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FOKUS Center for Next Generation Network Infrastructures (NGNI)

Applying Software Defined Networks and Virtualization Concepts for Next Generation Mobile Broadband Networks

Marc Emmelmann, Julius Mueller

Marc.Emmelmann@fokus.fraunhofer.de
www.fokus.fraunhofer.de/go/ngni

Julius.mueller@tu-berlin.de
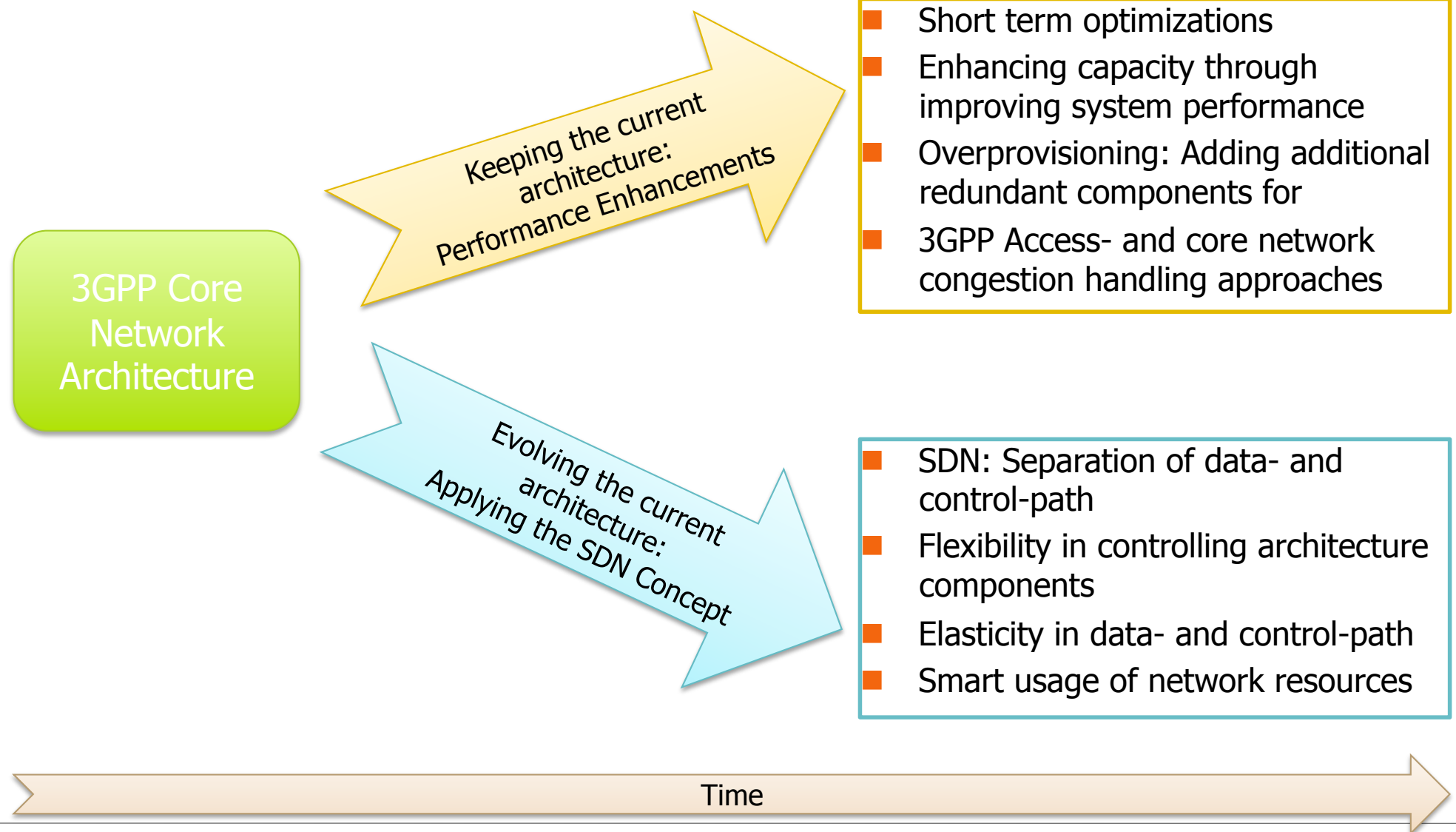www.av.tu-berlin.de/jm

Agenda for this talk

" Applying Software Defined Networks and Virtualization Concepts for Next Generation Mobile Broadband Networks"

- Introduction
  - Problem Statement
  - Solution Approaches
  - SDN Concept
  - OpenFlow Overview
- Virtualization Impacts on Telecommunication Networks
  - Telecommunication Network Evolution Path
  - Applying SDN Concepts on 3GPP Evolved Packet Core
  - New Policy and Charging Models
  - Showcase OpenEPC and OpenFlow
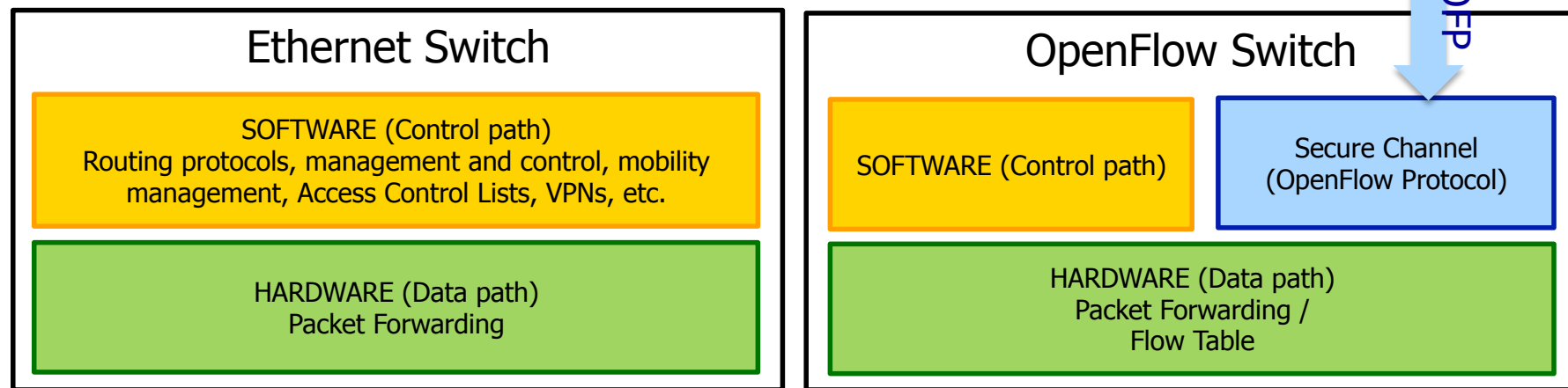- Summary and Future Work

Problem Statement

- Main trends in telecommunication networks
  - Heterogeneous and partially RAN deployment (WiFi, 4G, Femto Cells, …)
  - 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, elasticity and flexibility on the data path, etc.
- Today's approaches: Access- and core network congestion handling approaches
  - TR 22.805 FS_UPCON: 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 (empty)
  - 3GPP Policy Control and Charging (PCC) architecture (TS 23.203)

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 for
- 3GPP Access- and core network congestion handling approaches

Evolving the current architecture: Applying the SDN Concept

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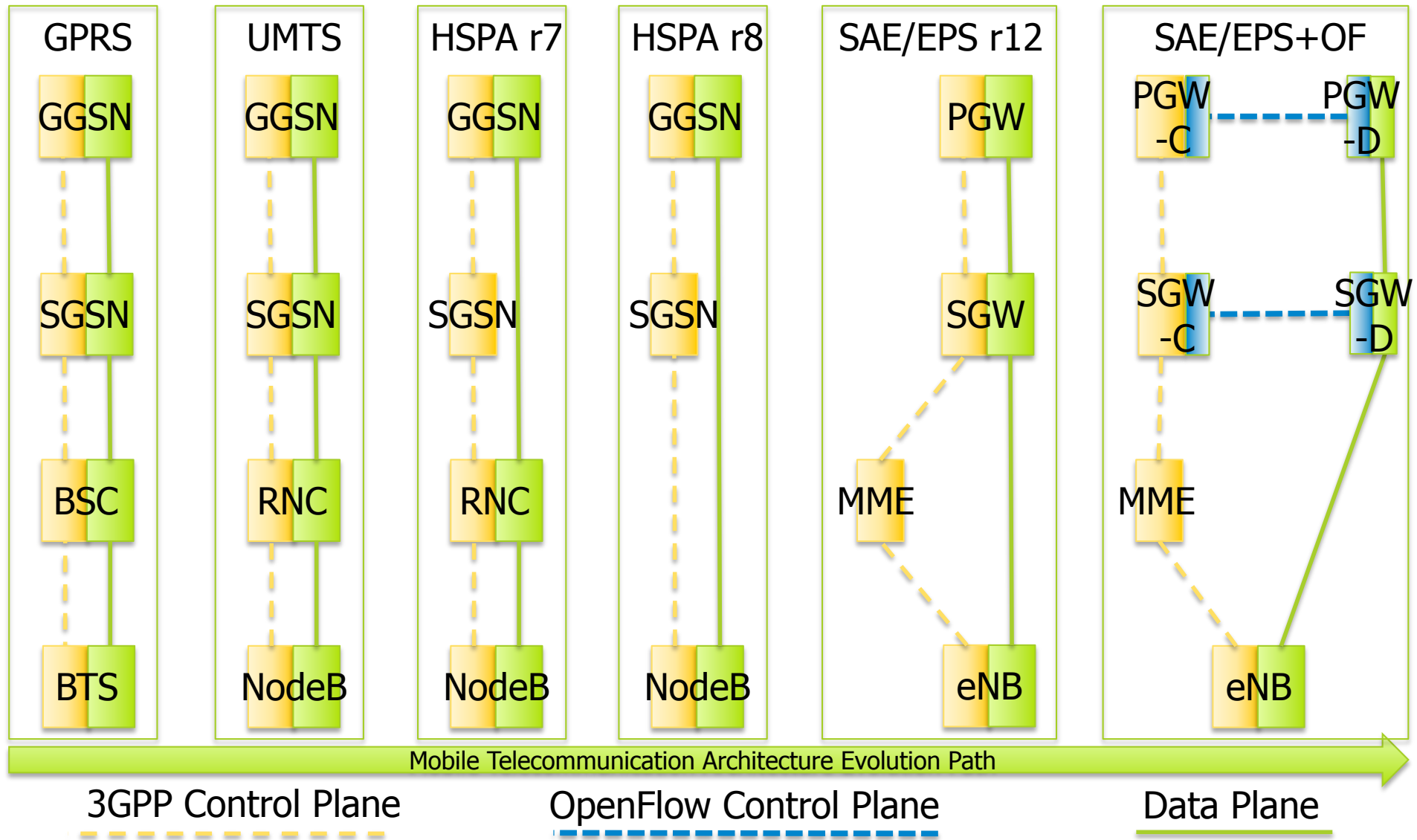- Smart usage of network resources

Time

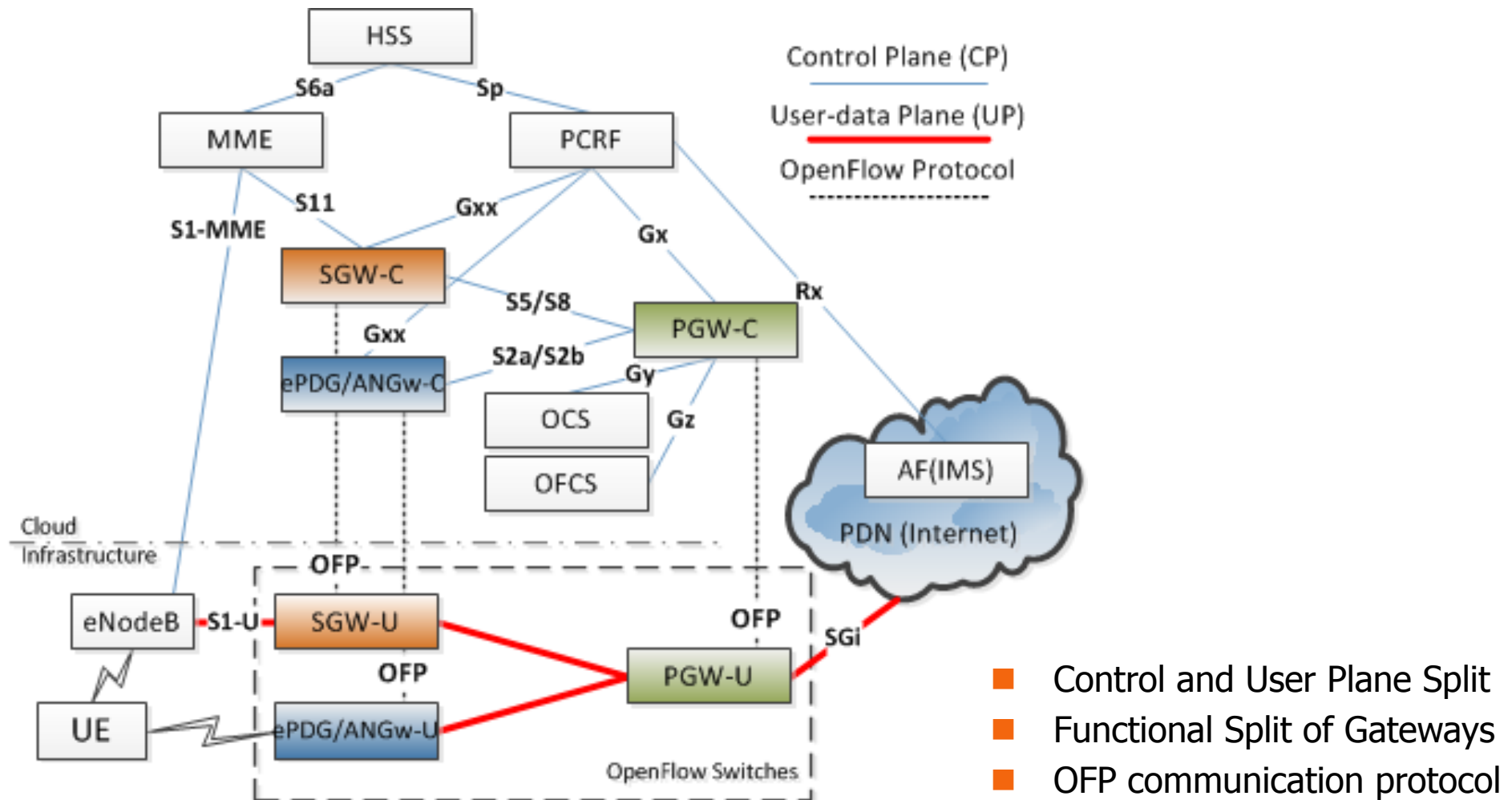# Software-Defined-Networks (SDN) / OpenFlow Overview

- The concept of SDN separates forwarding and control from switches and routers into OpenFlow controller.
- OpenFlow Protocol specified by Open Networking Foundation (ONF)
  - Control of layer 2-4, Specification version 1.3.1
- Implementations and Specifications
  - OpenFlow Protocol, OF Config
  - OpenVSwitch, OpenFlow switch, etc.
  - POX, NOX, Beacon, Trema, etc.

Northbound-interface

OpenFlow Controller

SOFTWARE (Control path)
Routing protocols, management and control, mobility management, Access Control Lists, VPNs, etc.

OpenFlow Protocol

OFP

Ethernet Switch

SOFTWARE (Control path)
Routing protocols, management and control, mobility management, Access Control Lists, VPNs, etc.

HARDWARE (Data path)
Packet Forwarding

OpenFlow Switch

SOFTWARE (Control path)

Secure Channel
(OpenFlow Protocol)

HARDWARE (Data path)
Packet Forwarding /
Flow Table

Mobile Telco Architecture Evolution Path

GPRS	UMTS	HSPA r7	HSPA r8	SAE/EPS r12	SAE/EPS+OF
GGSN	GGSN	GGSN	GGSN	PGW	PGW-C ---- PGW-D
SGSN	SGSN	SGSN	SGSN	SGW	SGW-C ---- SGW-D
BSC	RNC	RNC		MME	MME
BTS	NodeB	NodeB	NodeB	eNB	eNB

Mobile Telecommunication Architecture Evolution Path

3GPP Control Plane   **OpenFlow Control Plane**   **Data Plane**

3GPP EPC and OpenFlow

- Control and User Plane Split
- Functional Split of Gateways
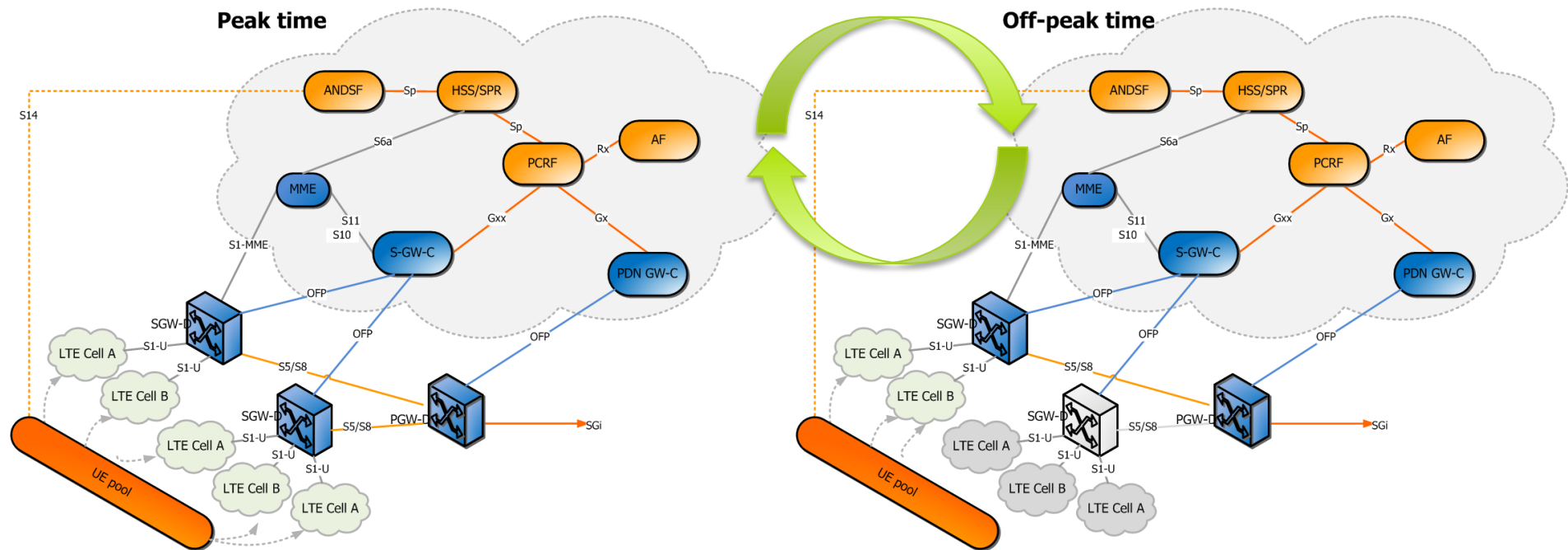- OFP communication protocol

OpenFlow Enhanced EPC Architecture
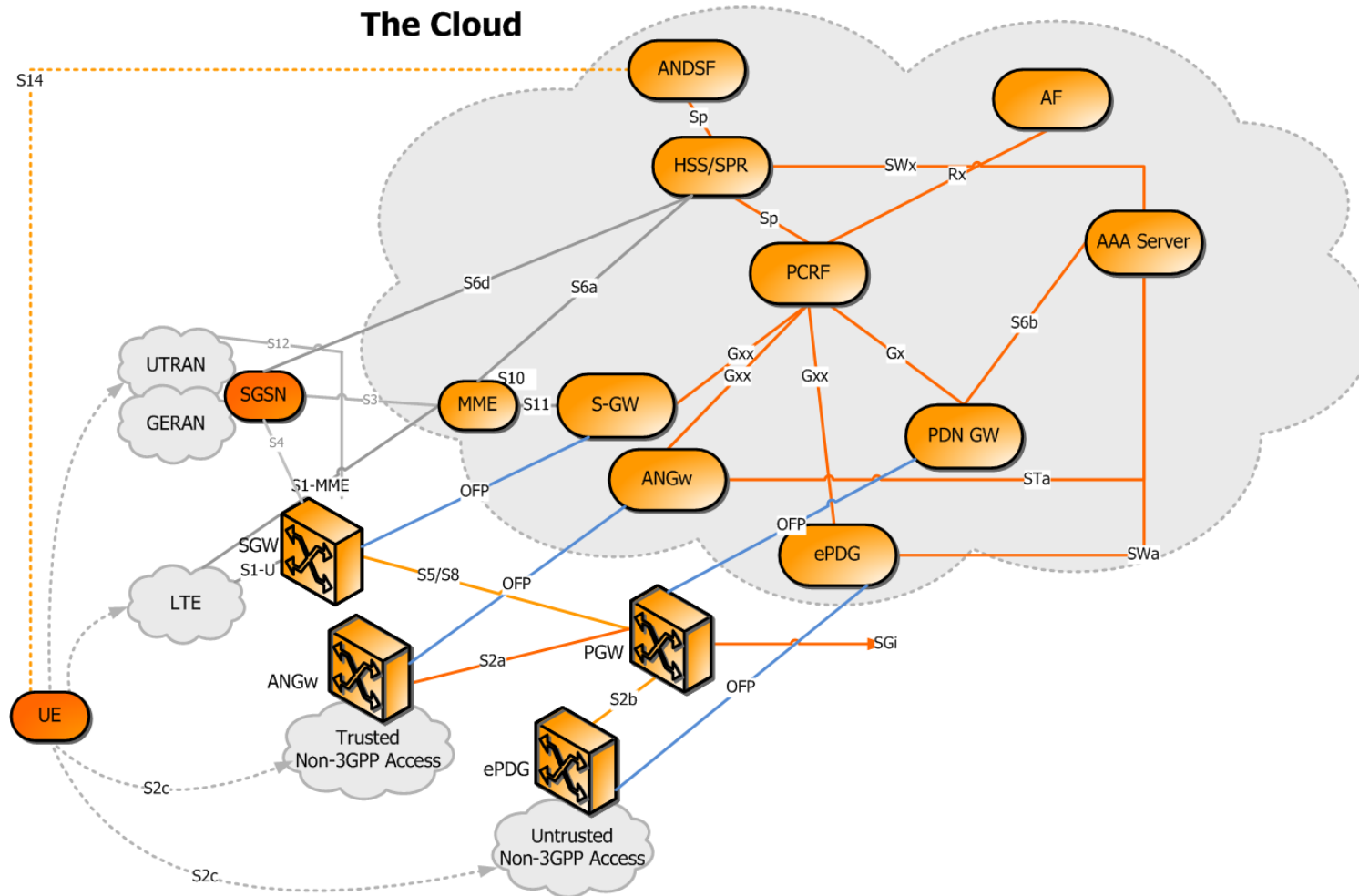
Elastic and Flexible Network Design - Example EPS

- 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 Recourses as a Service (NRaaS) and on demand

Applying SDN Concepts on Telco Networks? Pros and Cons!

Pros	Cons
Efficient data plane control	Additional complexity in the architecture
Efficient centralized control components	Additional delay for OFController and OFSwitch communication
Cost aware networking: Flexible data path topology control/mgmt and faster topology re-configuration	Additional costs for supporting 3GPP protocols
Data path elasticity + flexible and optimized service data flow placement	New dimension in complexity for compliance testing
Support for shared network / MVNO concepts	Delay constraints: Potentially geographical distance between operator core and cloud control
Performant QoS controll on the data path	
New policy models enable more fine granular service charging for additional revenue streams	
Standard-based Solution	

Challenges of Combining OpenFlow and EPC

- Backwards compliance and interoperability against standard conform 3GPP SAE/EPS solutions.
- GTP and GRE control in OpenFlow switches.
- Delay constraints between core network OpenFlow switches and cloud telco control components.
- Translation from Diameter into OpenFlow Protocol.

What is FOKUS OpenEPC Platform?

- Future massive broadband communications will be realized through multi-access support (LTE, 3G, 2G, WiFi, fixed networks ...) and multi-application domains (OTT, IMS, P2P, M2M, Cloud, ...)

- Fraunhofer FOKUS is developing the **NON-OPEN SOURCE** OpenEPC toolkit, enabling to:
    - integrate various network technologies and
    - integrate various application platforms
    - into a single local testbed, thus lowering own development costs

- This platform can be used to perform R&D in the fields of
    - QoS, Charging, Mobility, Security, Management, Monitoring

- OpenEPC represents a software implementation of the 3GPP

EPC standard addressing academia and industry R&D:
    - Based on 3GPP standards
    - Configurable to different deployments
    - Customizable to the various testbed requirements
    - Extensible to specific research needs
    - Reliable & highly performant

- More information: **www.OpenEPC.net**

Multimedia   **Cloud Computing**
OTT   **M2M**   **VoLTE**
IMS   **FI**
Applications & Services

3GPP EPC   **Mobility**
Scalability
Security   **QoS & Charging**
App. Delivery
IP Connectivity   **Self-Management**

WiFi   **Femto-cells**
3G
LTE   **2G**
Access Networks   **Fixed Networks**

OpenEPC Rel. 4: Mirroring the Future Operator Core Network

- OpenEPC includes the main functions of 3GPP Evolved Packet Core (Release 8,9, 10, 11,…)
- The principles of standard alignment, configurability and extensibility have been respected in the overall architecture and in the specific components implemented
- OpenEPC Rel. 4 enables the establishment of small operator network testbeds including:
- Core network mobility support (GTP, PMIP)
- Integration with real LTE, 3G, 2G and WiFi
- AAA for 3GPP and non-3GPP accesses
- Policy and Charging Control
- Access network selection
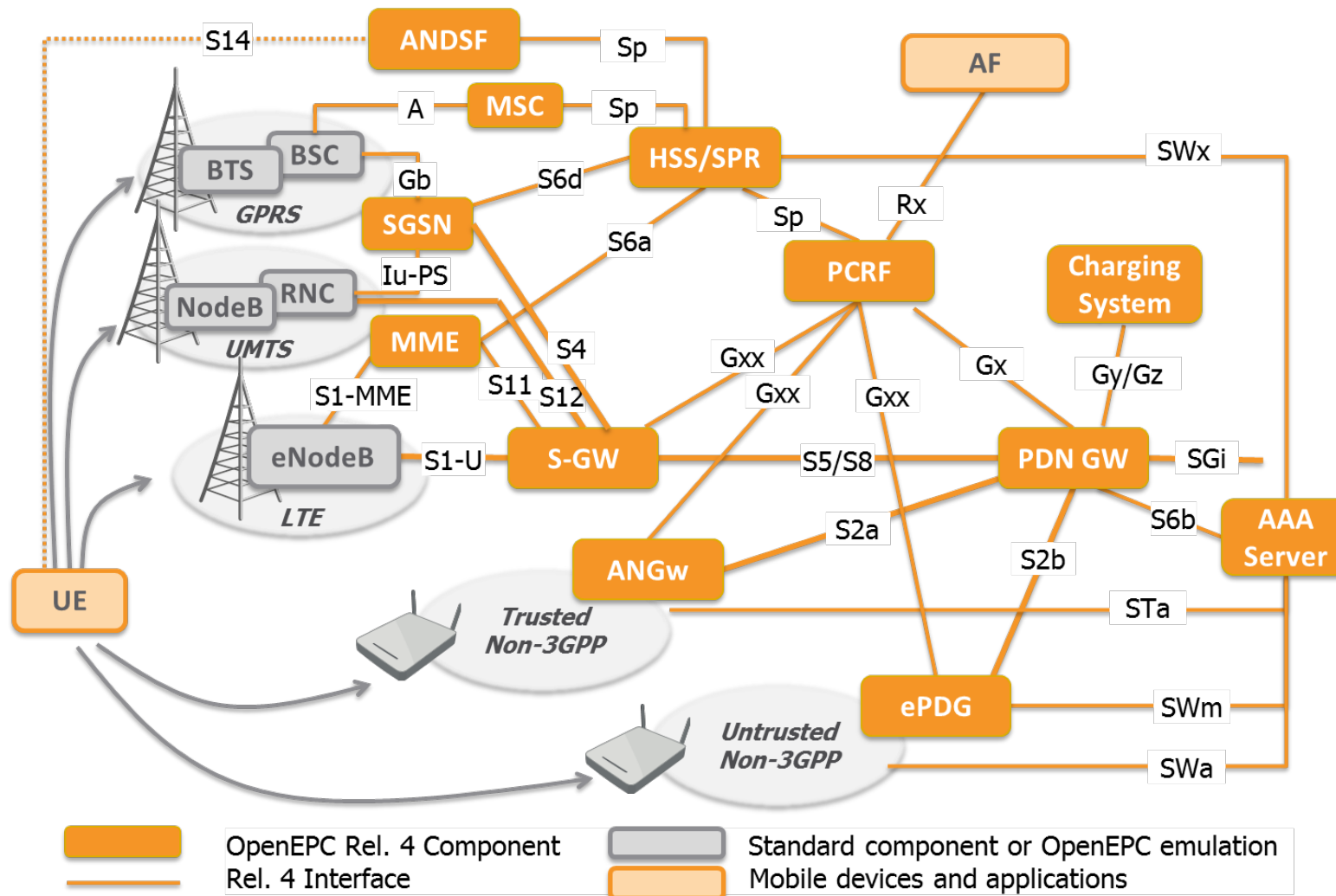- Common mobile equipment support
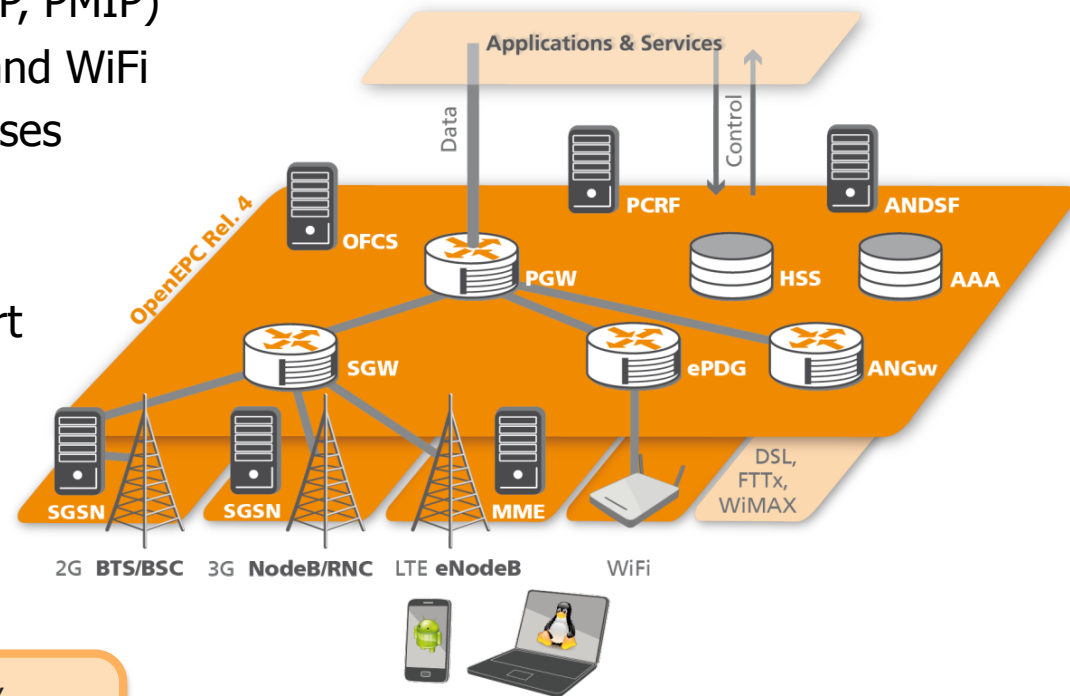
PLEASE NOTE: OpenEPC does not claim 100% standard compliance, but allows for early prototyping
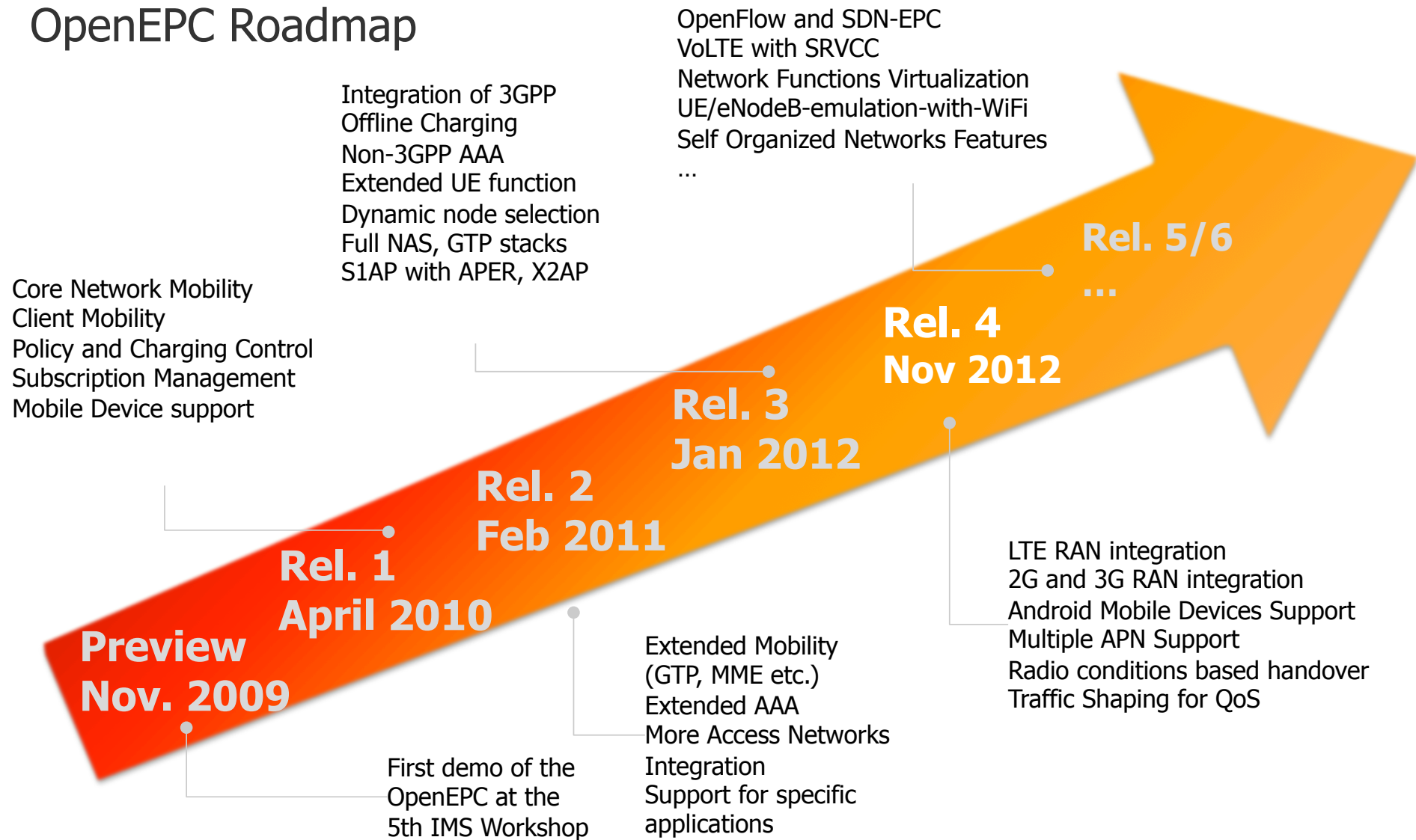
OpenEPC
Releases and Roadmap – Technical Overview

OpenEPC Roadmap

OpenFlow and SDN-EPC
VoLTE with SRVCC
Network Functions Virtualization
UE/eNodeB-emulation-with-WiFi
Self Organized Networks Features
…

Integration of 3GPP
Offline Charging
Non-3GPP AAA
Extended UE function
Dynamic node selection
Full NAS, GTP stacks
S1AP with APER, X2AP

Core Network Mobility
Client Mobility
Policy and Charging Control
Subscription Management
Mobile Device support

Rel. 5/6
…

Rel. 4
Nov 2012

Rel. 3
Jan 2012

Rel. 2
Feb 2011

Rel. 1
April 2010

Preview
Nov. 2009

LTE RAN integration
2G and 3G RAN integration
Android Mobile Devices Support
Multiple APN Support
Radio conditions based handover
Traffic Shaping for QoS

Extended Mobility
(GTP, MME etc.)
Extended AAA
More Access Networks
Integration
Support for specific
applications

First demo of the
OpenEPC at the
5th IMS Workshop

Summary and Future Work

Overall Data Traffic Forecast

- IP data and 3GPP Diameter protocol signaling dominated
  - Dominating factors: Video, file transfer, M2M and downloads

Core Network Evolution Strategies

- Keeping the current architecture: Performance Enhancements
- Evolving the current architecture: Applying the SDN Concept

Envisioned Mobile Network Architecture

- Towards simple and flat IP core network architecture
  - low complexity, low latency, lower costs, higher performance, higher throughputs, less costs (CAPEX and OPEX)
- Further separation of control and user (data) plane
  - Scalability, flexibility, reliability of the system components through SDN & NFV

Future Work

- Implementation of OFController and OFSwitch in version 1.3.1 within OpenEPC
- Extending GTP and GRE support in OpenFlow
- Scalability and Interoperability use case validation

Abbreviations

- ADC Application Detection and Control
- AF Application Function
- BBERF Bearer Binding and Event Reporting Function
- BBF Bearer Binding Function
- CSG Closed Subscriber Group
- CSG ID Closed Subscriber Group Identity
- DRA Diameter Routing Agent
- H-PCEF A PCEF in the HPLMN
- H-PCRF A PCRF in the HPLMN
- HRPD High Rate Packet Data
- HSGW HRPD Serving Gateway
- IP-CAN IP Connectivity Access Network
- MPS Multimedia Priority Service

- OFCS Offline Charging System
- OCS Online Charging System
- PCC Policy and Charging Control
- PCEF Policy and Charging Enforcement Function
- PCRF Policy and Charging Rules Function
- QCI QoS Class Identifier
- vSRVCC video Single Radio Voice Call Continuity
- SPR Subscription Profile Repository
- TDF Traffic Detection Function
- UDC User Data Convergence
- UDR User Data Repository
- V-PCEF A PCEF in the VPLMN
- V-PCRF A PCRF in the VPLMN

References

- OpenEPC, http://www.openepc.net/
- OpenIMSCore, www.openimscore.org/
- FOKUS Open SOA Telco Playground, www.opensoaplayground.org/
- NGN to Future Internet Evolution, NGN2FI, www.ngn2fi.org/
- Fraunhofer FOKUS – NGNI, www.fokus.fraunhofer.de/go/ngni/

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"

open epc

Fraunhofer
FOKUS

Marc.Emmelmann@fokus.fraunhofer.de

Questions ???

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