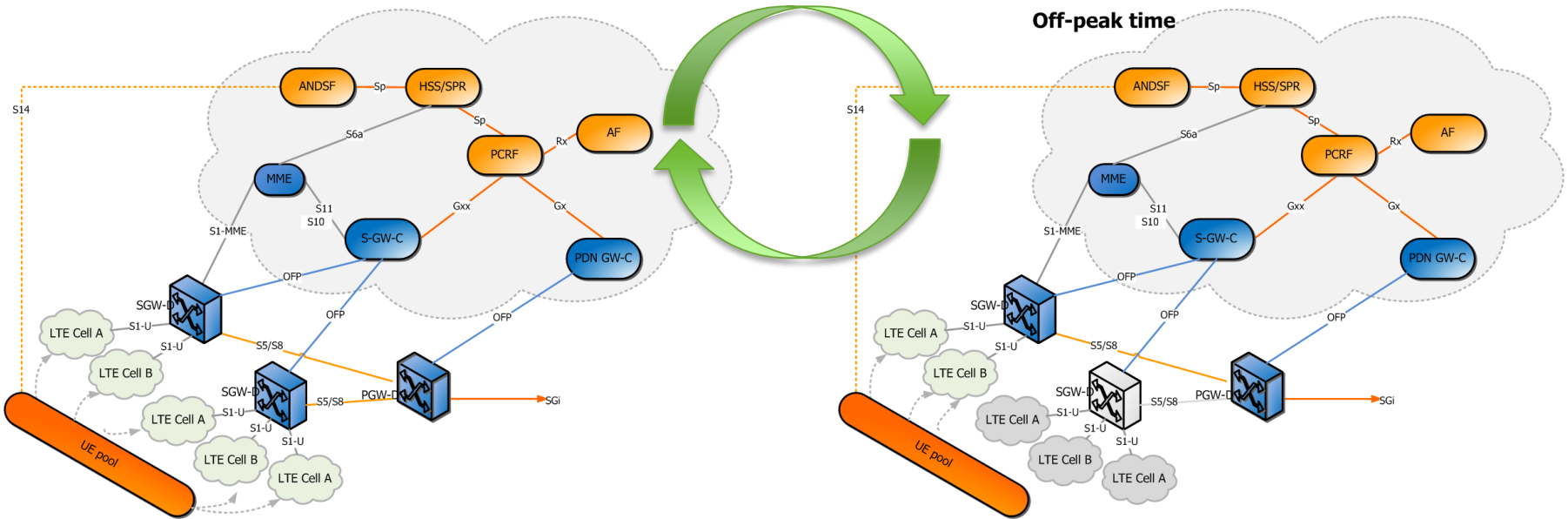- Dynamic Service Chaining

Time

Mobile Core Network Architecture Evolution Path
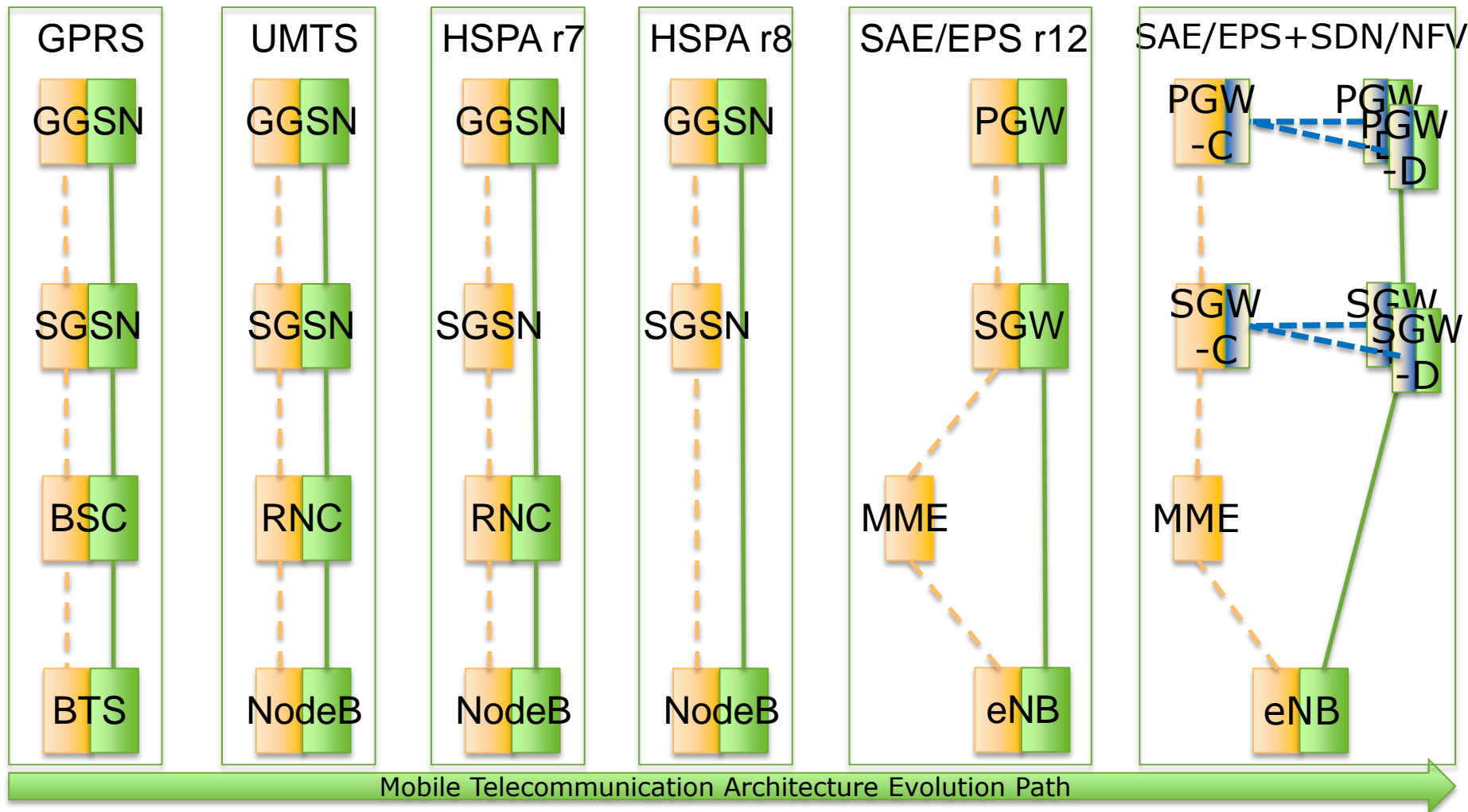
Business Driver: Elastic and Flexible Network Design - Example EPS

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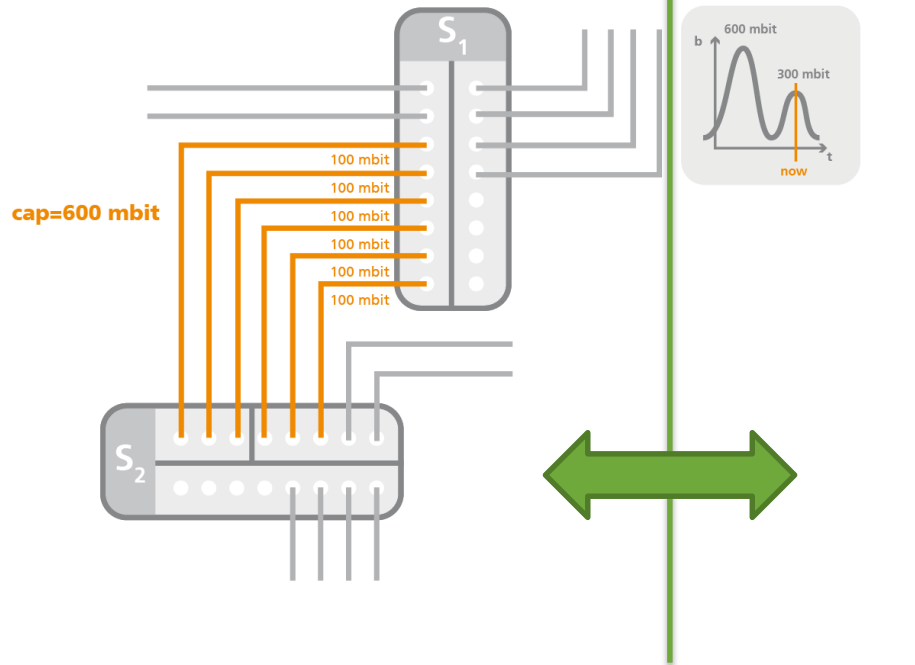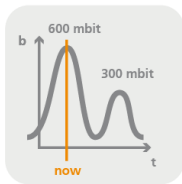

- Elastic network design aligned on real-time network load situations
- Enablement and disablement of redundant access- and core-network elements
- Optimized energy consumption of the access- and core-network
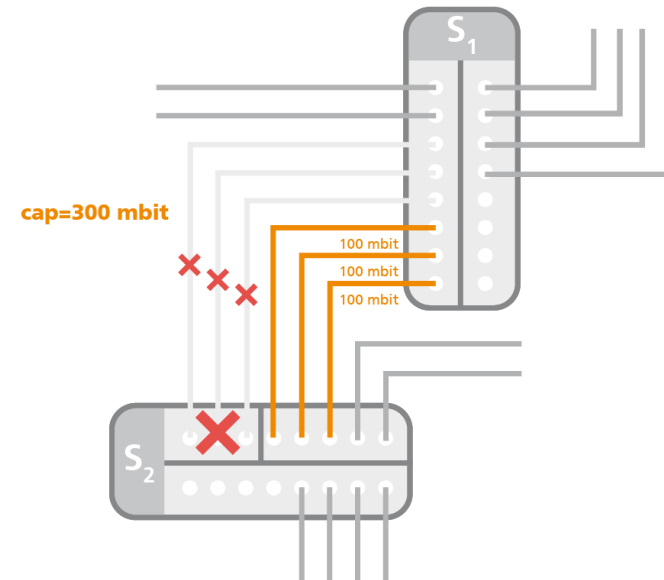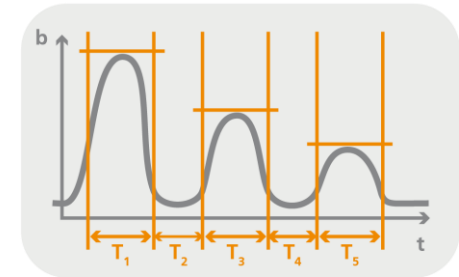- Network Resources as a Service (NRaaS) and on demand

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

Physical Network

How to choose traffic patterns?

cap=600 mbit

cap=300 mbit

[1] J. Chabarek, J. Sommers, P. Barford, C. Estan, D. Tsiang, and S. Wright, Power awareness in network design and routing, INFOCOM 2008. The 27th Conference on Computer Communications. IEEE, april 2008, pp. 457 –465.
[2] GreenTouch Green Meter Research Study: Reducing the Net Energy Consumption in Communications Networks by up to 90% by 2020, A GreenTouch White Paper, Version 1.0, June 26, 2013

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

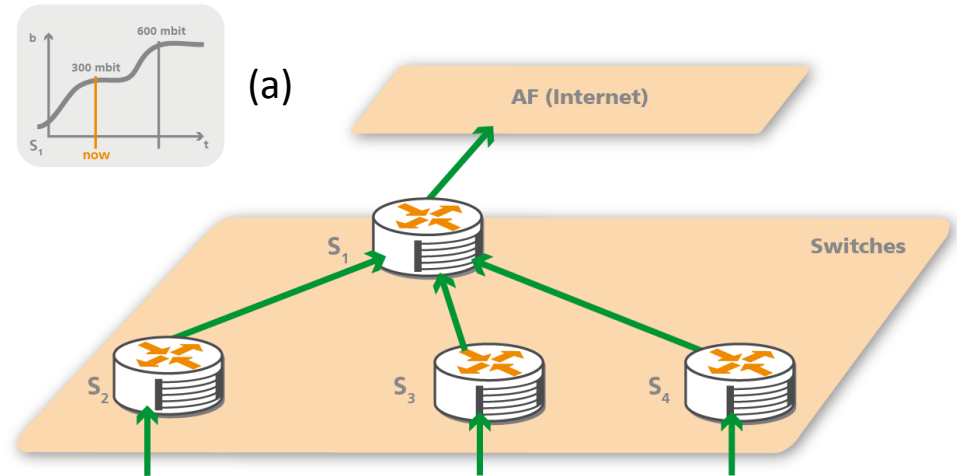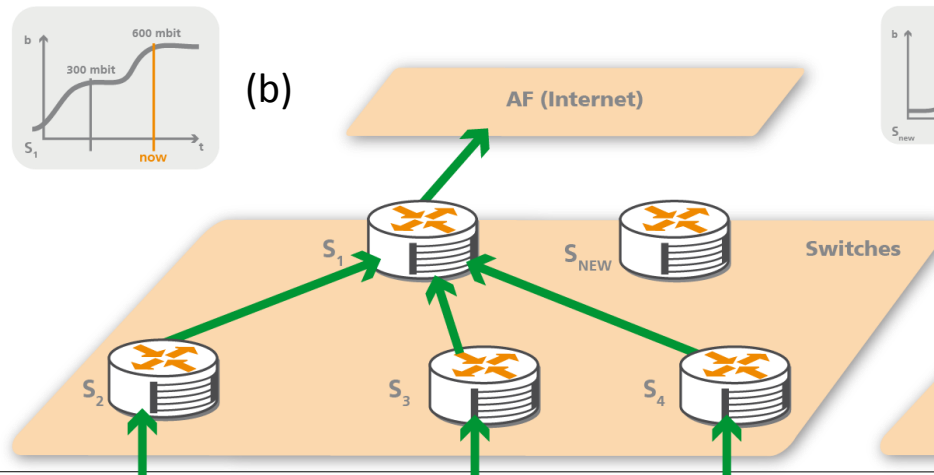- Approach: Dantzig-Wolfe reformulation as Mixed Integer Program
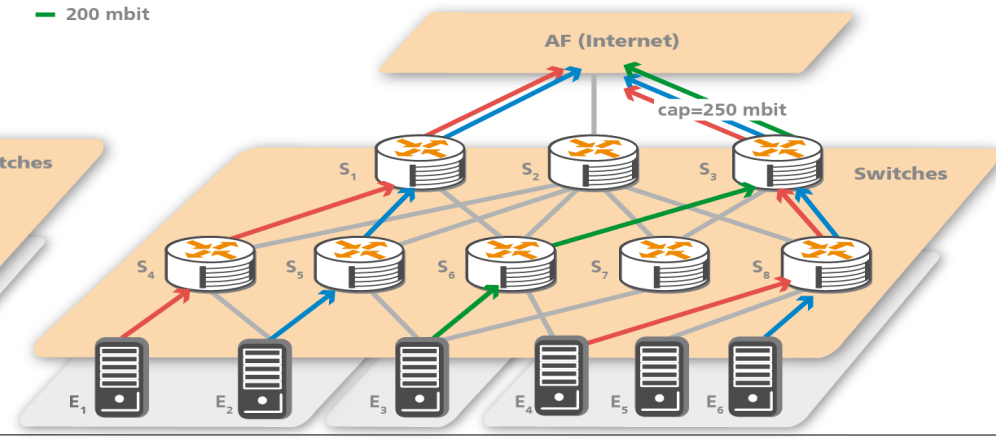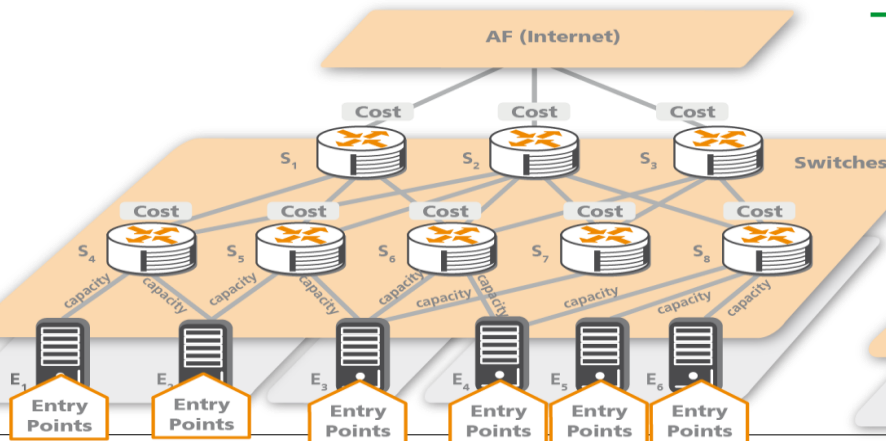
Elastic Network Design with SDN & VNFs

- Adding a new Virtual Network Function (VNF) (e.g. switch) to the network requires new routing metric
- New switch S_{NEW} added
- Calculate new routing metric (red)
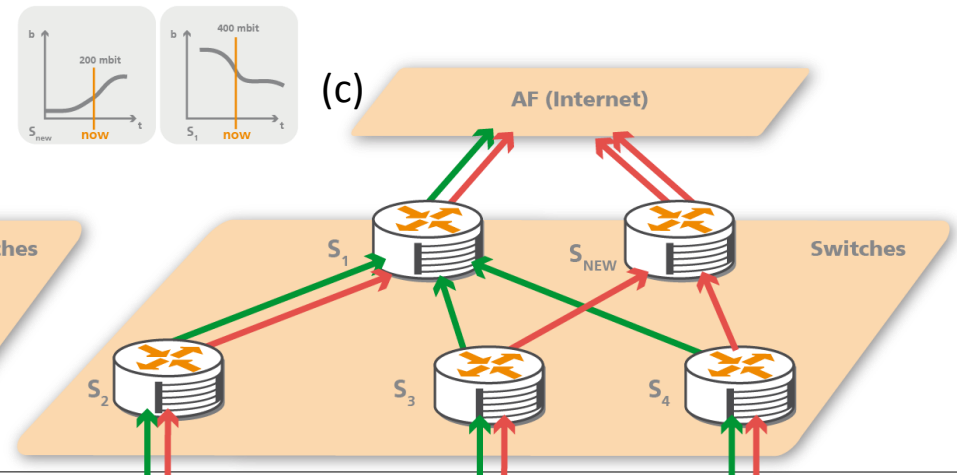- Sequential handover from old to new routes

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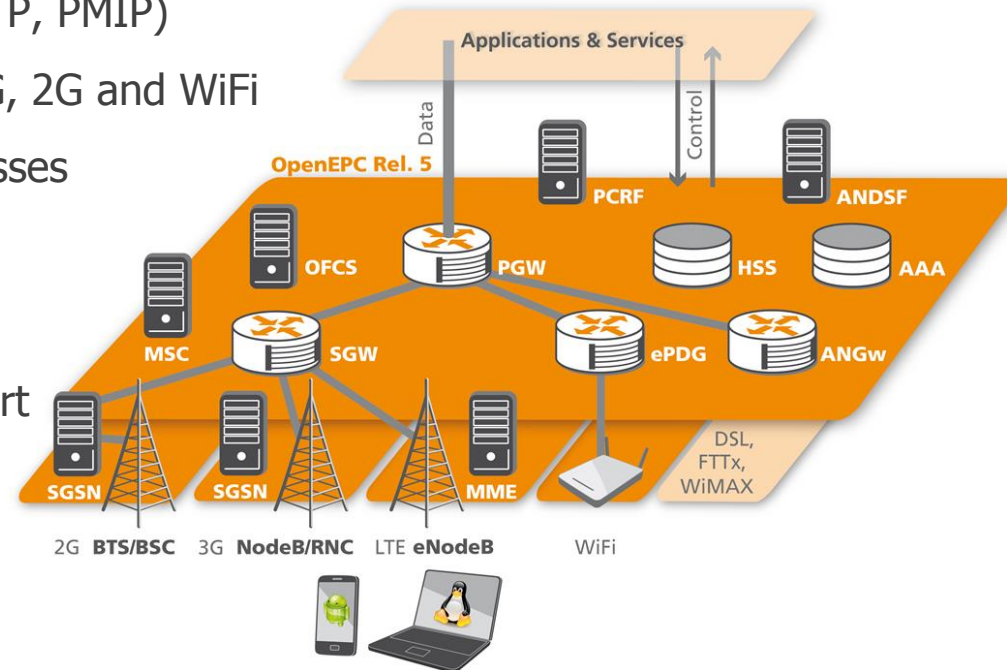
PLEASE NOTE: OpenEPC does not claim 100% standard compliance, but allows for early prototyping

≡ **Fraunhofer**
FOKUS

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
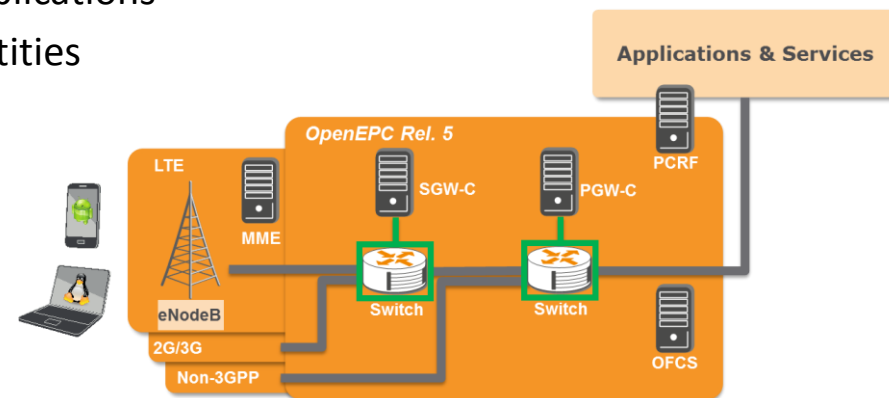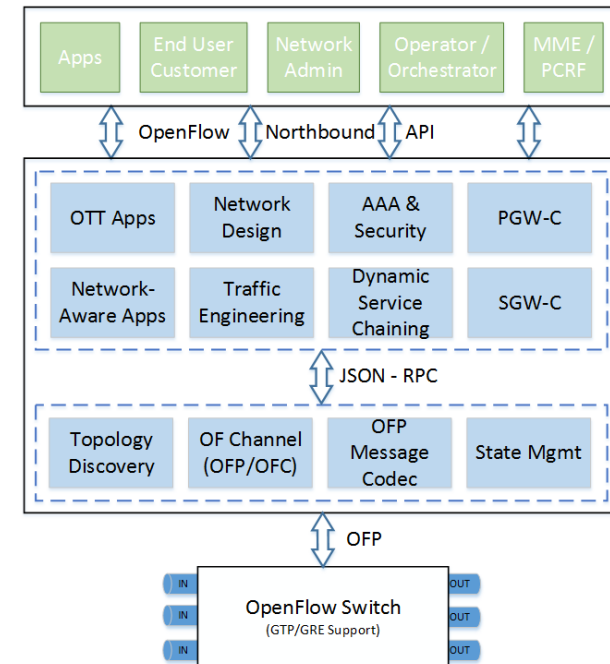
Summary and Outlook

Summary

- Telco Network Evolution – influences of SDN and NFV
- Business Driver: Elastic and Flexible Network Design, Flexible data path, Network as a Service
- Algorithms and Specifications
    - Elastic Network Design
    - Adaptive Flow Placement
- Implementation and Integration

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
- 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"*

Fraunhofer FOKUS

open epc

Fraunhofer
FOKUS

open sdn core

Fraunhofer
FOKUS

Julius.Mueller@fokus.fraunhofer.de

Questions ???

4th FOKUS Future Seamless Communication Forum (FFF)

Berlin, Germany, November 28-29, 2013

Visit our Website: www.fuseco-forum.org/