



THE FUSECO 5G PLAYGROUND

FOR GROWING TOGETHER THE 5G TECHNOLOGY

Yahya Al-Hazmi | GENI-FIRE Workshop | Washington DC | September 17-18, 2015

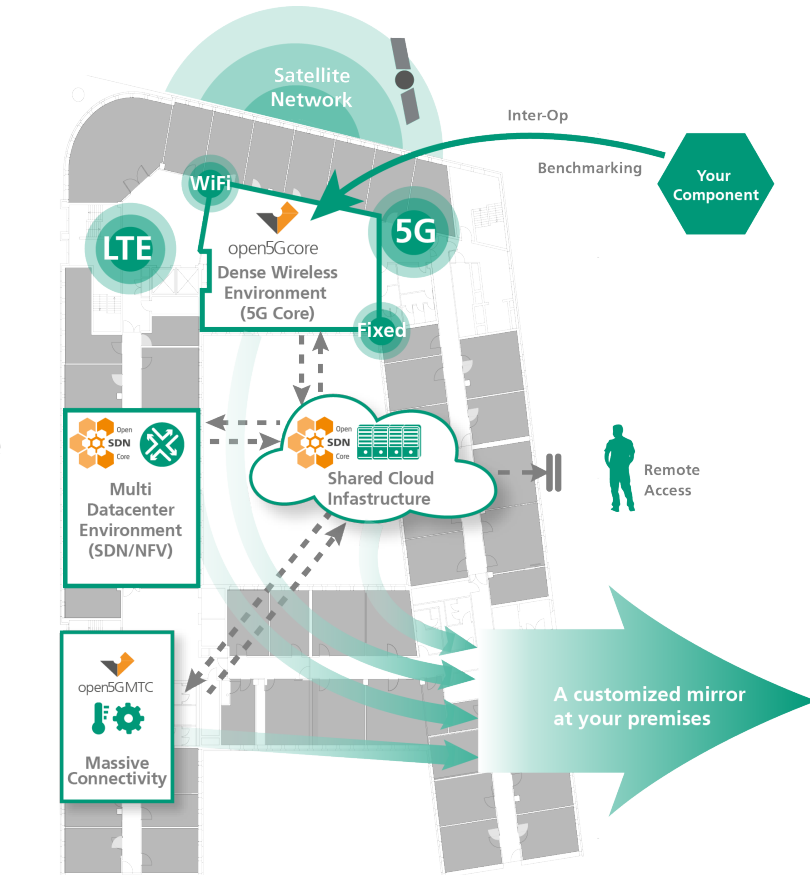
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Contact: info@open5Gcore.net



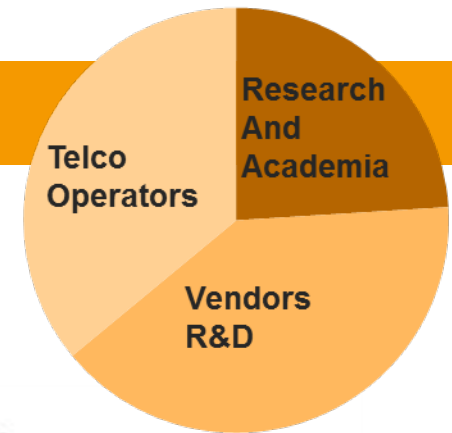
What is the FUSECO 5G Playground?

- The FUSECO 5G Playground a common R&D ground where researchers and engineers around the world are able to build together the future 5G environment
- 5G PG enables the following use cases:
 - **Interoperability**
 - **Product Prototyping**
 - **Remote experimentation**
 - **Calibration and benchmarking**
- The fundament of the 5G playground includes:
 - **A comprehensive set of toolkits** mirroring the advances towards 5G
 - Methodology and tools for **benchmarking**
 - **Automation and commodity tools:**
 - Federation tools
 - Automatic network customization and management for experiment control
 - Independent experimentation slices



Our Users (since mid-2014)

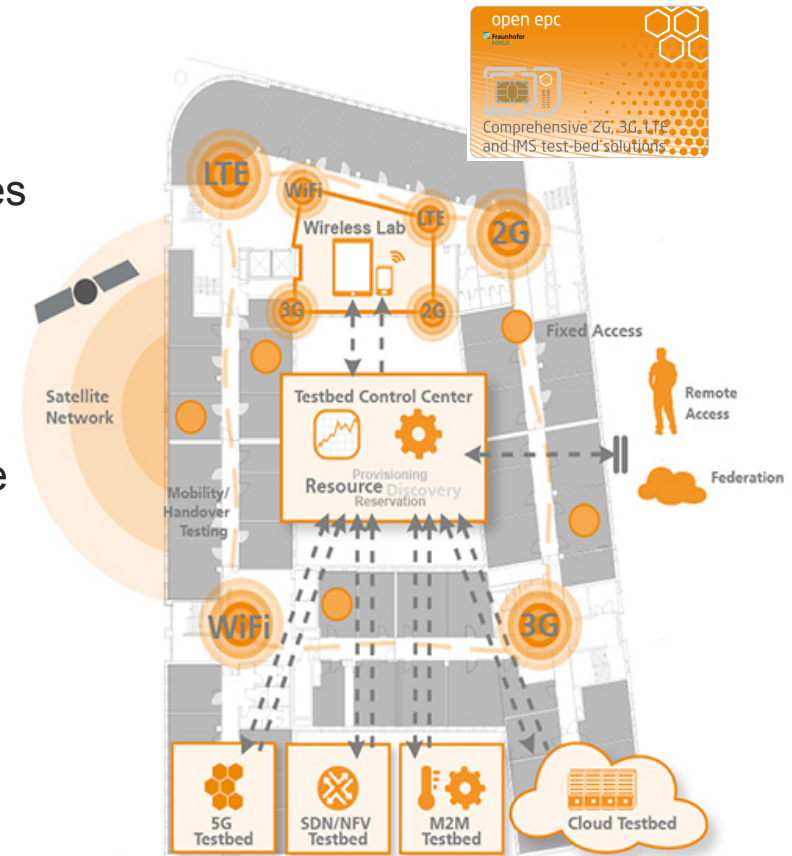
- Fraunhofer FOKUS has a long standing collaboration in providing comprehensive standard oriented infrastructures for R&D activities of industry and academia



Background and Support: FUSECO Playground (2010 - ...)

Blueprint for a Operator Future Seamless Communication (FUSECO) Infrastructure

- FUSECO Playground includes an own mobile network for experimenting with:
 - Future mobile IP-based communication services
 - M2M services
- FUSECO Playground offers Testbed as a Service for research and prototype development of mobile broadband communication and service platform for the LTE/4G environment
- 5G Playground re-uses parts and builds on the FUSECO Playground a novel infrastructure addressing the needs of the industry and academia for 5G communication



5G Playground answers industry experimentation requirements



Interoperability

Providing a common ground for product development

Product Prototyping

Usage of parts of the 5G Playground software for developing proof-of concept prototypes for new products

Remote Experimentation

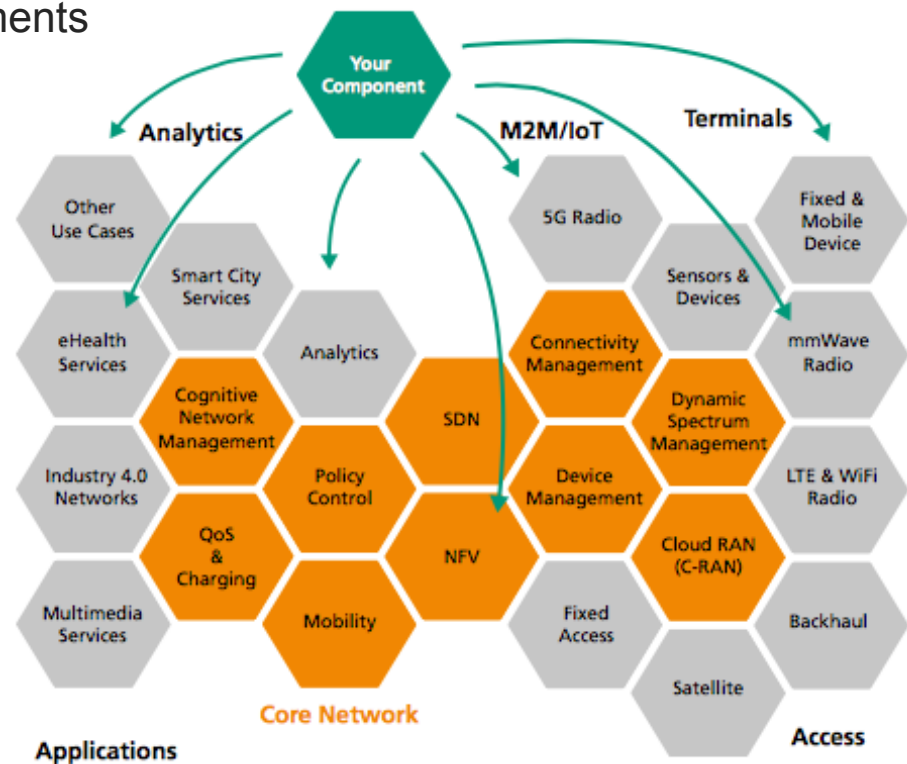
Experimenting using the Fraunhofer FOKUS Facilities

Calibration and Benchmarking

Customizing prototypes and products for the specific market

I. Interoperability

- The 5G Playground offers from the beginning a comprehensive environment where new prototypes and products can be tested for interoperability
 - Covering a comprehensive set of functionality
 - Mirroring the 5G standard advancements
 - Addressing end-to-end use cases
- Enabling a coherent development with other areas of the 5G ecosystem
 - By interoperability with other partners
- The live demonstration offers the possibility to advertise the new products as part of a growing ecosystem
 - Visibility towards other stakeholders
 - Visibility towards customers



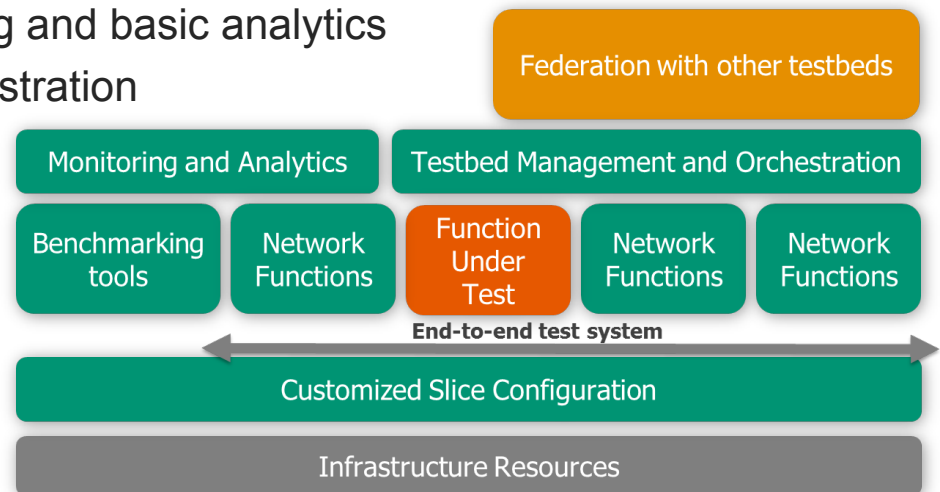
II. Product Prototyping

- Customizing and further extending the toolkits of Fraunhofer FOKUS to provide innovative product prototypes
 - Based on the existing product base of the customers (or third parties)
 - Using a customized version of the Fraunhofer FOKUS toolkits
 - Providing new functionality coming directly from research
 - Prototyping the new product
 - Opening new market opportunities through raising awareness (demos, whitepapers)



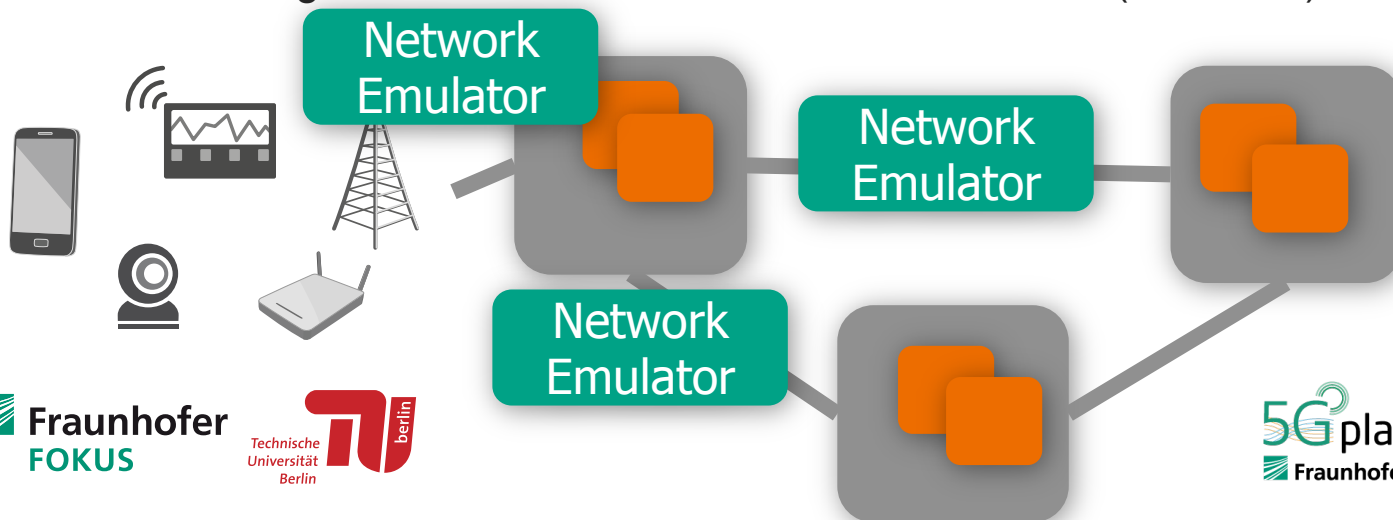
III. Remote Experimentation

- Options:
 - Adding a new functionality as a black box in a comprehensive system
 - Using the 5G Playground installation for new algorithms and optimizations
- Separated by functional layers:
 - Based on customized slices on top of multi-data center environment
 - Composing an end-to-end service with NFs based on FOKUS toolkits
 - Loaded by benchmarking tools
 - With integrated end-to-end monitoring and basic analytics
 - With testbed management and orchestration
 - Federated with other testbeds



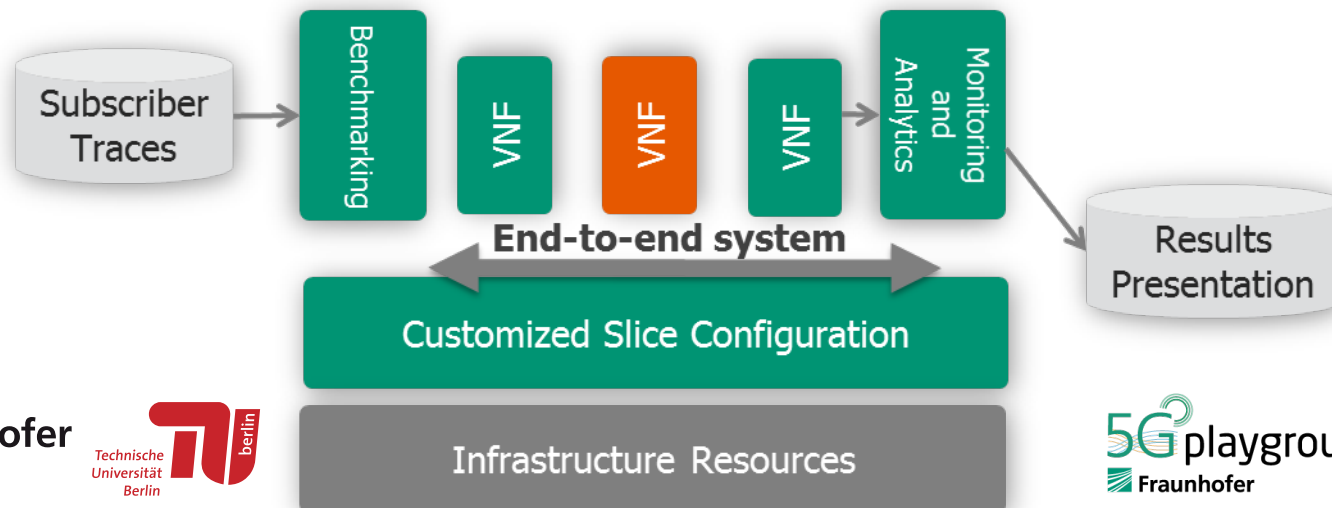
III. Remote Experimentation (cont.) – Slice Configuration (IaaS)

- Creating a virtual network with virtual functions for each experiment
 - With multiple deployment models on top of multiple data centers
 - Edge networking
 - Central/edge interoperation
 - Emulating the communication on top of different network environments:
 - Wireless and satellite networks
 - Inter-data center high capacity backhauls
 - With different network programmability levels
 - Creating a virtual SDN network infrastructure
 - Interworking with real devices and real radio networks (if needed)



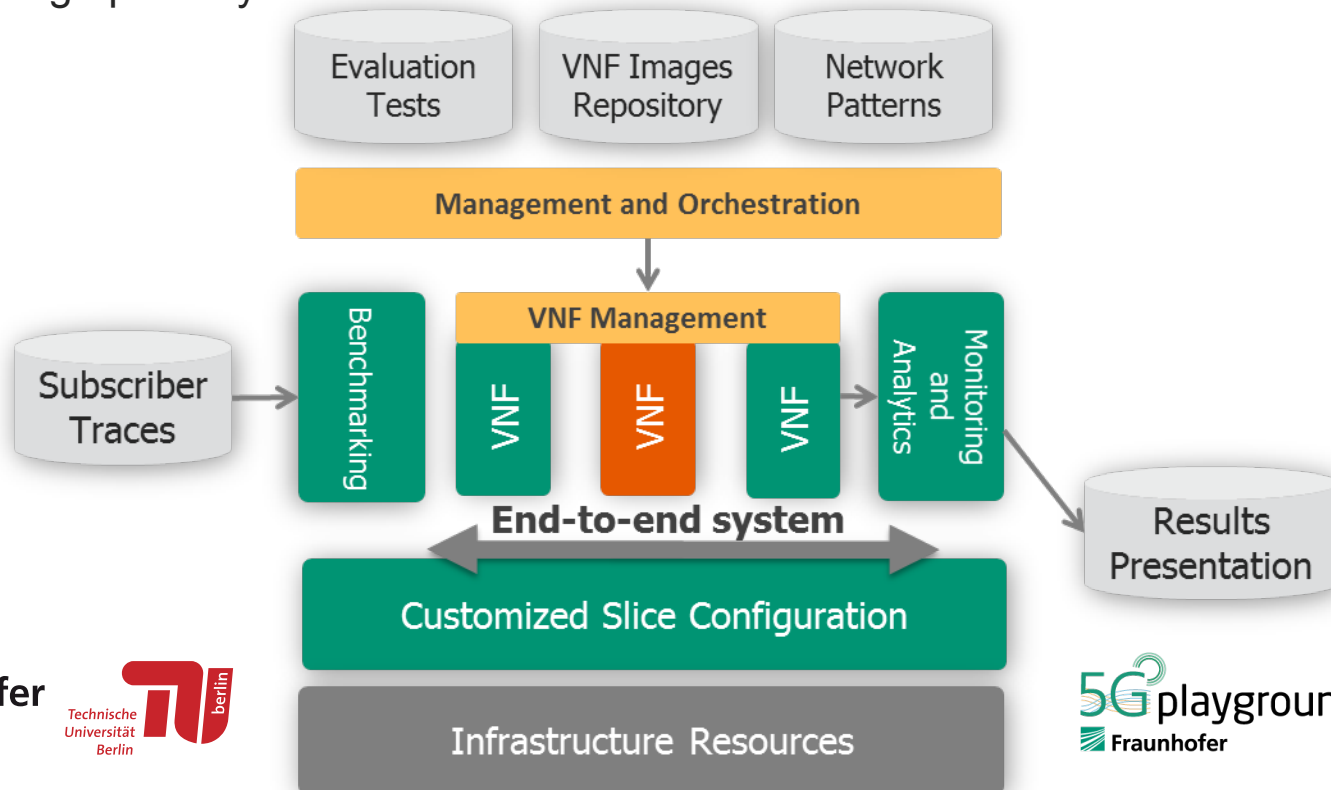
III. Remote Experimentation – End-to-end test system

- Providing a comprehensive end-to-end experimentation system
 - Based on an end-to-end system under test (emulating a real system)
 - With benchmarking tools, emulating a large number of devices (based on traces)
 - Monitoring and Analytics able to present on-demand the experiment results
- Evaluating the opportunity of the specific network function into the end-to-end use case
 - With different load levels and with different subscriber traces
 - Monitoring KPIs at service user and at network side



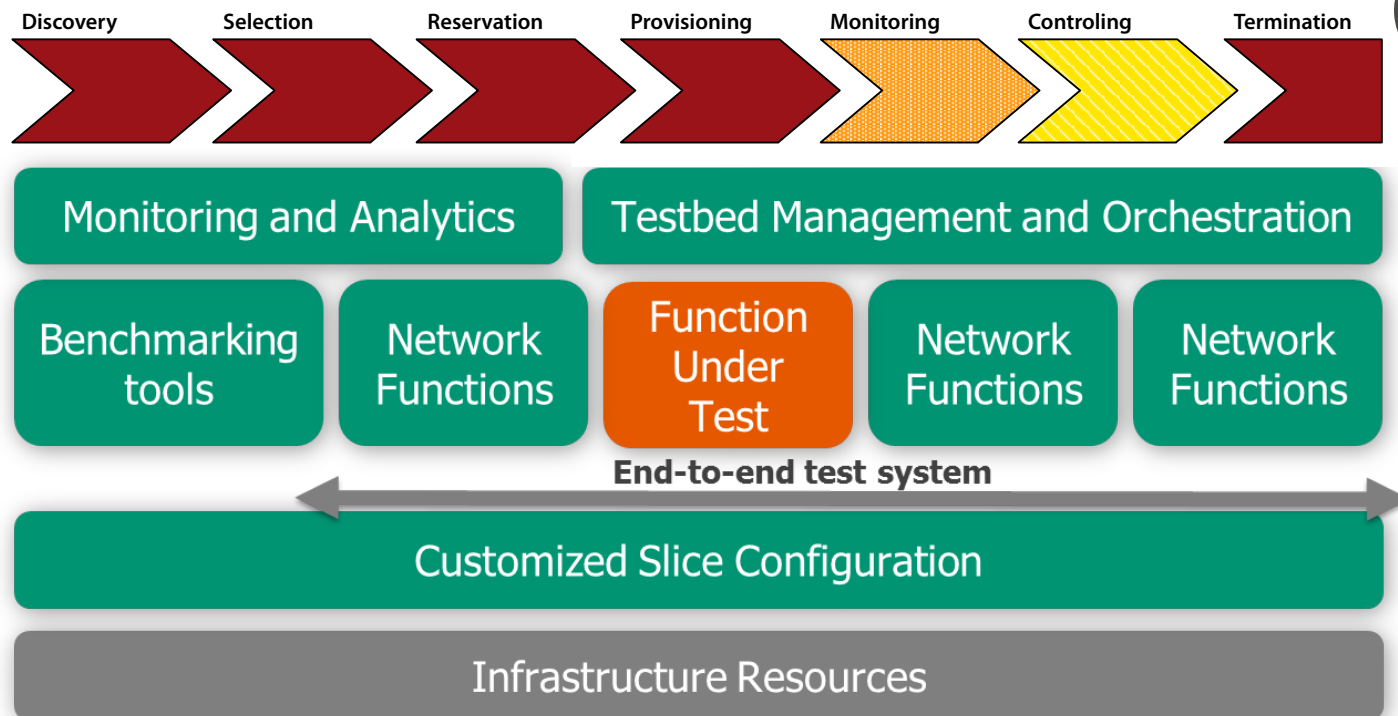
III. Remote Experimentation - Management and Orchestration

- 5G Playground includes a comprehensive management and orchestration environment adapted for automated experimentation
 - Installation and provisioning of the experiment
 - Creating initial experimentation conditions (including network patterns)
 - Executing the experiments and providing the results
 - Cleaning up the system



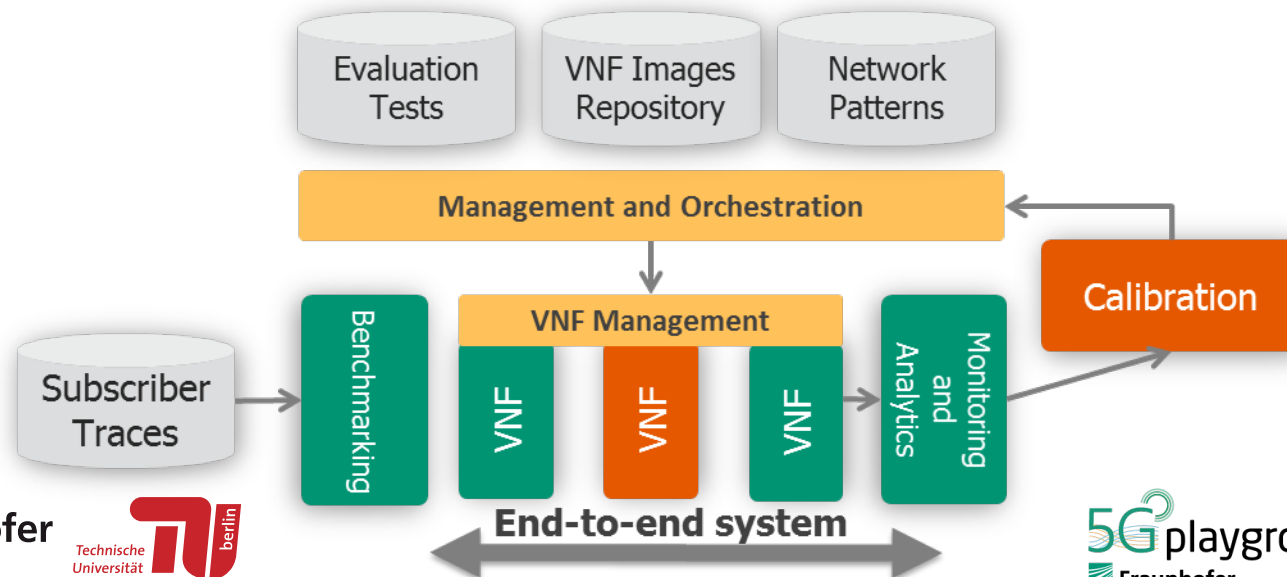
III. Remote Experimentation – Federation

- 5G Playground includes (on demand) remote testbed control tools which enable the management of the full experiment life-cycle management
 - From remote locations
 - As part of the FIRE federation

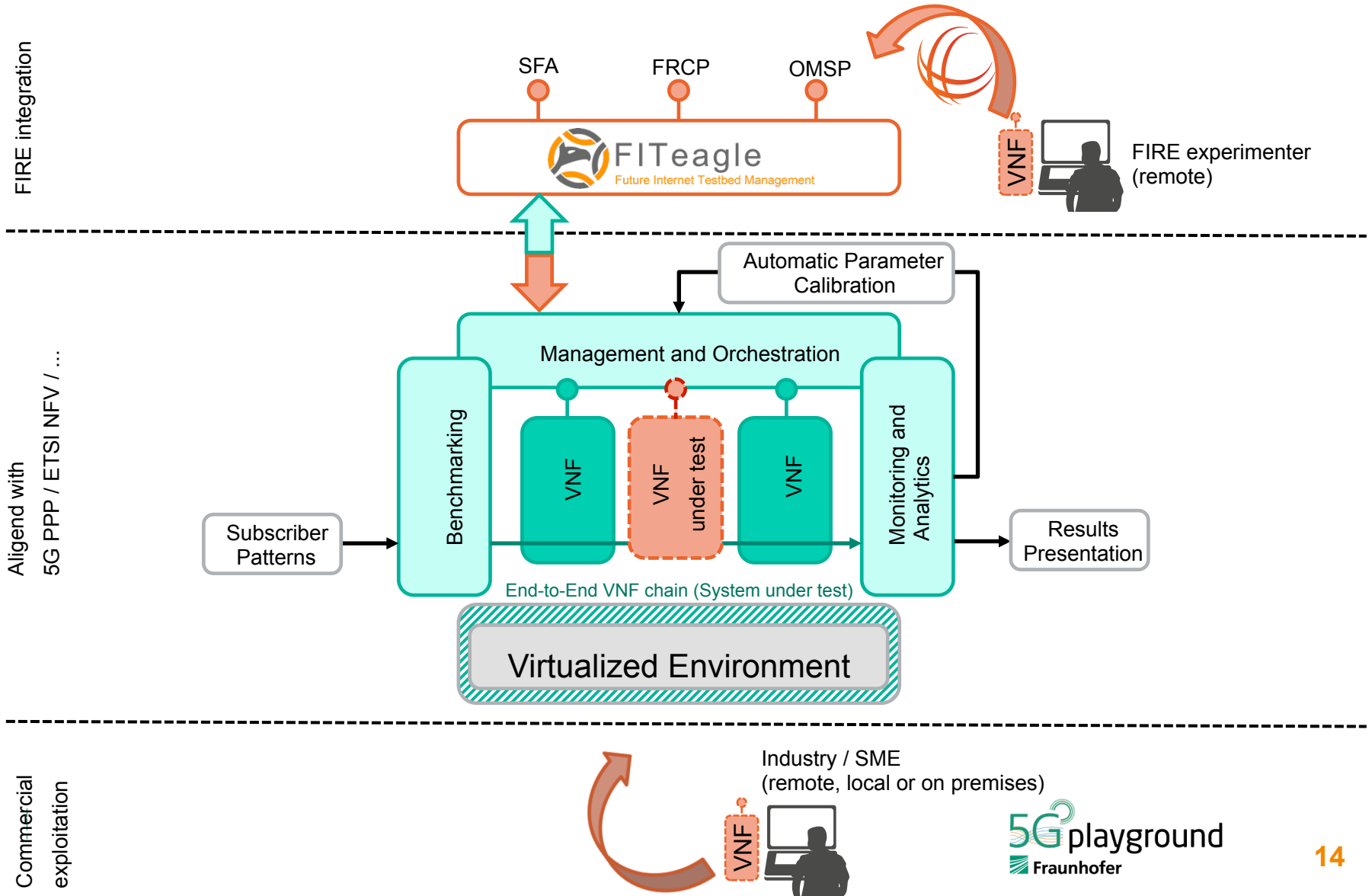


IV. Calibration and Benchmarking

- 5G Playground provides a reference environment for benchmarking of the new products and prototypes
 - Within different emulated network environments
 - With different subscriber traces (e.g. for mobile users, for M2M, etc.)
- With 5G the customization to the different deployment environments becomes essential
 - 5G Playground offers the means for automatic calibration of network functions
 - 5G Playground includes the technology for long term testing

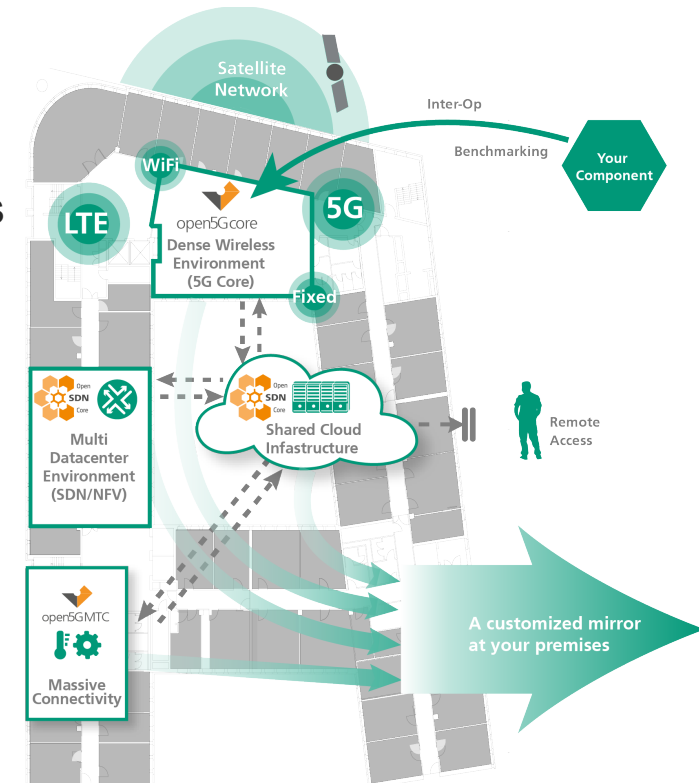


Example: Comprehensive 5G VNF Testing and Benchmarking

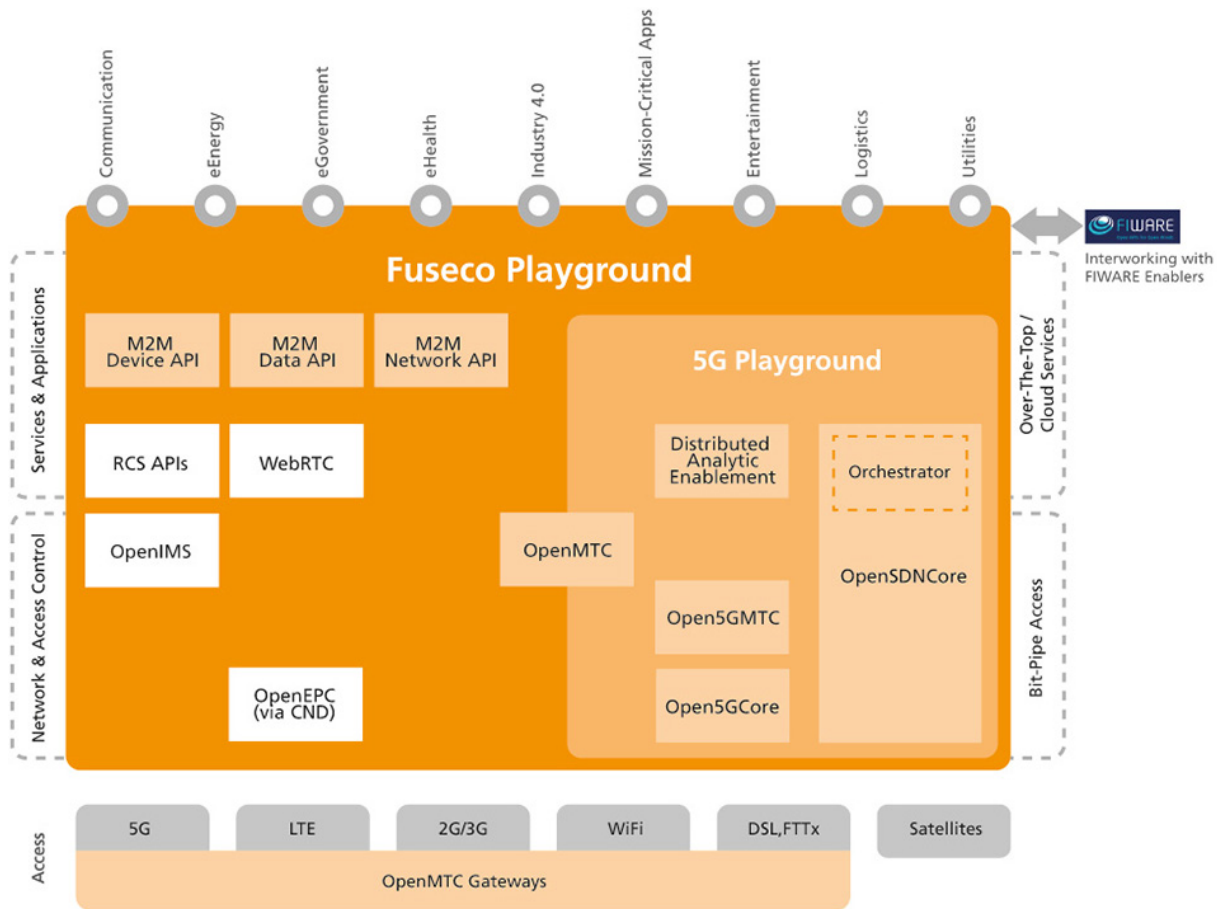


What the 5G Playground contains?

- A comprehensive set of toolkits enabling the setup of the environment and the development of an end-to-end testing environment
 - NFV Orchestrator – for automatic deployments, experiment control and runtime management
 - OpenSDNCore – the underlying SDN infrastructure
 - Open5GCore – radio and core network components + benchmarking tool
 - Open5GMTC – device connectivity control, emulated device management and benchmarking tool
 - FITeagle – for federation and remote access
- Methodology and tools for benchmarking prototypes and products
- Commodity and price efficiency:
 - Automatic installation & Experiment control
 - Independent experimentation slices



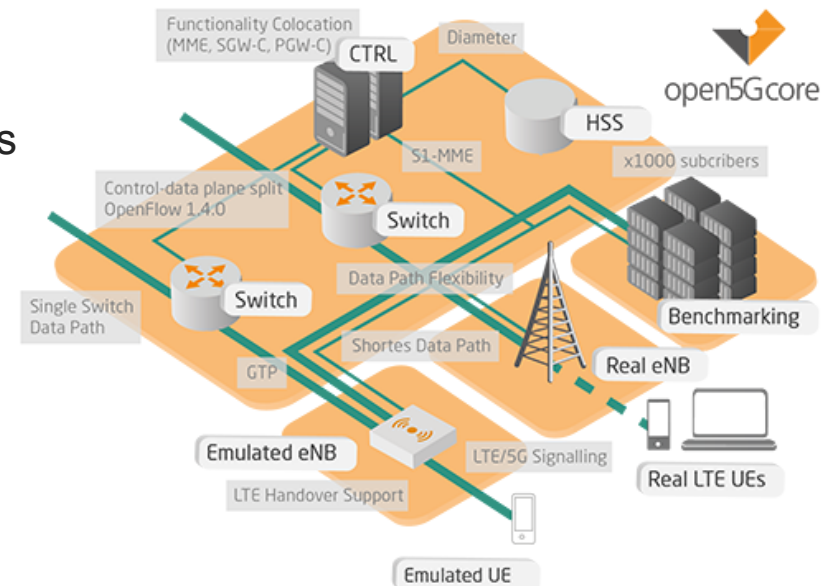
5G Playground Architecture Overview



Open5GCore Toolkit

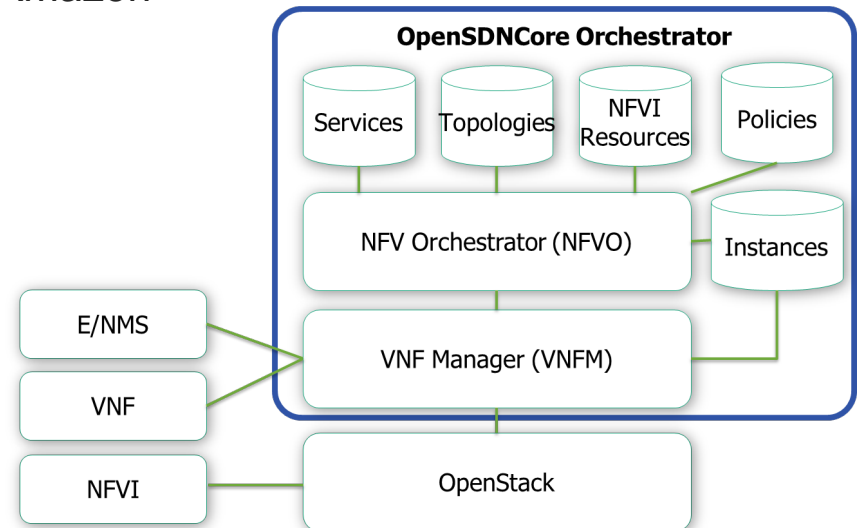
Providing the basis for the 5G research

- Open5GCore is an R&D prototype, including features with high industry relevance from the Fraunhofer FOKUS research activities, based on 3GPP standards (Rel. 12, 13, ...)
- Open5GCore represents the R&D successor of the OpenEPC, using the same platform
- Open5GCore enables the establishment of a small test operator network including:
 - Fundamental core network functionality for LTE and trusted non-3GPP WLAN
 - Runtime flexibility and robustness features
 - Co-location of control plane functions
 - Dynamic reselection of data plane functions (OpenFlow)
 - Proxy and re-targeting mechanisms for Diameter, GTP-C and GTP-U
 - Multi-access device support
 - Short data path support (UE-eNB-UE)
 - Benchmarking tools



NFV Orchestrator Toolkit

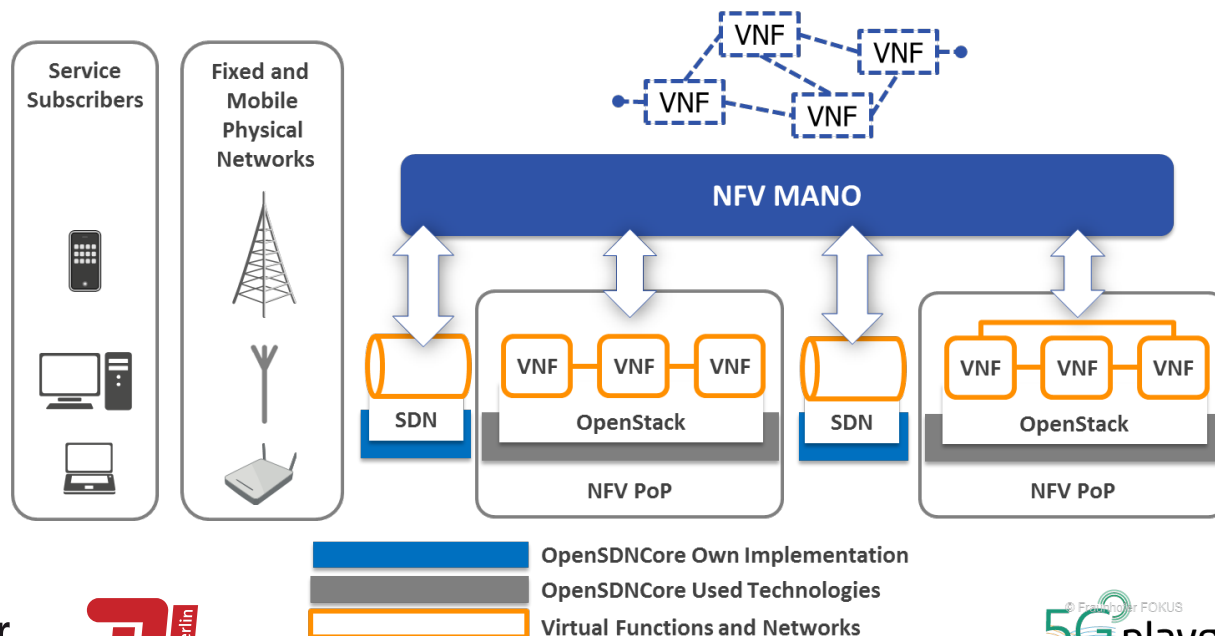
- Following the ETSI MANO specifications
 - Maintains information on services, topologies, resources, policies, infrastructure, ...
 - Orchestrates end-to-end services
 - Executes runtime updates for elasticity, failure mitigation, etc.
 - Supports network functions placement
- Integrates directly with OpenStack [API] and Amazon
 - Establishment of virtual networks
 - Provisioning of VMs
 - Based on different images
 - Across multiple data centers
- Management of components
 - Lightweight EMS using <http://bottlepy.org>
 - Based on service specific parameters



OpenSDNCore Toolkit

OpenSDNCore is an R&D prototype, providing advanced features with high industry relevance for carrier-grade NFV/SDN solutions, addressing a multi-data center environment:

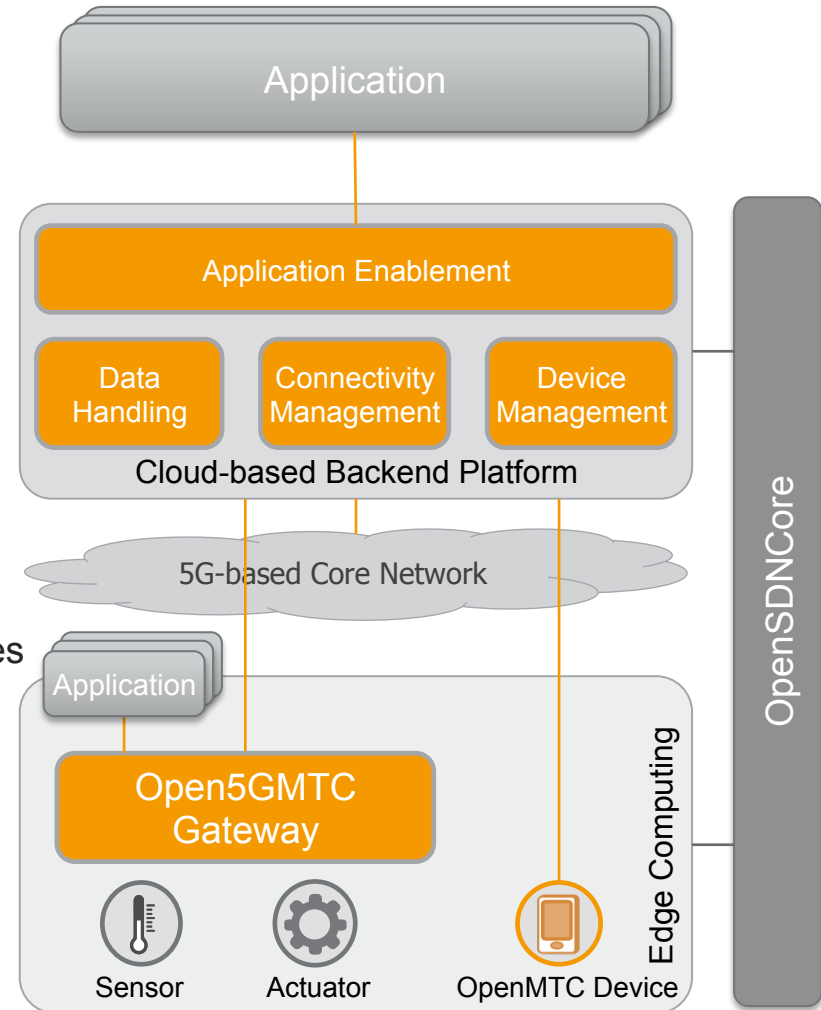
- ETSI MANO based orchestrator incl. network functions placement support
- SDN network for the inter-data center communication incl. service function chaining
- Managing the vEPC, vIMS, vM2M platforms



Open5GMTC Toolkit

High scalable M2M/IoT platform for communication over 5G

- Enable the academia and industry to
 - Develop and validate domain-specific M2M/IoT applications and services over 5G core
 - Integrate various machine devices with operator networks
- Scalable M2M/IoT deployment
 - Over managed or unmanaged core
- Distributed data processing
 - Between multiple managed domains
 - Service platforms, the operator network, and devices
- Aligned with international standards
 - Extensible to specific research needs
 - Configurable & high performance



FIteagle Semantic Testbed Management and Federation Access

- Single testbed toolkit to enable the remote experiment life cycle workflow
 - **Provisioning**: Slice-based Federation Architecture (**SFA**) Aggregate Manager (**AM**) and Slice Authority (**SA**)
 - **Measurements**: OML Measurement Stream Protocol (**OMSP**)
 - **Control**: Federated Resource Control Protocol (**FRCP**)
 - **Linked Data**: Resource Description Framework (**RDF**) based models
- Including functionality for
 - Semantic information modeling
 - X.509 based Authentication and Authorization
 - Resource Reservation



5G playground
Fraunhofer

Clone and customize your own 5G Playground

- The 5G Playground was designed from the initial phases for commodity for being deployed at customer premises
 - Mirroring the advancements from the Berlin testbed
 - Providing a separate isolated testing facility
 - Including only the interesting functionality from the comprehensive environment
 - Customizing the test environment for the specific requirements



5G playground
Fraunhofer



**Your
Premises**

5G Playground SDN and 5G related Projects



CogNet
<http://www.cognet.5g-ppp.eu/>



MCN
<http://mobile-cloud-networking.eu/site/>



SDN@Edge
<https://www.eitdigital.eu/innovation-entrepreneurship/future-networking-solutions/>



Bercom
(Website under preparation)



Arcadia
<http://www.arcadia-framework.eu/wp/>



Flexcare
<http://www.flex-project.eu/>



SoftFIRE
<http://www.ict-fire.eu/home.html>



Unifi/TEAM
<http://daad-unifi.org/>

What the 5G Playground offers to GENI-FIRE community?



Part of the Community

Federation Projects



FED4FIRE



TRESCIMO

BonFIRE



OpenLab



THE INFINITY PROJECT

unifi



Panlob

G-Lab DEEP



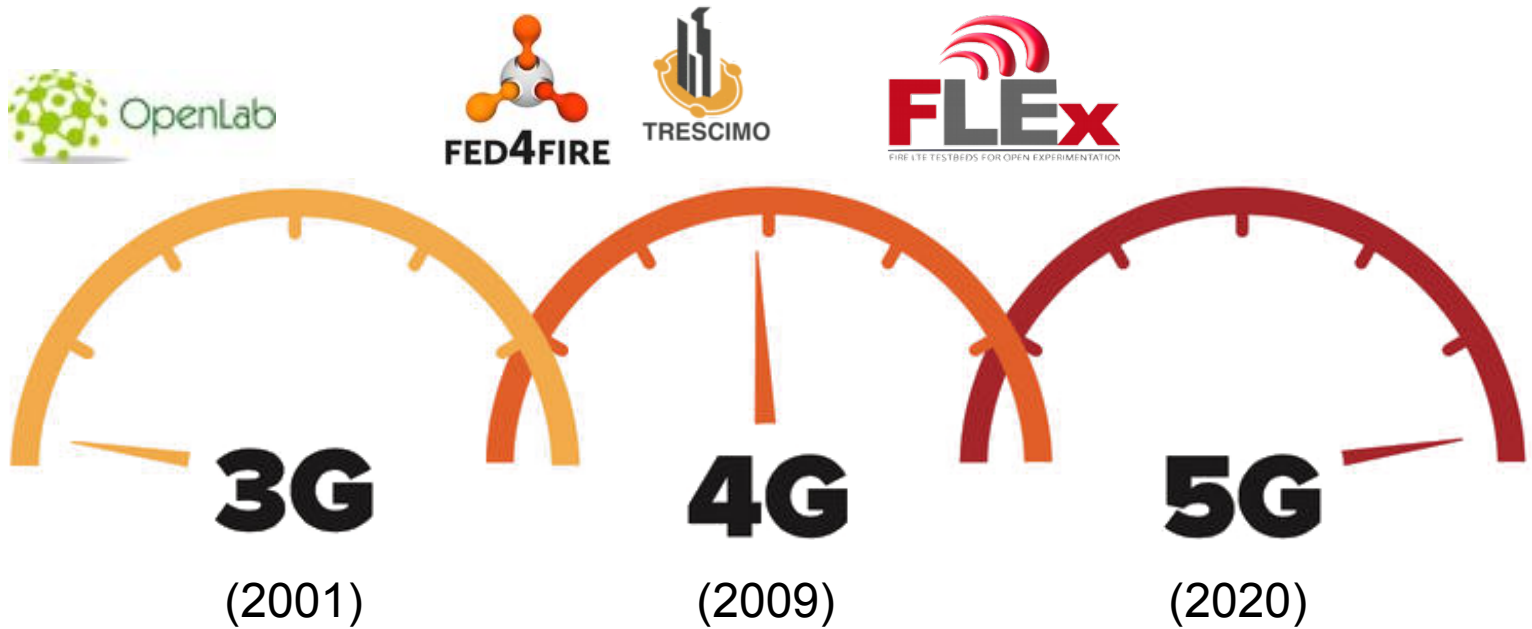
Federation Tools and Communities



OneLab
FUTURE INTERNET TESTBEDS



Standard oriented practical implementations and experimentation



open ims core

Fraunhofer
FOKUS

Open
EPC
Evolved
Packet Core

open mtc

open5Gcore

Open
SDN
Core

open5GMTC



An Initiative for collaborative research towards 5G

5G –Access, -Core, -NFV, -MTC & Xhaul Technology
to be tested in one place

5G Berlin contributes in the global research arena being
a place to have 5G related researchers join their effort,
interact across disciplinary borders and test latest
technologies, system components and applications in a
real world setup.

Join 5G Research
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OUR TESTBEDS



For further information, technical questions, licensing and pricing requests, contact us at info@Open5GCore.net

www.5G-Playground.org

6th FOKUS FUSECO Forum

Thu., Nov. 05, 2015 to Fri., Nov. 06, 2015 , Berlin, Germany

FUSECO
Forum  2015
FUTURE SEAMLESS COMMUNICATION

“Digital Convergence and Seamless Connectivity for everyone and everything – Bringing 5G, SDN/NFV and M2M/IOT together”

FOKUS FUSECO Forum 2014 has been a great success with more than 230 international experts from 31 countries

**FFF 2015 will be in
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November 5/6, 2015**

For more details see
www.fuseco-forum.org

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