

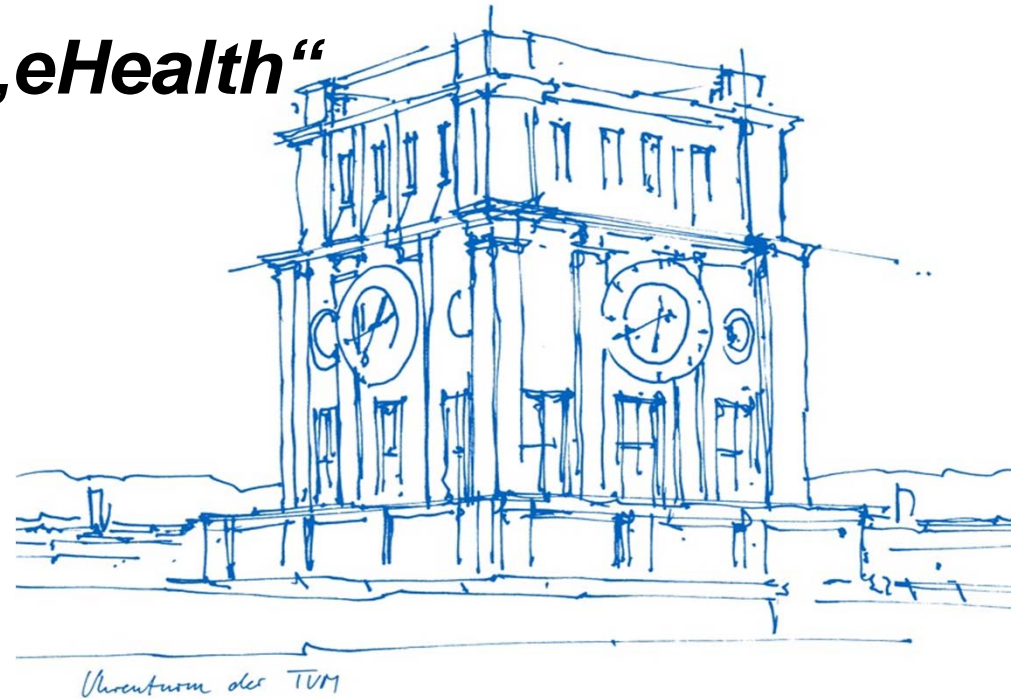
# **5G Research Hub Munich - 5G-Munich**

## **5G Testbed Bayern**

### **mit Schwerpunktanwendung „eHealth“**

Prof. Dr.-Ing. Wolfgang Kellerer  
Prof. Dr.-Ing. Eckehard Steinbach  
*CoC COM Industry Day, 19.7.2019*

*This project receives funding from the Bavarian Ministry of Economic Affairs, Regional Development and Energy*



# Overview



The 5G Research Hub Munich targets the

**development of an experimental 5G platform** at the Technical University of Munich

based on a **joint research project** started in 2019 between the

*Chair of Communication Networks (Prof. Wolfgang Kellerer)* and the

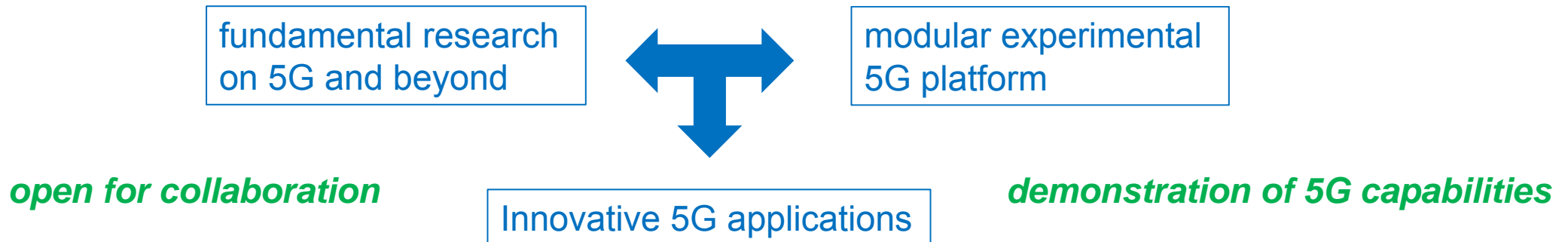
*Chair of Media Technology (Prof. Eckehard Steinbach)*

funded by the Bavarian Ministry of Economic Affairs, Regional Development and Energy.

The experimental platform is open for collaboration.

# Objectives

- **Realization of a 5G experimental lab platform** and its continuous advancement according to latest 5G standard releases and related research
- **Fundamental research** to significantly shape the state of the art for selected areas in 5G technologies and applications
- **Realization of a methods and technologies platform** as a modular framework being open for emerging applications



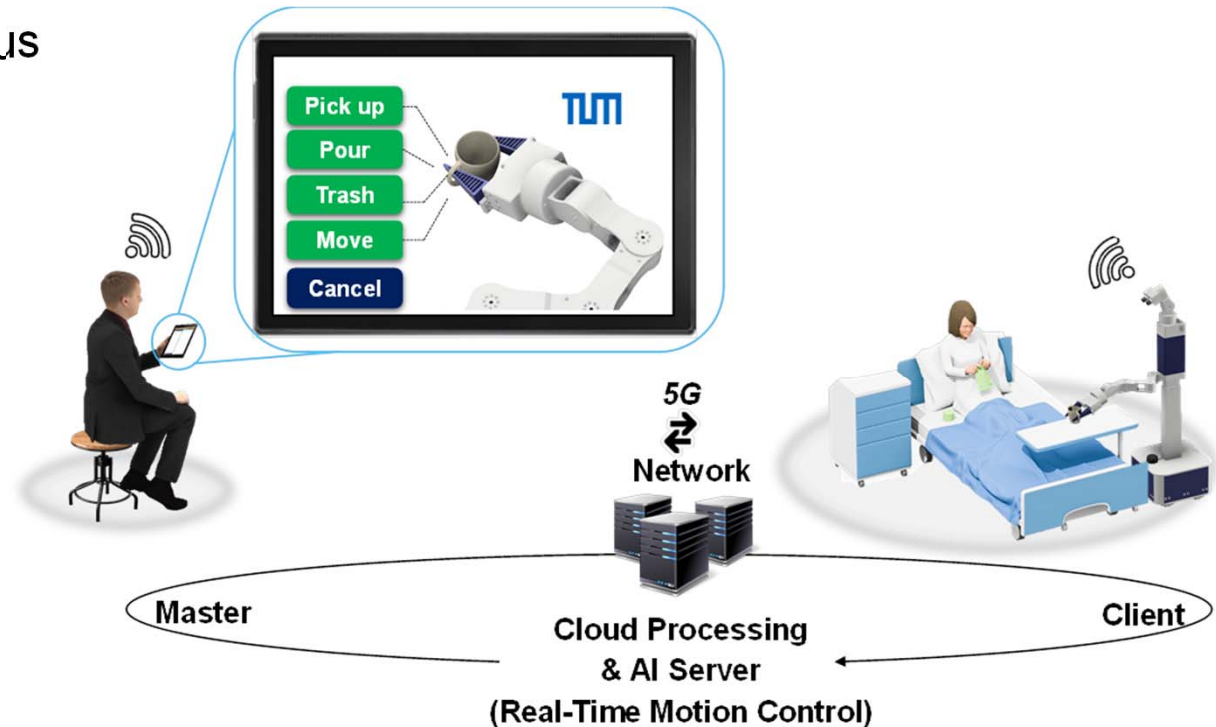
# Focus application area: eHealth

## Scenario: Telepresence and Teleservice

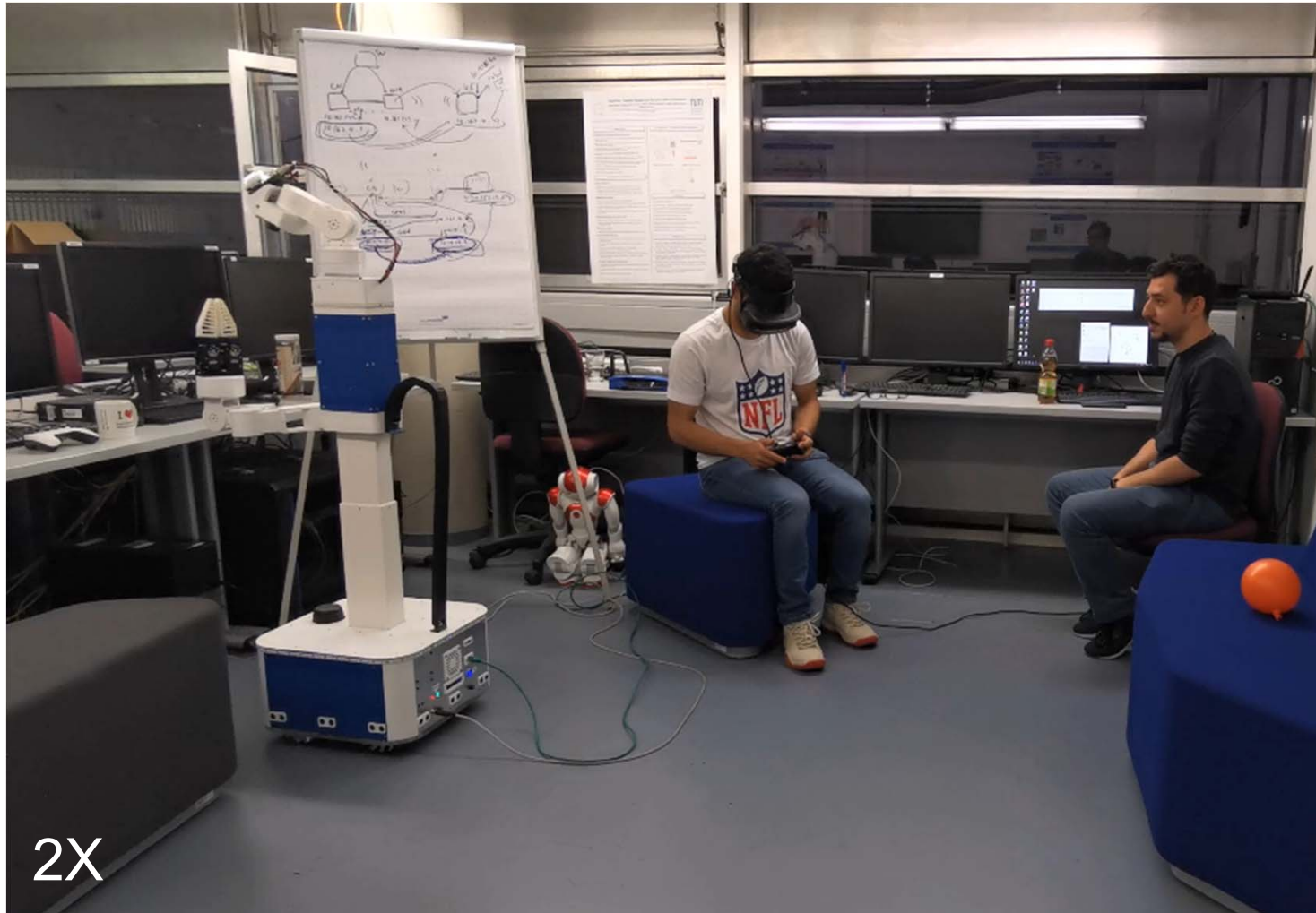
- Teleoperation and semi-autonomous task execution
- Visual immersion: 3D 360° video
- Object recognition
- Localization and mapping

## 5G requirements

- Ultra low delay
- Network-based processing
- High reliability
- High data rates (video)
- QoS differentiation → Slicing

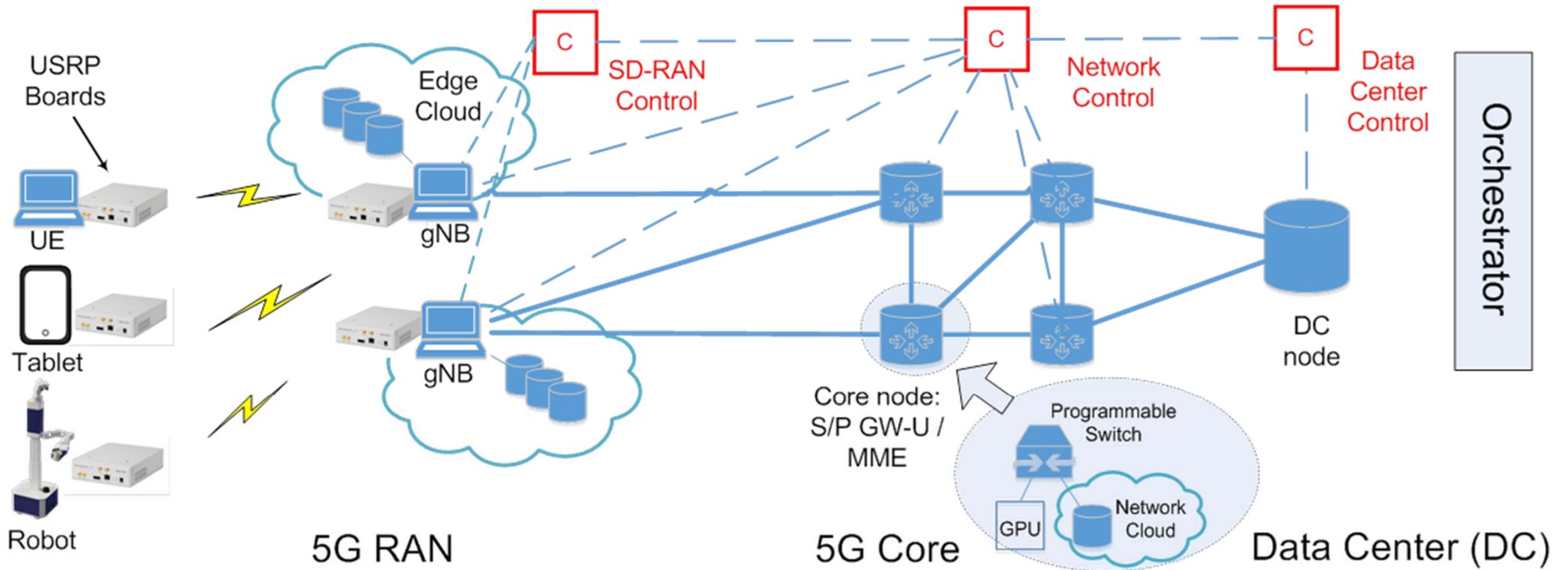


# Teleoperation robot demo

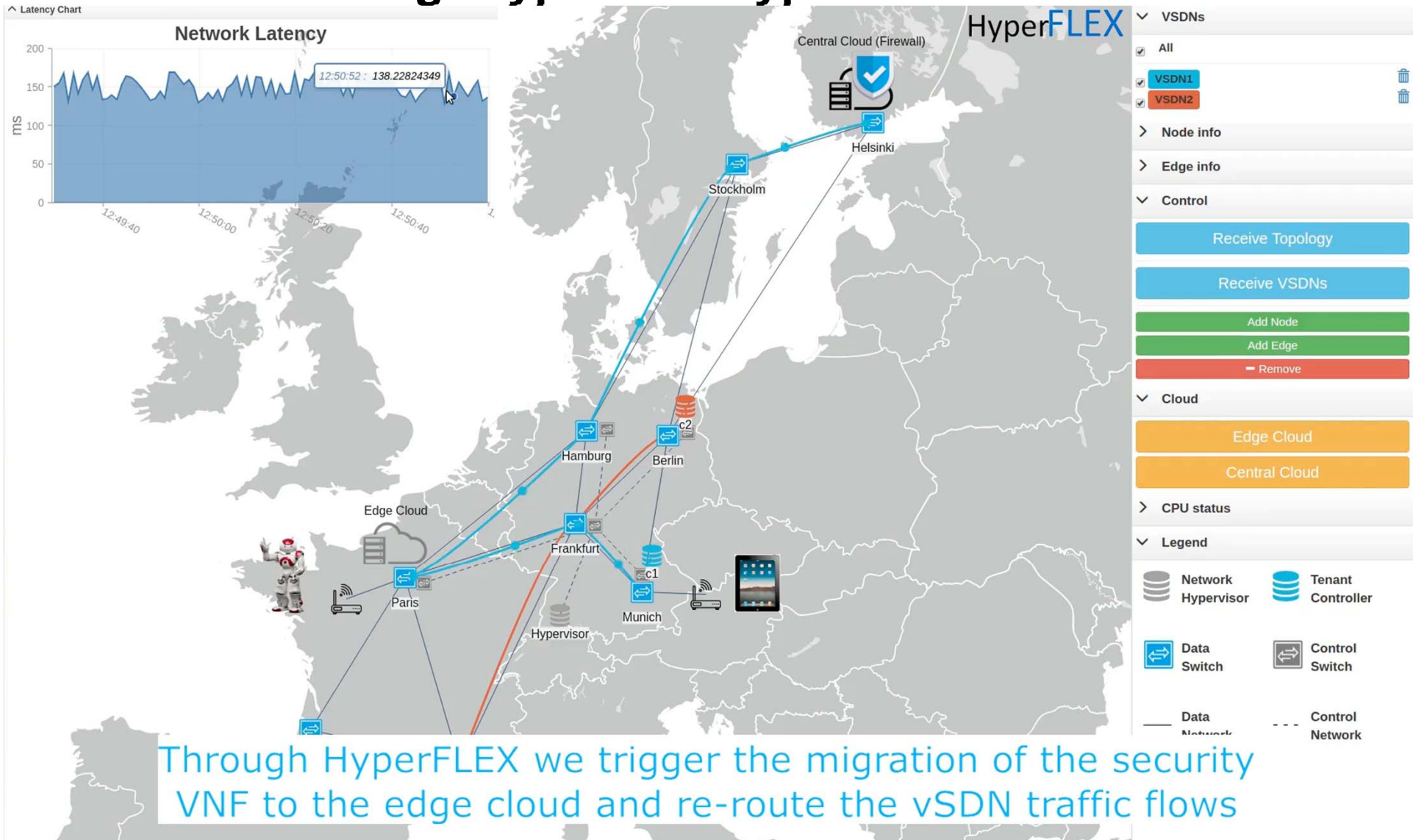


# Network Model

## Planned lab setup



# Core network slicing: HyperFlex Hypervisor



Through HyperFLEX we trigger the migration of the security VNF to the edge cloud and re-route the vSDN traffic flows

# Research directions

## Radio Access Network

- *Low latency high reliability* to support critical application functions
- Radio network *slicing* for reliable co-existence of different applications
- RAN *functions split* and its impact on latency and reliability
- Dynamic base station coordination and radio resource management
- *Reliability* in 5G New Radio

## Core Network

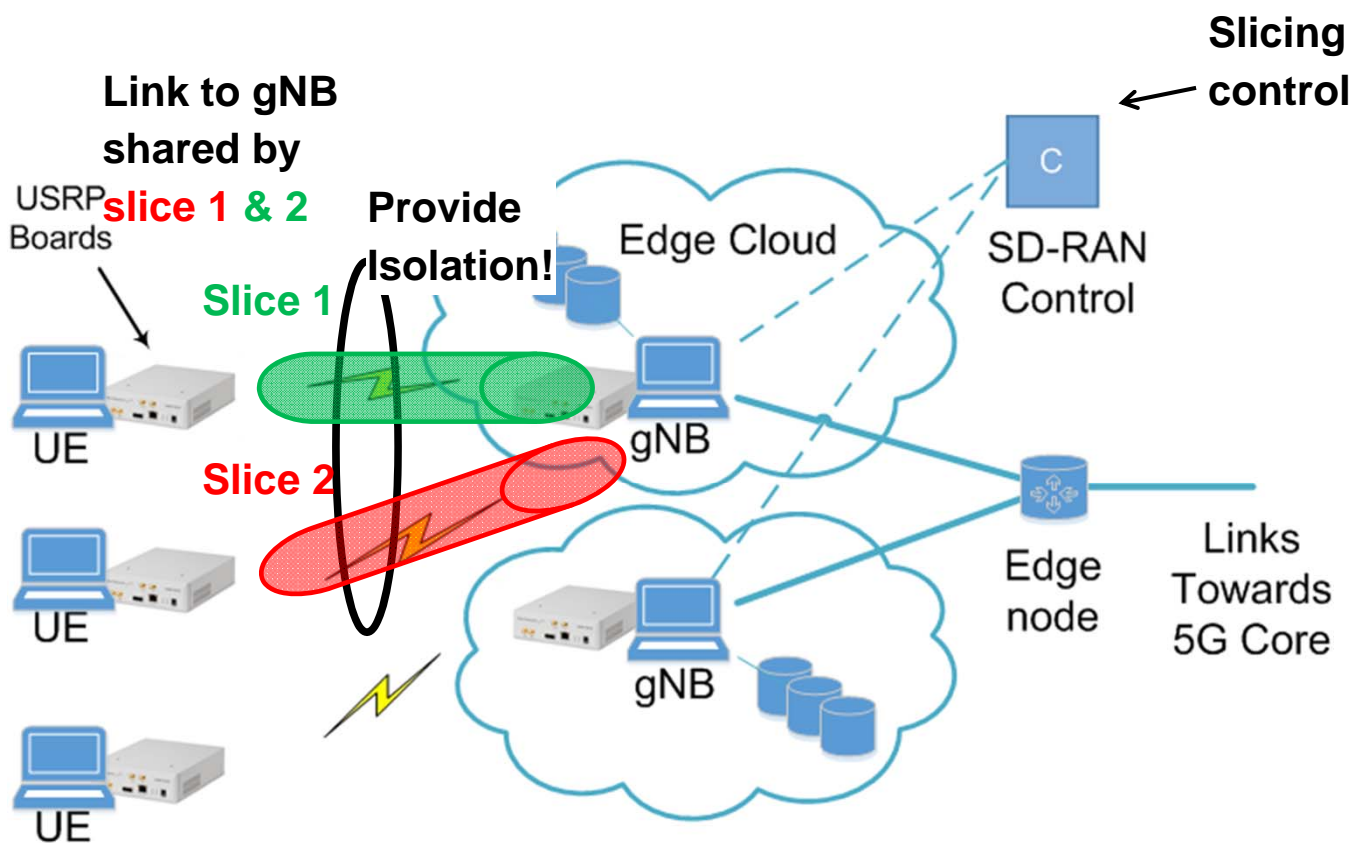
- Resource provisioning and *isolation of data and control plane* incl. network hypervisors
- Function *placement* and operation in distributed *edge cloud* environments
- *In-network processing* to support emerging 5G applications
- Hardware acceleration and *offloading* of virtualization functions

## Telepresence Robot

- *3D 360° immersive experience* of the remote scene (with delay compensation)
- HMD and tablet interface for natural remote control
- *Semi-autonomous* edge-based manipulation and object recognition
- Edge-based *navigation and SLAM*
- Edge-based *real-time motion* control and monitoring
- User-in-the-loop *real-time haptic & kinesthetic feedback*

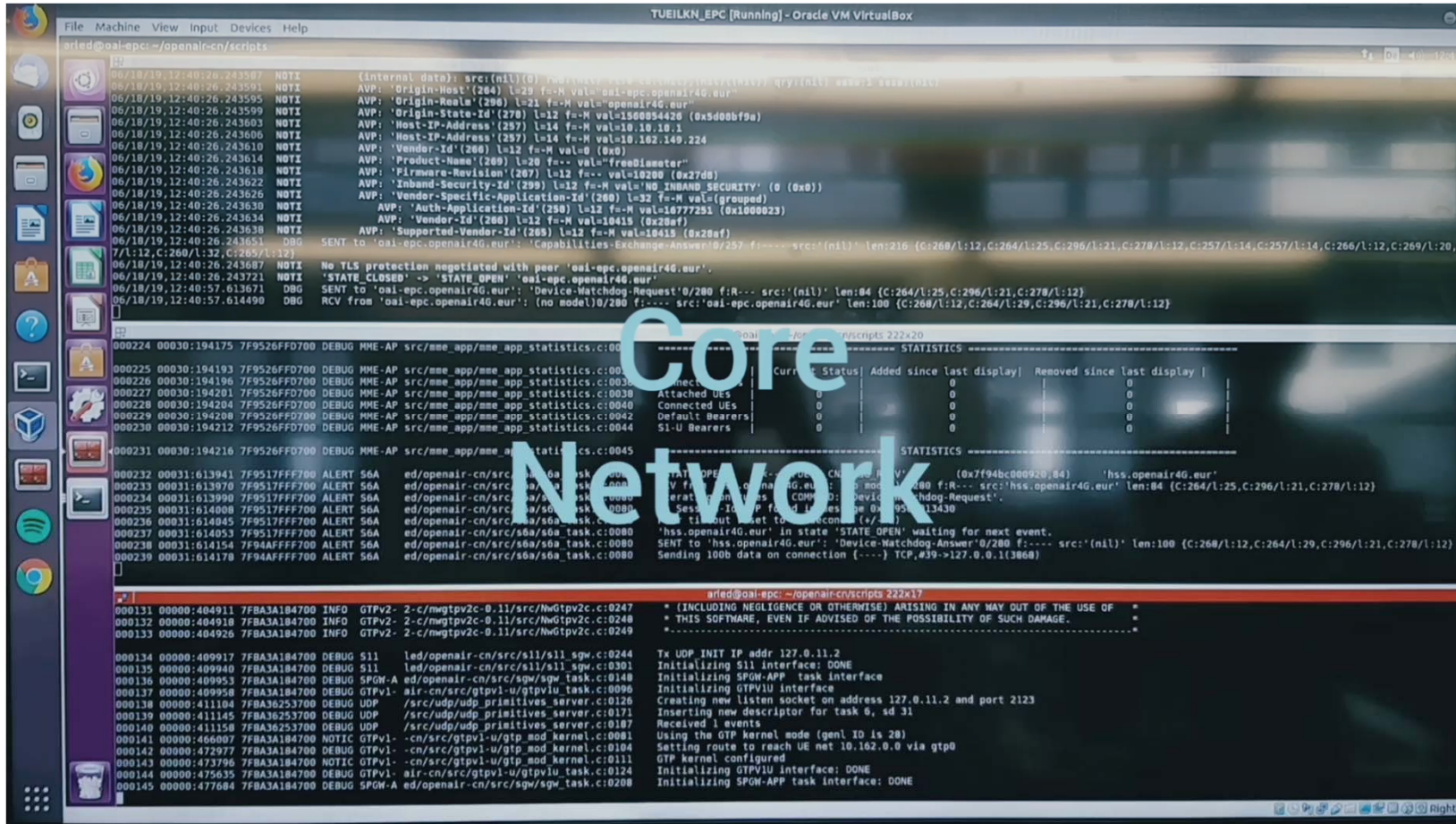


# Example: 5G Radio Access Network



- End-to-end slicing / Slice Isolation ✓
- Core slicing ✓
- RAN slicing ✓
- RAN function split / SD-RAN control ✓
- Grant-free access
- Edge cloud
- In-Network Processing

# Robot operated over Radio Access Network



```
ariel@oai-epc:~/openair-cn/scripts
06/18/19,12:40:26.243587 NOTI [Internal data]: src:(nil)() f=... val:(nil)()
06/18/19,12:40:26.243591 NOTI AVP: 'Origin-Host' (284) l=29 f=M val=...
06/18/19,12:40:26.243595 NOTI AVP: 'Origin-Host' (284) l=29 f=M val=...
06/18/19,12:40:26.243599 NOTI AVP: 'Origin-State-Id' (278) l=12 f=M val=1500054426 (0x5d00bf9a)
06/18/19,12:40:26.243603 NOTI AVP: 'Host-IP-Address' (257) l=14 f=M val=10.10.10.1
06/18/19,12:40:26.243606 NOTI AVP: 'Host-IP-Address' (257) l=14 f=M val=10.102.149.224
06/18/19,12:40:26.243610 NOTI AVP: 'Vendor-Id' (268) l=12 f=M val=0 (0x0)
06/18/19,12:40:26.243614 NOTI AVP: 'Product-Name' (269) l=28 f=M val='freeDiameter'
06/18/19,12:40:26.243618 NOTI AVP: 'Firmware-Revision' (267) l=12 f=M val=10200 (0x27d8)
06/18/19,12:40:26.243622 NOTI AVP: 'Inband-Security-Id' (299) l=12 f=M val=NO_INBAND_SECURITY: 0 (0x0)
06/18/19,12:40:26.243626 NOTI AVP: 'Vendor-Specific-Application-Id' (260) l=32 f=M val=(grouped)
06/18/19,12:40:26.243630 NOTI AVP: 'Auth-Application-Id' (258) l=12 f=M val=16777251 (0x1000023)
06/18/19,12:40:26.243634 NOTI AVP: 'Vendor-Id' (268) l=12 f=M val=10415 (0x28af)
06/18/19,12:40:26.243638 NOTI AVP: 'Supported-Vendor-Id' (269) l=12 f=M val=10415 (0x28af)
06/18/19,12:40:26.243651 DBG SENT to 'oai-epc.openair4g.eur': 'Capabilities-Exchange-Answer' 0/257 f=... src:(nil) len:216 [C:268/L:12,C:264/L:25,C:296/L:21,C:278/L:12,C:257/L:14,C:257/L:14,C:266/L:12,C:269/L:20,7/L:12,C:260/L:32,C:265/L:12]
06/18/19,12:40:26.243687 NOTI No TLS protection negotiated with peer 'oai-epc.openair4g.eur'.
06/18/19,12:40:26.243721 NOTI 'STATE_CLOSED' -> 'STATE_OPEN' 'oai-epc.openair4g.eur'.
06/18/19,12:40:57.613671 DBG SENT to 'oai-epc.openair4g.eur': 'Device-Watchdog-Request' 0/280 f=R-- src:(nil) len:84 [C:264/L:25,C:296/L:21,C:278/L:12]
06/18/19,12:40:57.614490 DBG RCV from 'oai-epc.openair4g.eur': (no mode)0/280 f=... src:'oai-epc.openair4g.eur' len:100 [C:268/L:12,C:264/L:29,C:296/L:21,C:278/L:12]

000224 00030:194175 7F9526FFD700 DEBUG MME-AP src/mme_app/mme_app_statistics.c:000224
000225 00030:194193 7F9526FFD700 DEBUG MME-AP src/mme_app/mme_app_statistics.c:000225
000226 00030:194196 7F9526FFD700 DEBUG MME-AP src/mme_app/mme_app_statistics.c:000226
000227 00030:194201 7F9526FFD700 DEBUG MME-AP src/mme_app/mme_app_statistics.c:000227
000228 00030:194204 7F9526FFD700 DEBUG MME-AP src/mme_app/mme_app_statistics.c:000228
000229 00030:194208 7F9526FFD700 DEBUG MME-AP src/mme_app/mme_app_statistics.c:000229
000230 00030:194212 7F9526FFD700 DEBUG MME-AP src/mme_app/mme_app_statistics.c:000230
000231 00030:194216 7F9526FFD700 DEBUG MME-AP src/mme_app/mme_app_statistics.c:000231
000232 00031:613841 7F9517FFF700 ALERT S6A ed/openair-cn/src/s6a/s6a_task.c:000232
000233 00031:613870 7F9517FFF700 ALERT S6A ed/openair-cn/src/s6a/s6a_task.c:000233
000234 00031:613990 7F9517FFF700 ALERT S6A ed/openair-cn/src/s6a/s6a_task.c:000234
000235 00031:614008 7F9517FFF700 ALERT S6A ed/openair-cn/src/s6a/s6a_task.c:000235
000236 00031:614045 7F9517FFF700 ALERT S6A ed/openair-cn/src/s6a/s6a_task.c:000236
000237 00031:614053 7F9517FFF700 ALERT S6A ed/openair-cn/src/s6a/s6a_task.c:000237
000238 00031:614154 7F94AFFFF700 ALERT S6A ed/openair-cn/src/s6a/s6a_task.c:000238
000239 00031:614170 7F94AFFFF700 ALERT S6A ed/openair-cn/src/s6a/s6a_task.c:000239

ariel@oai-epc:~/openair-cn/scripts 22x17
000131 00000:404911 7FBA3A184700 INFO GTPv2- 2-c/mwgtpv2c-0.11/src/mwgtpv2c.c:0247 * (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF *
000132 00000:404918 7FBA3A184700 INFO GTPv2- 2-c/mwgtpv2c-0.11/src/mwgtpv2c.c:0248 * THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE. *
000133 00000:404926 7FBA3A184700 INFO GTPv2- 2-c/mwgtpv2c-0.11/src/mwgtpv2c.c:0249 *

000134 00000:409917 7FBA3A184700 DEBUG S11 led/openair-cn/src/s11/s11_sqw.c:0244 Tx UDP INIT IP addr 127.0.11.2
000135 00000:409940 7FBA3A184700 DEBUG S11 led/openair-cn/src/s11/s11_sqw.c:0301 Initializing S11 interface: DONE
000136 00000:409953 7FBA3A184700 DEBUG SPGW-A ed/openair-cn/src/sqw/sqw_task.c:0148 Initializing SPGW-APP task interface
000137 00000:409958 7FBA3A184700 DEBUG GTPv1- air-cn/src/gtpv1-u/gtpv1u_task.c:0096 Initializing GTPV1U interface
000138 00000:411104 7FBA36253700 DEBUG UDP /src/udp/udp_primitives_server.c:0126 Creating new listen socket on address 127.0.11.2 and port 2123
000139 00000:411145 7FBA36253700 DEBUG UDP /src/udp/udp_primitives_server.c:0171 Inserting new descriptor for task 6, sd 31
000140 00000:411158 7FBA36253700 DEBUG UDP /src/udp/udp_primitives_server.c:0187 Received 1 events
000141 00000:466007 7FBA3A184700 NOTICE GTPv1- -cn/src/gtpv1-u/gtp_mod_kernel.c:0081 Using the GTP kernel mode (genl id is 28)
000142 00000:472977 7FBA3A184700 DEBUG GTPv1- -cn/src/gtpv1-u/gtp_mod_kernel.c:0104 Setting route to reach UE net 10.102.0.0 via gtp0
000143 00000:473796 7FBA3A184700 NOTICE GTPv1- -cn/src/gtpv1-u/gtp_mod_kernel.c:0111 GTP kernel configured
000144 00000:475635 7FBA3A184700 DEBUG GTPv1- air-cn/src/gtpv1-u/gtpv1u_task.c:0124 Initializing GTPV1U interface: DONE
000145 00000:477684 7FBA3A184700 DEBUG SPGW-A ed/openair-cn/src/sqw/sqw_task.c:0208 Initializing SPGW-APP task interface: DONE
```

*more coming soon on*

[www.5G-munich.de](http://www.5G-munich.de)

*we are open for collaboration*