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WWW: www.5G-Playground.org

FOKUS Toolkits enabling 5G/SDN Testbeds
The Fraunhofer Gesellschaft is Europe‘s largest organization for applied research.

- Fraunhofer develops products and processes through to technical or commercial maturity
- Individual solutions are elaborated in direct contact with the customers
- The Fraunhofer Gesellschaft maintains 66 self-contained Fraunhofer Institutes throughout Germany
- with a staff of 22,000 scientists and engineers
- 1.9 billion Euro annual budget
- More than 70% of funding are raised through innovative development projects, license fees and contract research
- Sub-companies and representative offices all over the world
ABOUT FRAUNHOFER FOKUS

- Founded in 1988
- The institute addresses important challenges in the society and the smart cities of the future.
- Today around 510 employees from more than 30 countries are working on promising technologies in the research and development sector.
- Fraunhofer FOKUS maintains an international network of strategic partners from industry, research organizations and public sector.
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**System Quality Engineering**

- Innovation Management

**Smart Communication**

- 5G and M2M
- Critical Infrastructures
- Identity Management
- Testing and Certification
- Internet of Things
- Linking Legislation and Technology
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NGNI GENERAL STRATEGY

New technologies

Platform & protocol prototyping in key areas of convergence

Existing markets

Operators

Integrators

Vendors

- Toolkit licenses
- Prototyping
- Strategic studies
- IP generation
- Showcasing
- Testing
- Benchmarking
- Seminars & Tutorials
- Conferences

Based on our OpenXXX toolkits
Cross-financed with EU and BMBF public funding
FOKUS TESTBED AND TOOLKIT EVOLUTION

3G (2001)  
open ims core

4G (2009)  
open ims core

5G (2020)  
open mtc
op5G MTC
open5G core
OPEN BATON
Deployed FOKUS Testbeds 2 GO Around The World

Testbeds are located at the customer premises
- Under the complete control of the local partners
- Remote support via VPNs (for a reduced number of testbeds)
- Bug fixes and updates are done via: email reports (network traces, cores) → svn updates
5G Playground: A comprehensive testbed environment for prototyping 5G-ready NFs using OpenBaton orchestration

- Open5GCore providing the next wireless system beyond LTE/EPC with more efficient communication for the subscribers and improved automation/reliability (applying SDN and NFV principles)
- Open5GMTC enabling connectivity management and end-to-end service establishment for a huge number of connected devices
- OpenSDNCore enabling SDN experimentation for data path, backhaul networks or customized network environments
- All those are Software components and can be customized, deployed and configured on demand via OpenBaton enabling automatic just-in-time test environment creation, experimentation and demonstration
The 5G Playground @ FOKUS Infrastructure

High Performance Data Center

- Cloud infrastructure providing high computing, storage and networking capacities
  - Dell Bladecenter (M620, >120 CPU cores, >640GB RAM)
  - Fully redundant NetApp Metro Cluster (>10TB Storage)
  - NVIDIA Tesla (C10, C20, K20)
  - SDN Datacenter copper/fiber switches (1/10/40Gbit/s, HP3800, Pica-8)
  - Cisco ASA Routers (redundant Internet connectivity)
  - Mostly Linux OS (Ubuntu LTS) and OpenStack (Juno & Kilo)

- Usage
  - Operational (high availability) shared cloud environment for multiple live instances of the 5G Playground
  - Computing and networking platform for experimenters
  - Toolkit and benchmark hosts
  - Update servers for remote 5G Playground instances
  - Public cloud complementing edge computing experiments
Mini and Micro-data centers

- Orange Box: Facility edge network computing environment
  - Supports up to 20 4G small cell base stations
  - 10x Intel NUCs (Ivy Bridge D53427RKE model),
    i5-3427U CPU, 16GB of DDR3 RAM, 120GB SSD root disk, Gb Ethernet
  - D-Link DGS-1100-16 managed gigabit switch with 802.1q VLAN
- Lenovo M93P: Desktop core network for each researcher
  - Intel® CoreTM i5-4570T 2.9GHz 4M (4th generation), 16GB DDR3 RAM,
    Gigabit Ethernet, 3x USB 3.0, 1x USB 2.0
- Raspberry Pi 3: The smallest core network available
  - 1.2 GHz 64-bit quad-core ARM Cortex-A53, 1GB SDRAM,
    4 USB 2.0 ports, 100Mbit/s Ethernet

- Usage
  - Pool of heterogeneous edge computing environments for dedicated R&D use cases,
    trial experiments and showcases
Wireless Access

- LTE
  - 2 ip.access eNodeB’s LTE 245F (supporting LTE FDD bands 7, 13)
  - 3 UEs (Huawei E3276 compatible with the LTE FDD)
  - 3 Android (LTE capable Smartphones (Samsung Galaxy S6))

- WLAN
  - 3 WiFi APs Cisco Aironet 3602e (802.11 a/b/g/n/ac 2.4 GHz and 5 GHz in parallel)

- Software Defined Radio
  - Ettus Research USRP (USRP 1&2, N2, N210, B200, X310) with several RF boards
  - National Instruments HIL/RTT Suite

- RF Signal Conditioning
  - Handover Test System (Frequency range 700MHz – 3GHz; Configuration 6x1; Attenuation range 1 - 127dB in 1dB steps; Switching speed <4 ms)
  - Radio Signal Shield Box (>80dB shielding; USB 2.0 connector; Size inside 340 x 240 x 160 mm; Antenna Coupler with frequency range 700MHz – 2.7GHz)
The 5G Playground @ FOKUS infrastructure

Permanent Demonstration Environment

- Facilitates 5G Playground toolkits and infrastructure in a comprehensive micro-operator scenario (network slice)
- Placed on a vertical setup (“4G/5G Wall”)
- Showcases
  - Comprehensive environments
  - Different features within the same environment
  - Effects on live testbeds
  - Edge mobility
  - Live monitoring information
OPEN 5G PLAYGROUND - THE FIRST REAL 5G TESTBED

OPEN BATON

Multimedia
- Call center

Critical Comms

Logistics

Secure Enterprise

Automation

eUtilities

Multimedia

E-Energy

Multimedia

Critical Comms

Secure Enterprise

Automation

eUtilities

Multimedia

E-Energy

Critical Comms

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eUtilities

Multimedia

E-Energy

Secure Enterprise

Automation

eUtilities

Multimedia

E-Energy

End Users

Roles:
- Service User
- Virtual Service Provider
- Infrastructure provider(s)

Multimedia

E-Energy

Critical Comms

Secure Enterprise

Automation

eUtilities

Multimedia

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E-Energy
- **5G World** – The federation of 3rd Party 5G testbeds around the world that connect and share with the 5G Berlin.

- **5G Berlin** – The Berlin-located comprehensive testbed operated currently by Fraunhofer FOKUS and Fraunhofer HHI.

- **5G Playground @ FOKUS** – The local live testbeds situated at Fraunhofer FOKUS premises.

- **5G Access & Photonics @ HHI** – The HHI photonic, mmWave and advanced radio testbeds.
What is the 5G Playground

5G Playground provides a single stop for a comprehensive set of toolkits with virtually all that is needed to be installed for a live 5G testbed

- A comprehensive set of software toolkits enabling setup and development of 5G applications in an end-to-end testing environment.

**OPEN BATON**  
Management and orchestration for NFV environments, running on top of OpenStack (and soon OpenMANO).

**open5GMTC**  
A new, efficient approach for remote connectivity management of M2M and multimedia, based on standard protocols.

**Open SDN Core**  
Extensive platform for SDN added value features for flexible routing, virtual environments and core network data paths.

**open5Gcore**  
R&D prototype for mobile core networks beyond 3GPP Release 13, supporting 5G, 4G (LTE) and WLAN.

- A methodology and tools for benchmarking 5G prototypes and products.
- A commodity providing cost efficient automatic installation and experiment control.
The 5G Playground is made of:

**OPEN BATON**

- A standard aligned implementation of the ETSI NFV MANO
- Running on top of OpenStack (and soon OpenMANO)
- Providing independent infrastructure slices
- Support for runtime elasticity and fault management
- A large amount of use cases:
  - Core networks, multimedia, etc.
- Available on GitHub: [https://github.com/openbaton](https://github.com/openbaton)
- A new approach to device communication and M2M
- Addressing connectivity of a large number of devices
- Connectivity control on top of heterogeneous environments
  - Security
  - Customized connectivity
  - Service capabilities
- Based on standard protocols:
  - OMA LW M2M, eSIM, etc.
What is the 5G Playground made of

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  • OMA LW M2M, eSIM, etc.
  • Providing an extensive platform for SDN added value features
  • Based on standard components (IETF, ONF, etc.)
  • Establishment of dynamic data paths
  • Backhaul control for dedicated networks
  • Deep data plane programmability
  • Service Function Chaining
What is the 5G Playground made of

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  - Establishment of dynamic data paths
  - Backhaul control for dedicated networks
  - Deep data plane programmability
  - Service Function Chaining
  - R&D prototype of mobile core networks beyond 3GPP Release 13
  - Support for (5G), LTE and WLAN
  - Cloud-native core network for NFV
  - Seamless elasticity
  - Mobile edge network support
  - Service oriented data paths
  - Highly customizable (for DCNs)
  - Benchmarking and experimentation
Final Testbed Map

- 4 dedicated centralization nodes, each with its own radio access network deployments
Providing 5G access, 5G core, Xhaul with SDN/NFV/MEC service platforms within a single place

- Following the NGMN requirements for 5G
- Based on the combined experience of Fraunhofer FOKUS and Fraunhofer HHI
- Uniting the complete stakeholders value chain for 5G
- A unique combination of the current 5G advancements
- A place for operators, vendors and integrators to develop and test new 5G concepts
5G Berlin: Target Infrastructure View

Fraunhofer FOKUS

- Mobile Edge Data Center
- NFV Orchestration
- Local RAN Mgmt
- Flexible SDN
- Backhaul
- WAN SDN Control
- High Speed, High Capacity Backhaul Network

Fraunhofer HHI

- Mobile Edge Data Center
- NFV Orchestration
- Local RAN Mgmt
- Flexible SDN
- Backhaul
- WAN SDN Control
- Local RAN deployment

TUB

- Mobile Edge Data Center
- NFV Orchestration
- Local RAN Mgmt
- Flexible SDN
- Backhaul
- WAN SDN Control
- Local RAN deployment

TLabs

- Mobile Edge Data Center
- NFV Orchestration
- Local RAN Mgmt
- Flexible SDN
- Backhaul
- WAN SDN Control
- Local RAN deployment
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
UNIFI Mission

- **UNIFI** – **UNI**versities for **Future** **Internet**

- **UNIFI** is an initiative of the Chair of **Next Generation Networks (AV)** at the **Technische Universität Berlin** aiming at building sustainable teaching and research infrastructures in the areas of Future Internet through global collaboration among academic institutions.

- The initiative intends to reach its goals via enablement and empowerment of all stakeholders of academia:
  - the creation and development of high quality curricula, integration and exchange of teaching personnel, students, postgraduates and researchers among the partner universities

- the creation of Competence Centers for a sustainable development and bundling of local expertise

- the creation and development of an open, general purpose, and sustainable large-scale shared Next Generation Networks Infrastructures & Future Internet Technology Experimentation and Research Facility via federation of interoperable local testbeds.

- the creation and operation of an International Multilateral Academic Network as a communication hub and motor for intercultural understanding in the international FI academic community

[www.daad-unifi.org](http://www.daad-unifi.org)
DAAD Project University Future Internet
Unifying Education and Testbeds around the Globe

TU Berlin

Chair for Next Generation Networks (AV)

DAAD

unifi

University of Cape Town
www.uct.ac.za

Universidad de Chile
www.uchile.cl

Hanoi University of Science and Technology
en.hustech.edu.vn

Chulalongkorn University
www.chula.ac.th

Enabled by

teagle
A Pan-European Laboratory Project

www.daad-unifi.org
DAAD Project University Future Internet

Unifying Education and Testbeds around the Globe

Joint R&D Projects

R&D

Joint R&D

Awareness Creation

Workshops

Lectures

Testbeds

Enabled by
teadle

A Pan-European Laboratory Project

open mtc
osims
open epc

Federated Testbeds
Federated TRECIMO (FIRE) Testbeds
Demonstration 1:

**TUB Testbed**
- **Smart City Platform Dashboard**
- **OpenMTC Server**
- **OpenMTC Gateway**
- **OpenMTC IWP**
- **Sensors/Actuators**

**UCT Testbed**
- **Smart City Platform Dashboard**
- **OpenMTC Server**
- **OpenMTC Gateway**
- **OpenMTC IWP**
- **Sensors/Actuators**
USEFUL LINKS

- Fraunhofer FOKUS NGNI Competence Center: www.fokus.fraunhofer.de/go/ngni
- TU Berlin Chair for Next Generation Networks: www.av.tu-berlin.de

Testbed Toolkits:
- Open IMS Core Project: www.openimscore.org
- Open MTC Project: www.open-mtc.org
- Open EPC Project: www.openEPC.net
- Open 5GMTC Project: www.open5GMTC.org
- Open 5G Core Project: www.Open5GCore.org
- Open SDN Core Project: www.OpenSDNCore.org
- Future Internet testbed federation tool FITeagle: www.fiteagle.org

Testbeds
- Future Seamless Communication Playground: www.fuseco-playground.org
- Open 5G Playground: www.5G-Playground.org
- DAAD UNIFI Project: www.daad-unifi.org

Workshops and Conferences
- Future Seamless Communications Forum: www.fuseco-forum.org