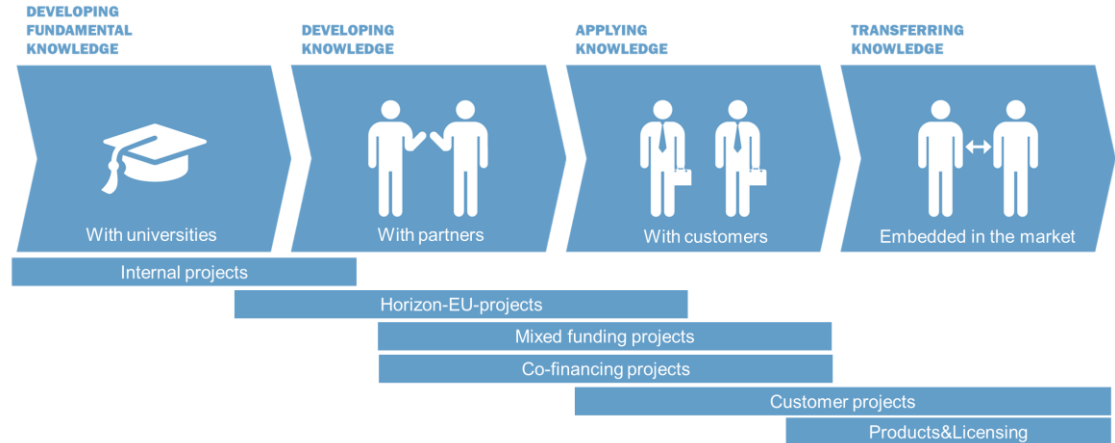
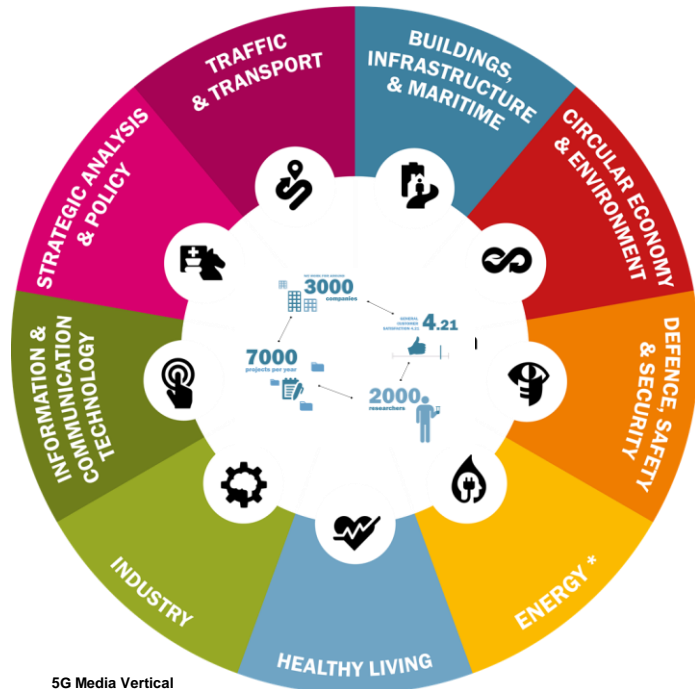


› 5G MEDIA VERTICAL

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TNO innovation
for life

TNO IS A DUTCH R&D INSTITUTE BRIDGING SCIENTIFIC AND COMMERCIAL WORLD



MEDIA APPLICATIONS

- › New levels of user experience
 - › 6 Degrees of Freedom VR
 - › Social eXtended Reality (XR)
 - › Ultra-high quality streaming
- › Challenges
 - › CPU/GPU/MEM/Bandwidth hungry
 - › Delay sensitive
 - › Synchronization
 - › Highly dynamic environment
- › TNO vision: app-aware slice



TNO RESEARCH CLOUD

› Platform available in-house:



› OpenStack/Ceph private cloud infrastructure

› OSM for orchestration, JuJu/MAAS for management

› Infrastructure-as-a-Code

› 15 physical servers (high-availability design)

› 2 top-of-the-rack switches, several SDN switches

› Programmable NICs, GPU NVIDIA Tesla V100



NETRONOME

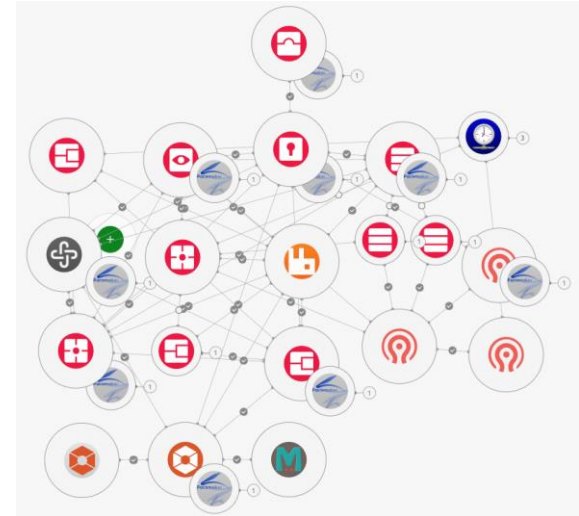


› Used for prototyping and experimentation

› Management and orchestration (MANO)

› 5G

› Post-quantum crypto, Blockchain, ICN,...



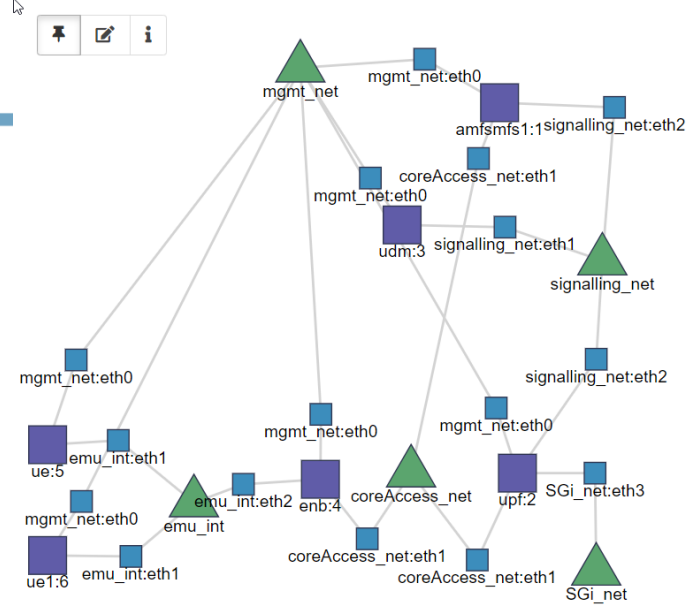
```

234 | neutron-gateway:
235 |   charm: cs:neutron-gateway
236 |   options:
237 |     bridge-mappings: physnet1:br-ex
238 |     data-port: br-ex:enp0s6
239 |     openstack-origin: cloud:xenial-queens
240 |     worker-multiplier: 0.25
241 |     vlan-ranges: 'physnet1:2:4094'
242 |     enable-isolated-metadata: true
243 |     enable-metadata-network: true
244 |   bindings:
245 |     "": maas-mgmt
246 |     data: os-tenantdata-space
247 |   to:
248 |     - kvm:0
249 |   constraints: "cores=8 mem=4G root-disk=20G"
  
```

5G AND TNO



- › Hi5 - 5G development platform
 - › Open5GCore (Fraunhofer), orchestrated by OSM
 - › Physical eNBs (Ericsson, Nokia, OpenAirInterface)
 - › Indoor spectrum, own SIM cards
 - › Geographically distributed
 - › Connected to national and international testbeds
- › Foundation for 5G research
 - › H2020, B2B, standardization, patents ...
 - › Relations with various verticals (media, satellite,...)

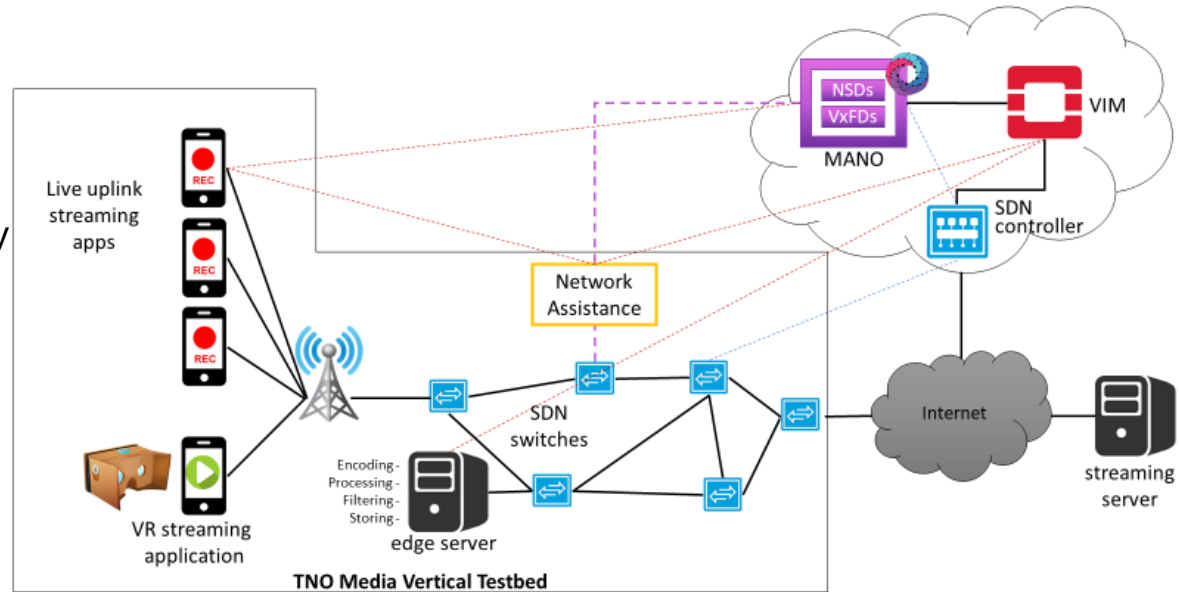


5G TESTBED FACILITIES



APPLICATION-AWARE NETWORK SLICE

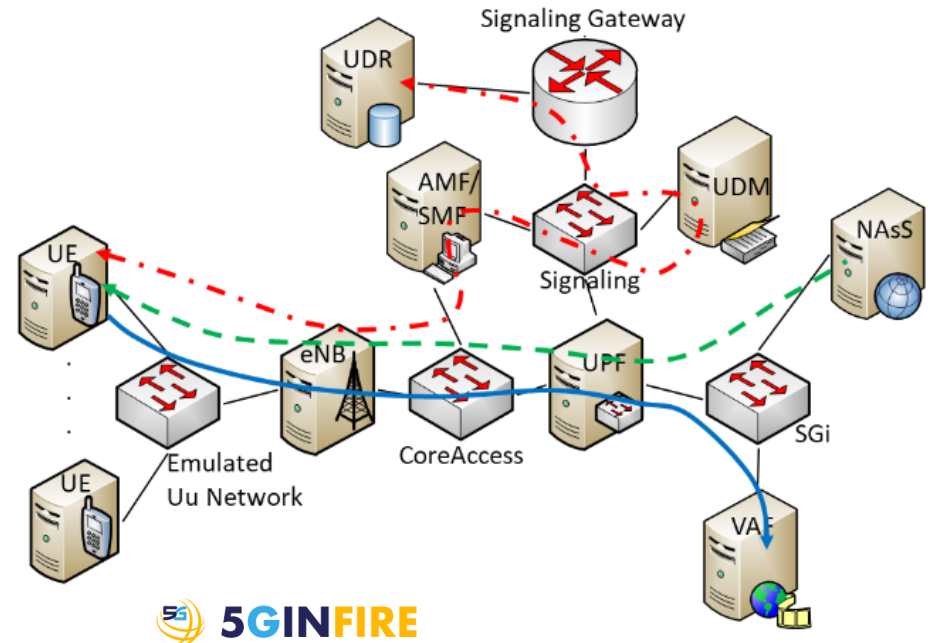
- › 1. Use adaptiveness of the application
 - › Congestion detected ?
Ask app to reduce video quality
- › 2. Exploit infrastructure programmability
 - › Too large delay ?
Switch traffic to fast path
- › ...but make sure 1. and 2. work in orchestrated way !



Network assistance: can make requests both to application (e.g., video quality) and to infrastructure (e.g., path delay)

PROFESSIONAL-QUALITY LIVE UPLOAD OVER 5G

- › Camera team members send live feeds
- › Creative director picks Camera-1 for broadcast
- › Slice gets reconfigured:
 - › Instruct Camera-1 to go HiQ
 - › Instruct Camera-2 to go LoQ
 - › Cap BW for Camera-2 to protect Camera-1
- › PoC developed in 5GINFIRE
- › Runs as OSM-orchestrated service



5G EDGE MASKER

- › 6 Degrees of freedom (6-DoF) VR –
 - › Not only look around but move in VR
 - › ...but: bandwidth hungry and delay sensitive
- › BW: instead of sending full spherical video, send only interesting part and mask the rest
- › If delay is too large, ask network to switch to faster path
- › Demo, if room

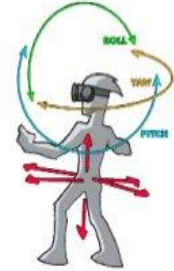
3-DoF vs. 6-DoF

3 degrees of freedom (3-DoF)

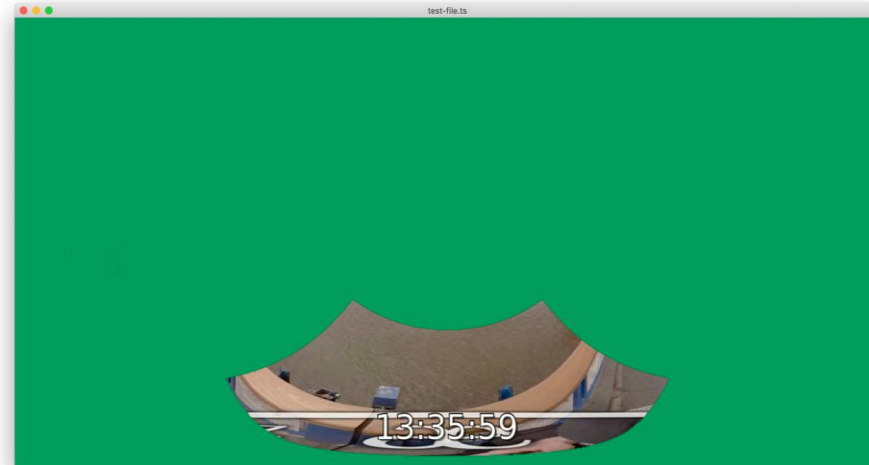


- "In which direction am I looking"
- Detect rotational head movement
- Look around the virtual world from a fixed point

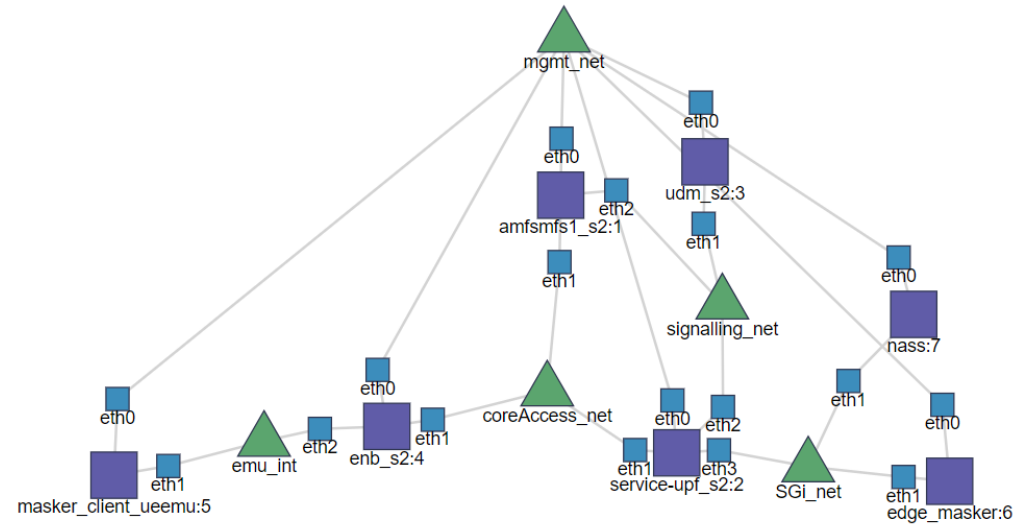
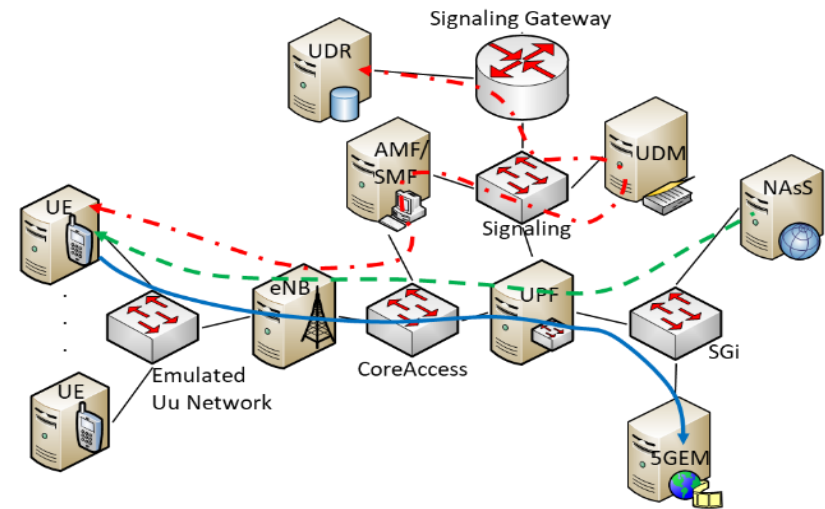
6 degrees of freedom (6-DoF)



- "Where am I and in which direction am I looking"
- Detect rotational movement and translational movement
- Move in the virtual world like you move in the real world



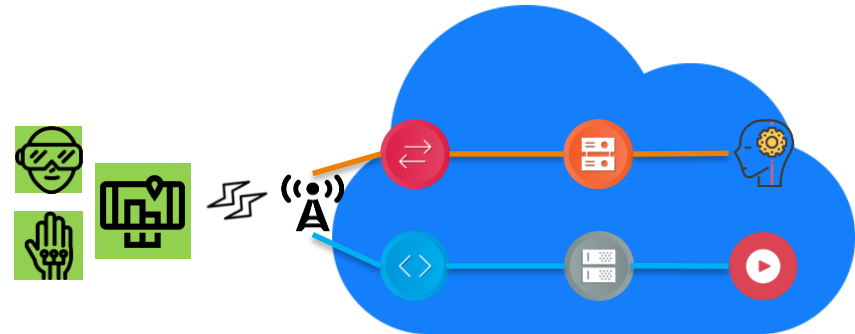
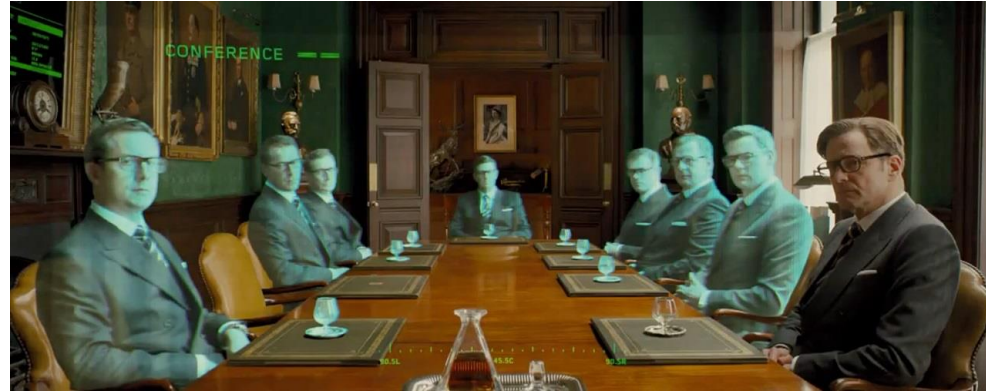
DEMO



SOCIAL EXTENDED REALITY (SOCIAL XR)

- › Virtual/augmented-reality teleconference...
- › ...with tactile interaction between participants
- › ...over 5G/SD-WAN with cloud support
- › First version: best MMSYS2019 demo award

- › Challenges:
 - › Resources hungry (tradeoff: edge vs client processing -> heat dissipation?)
 - › Tight delay budget (100-200ms)
 - › BW tradeoff – load more around FOV
 - › Video/haptic synchronization



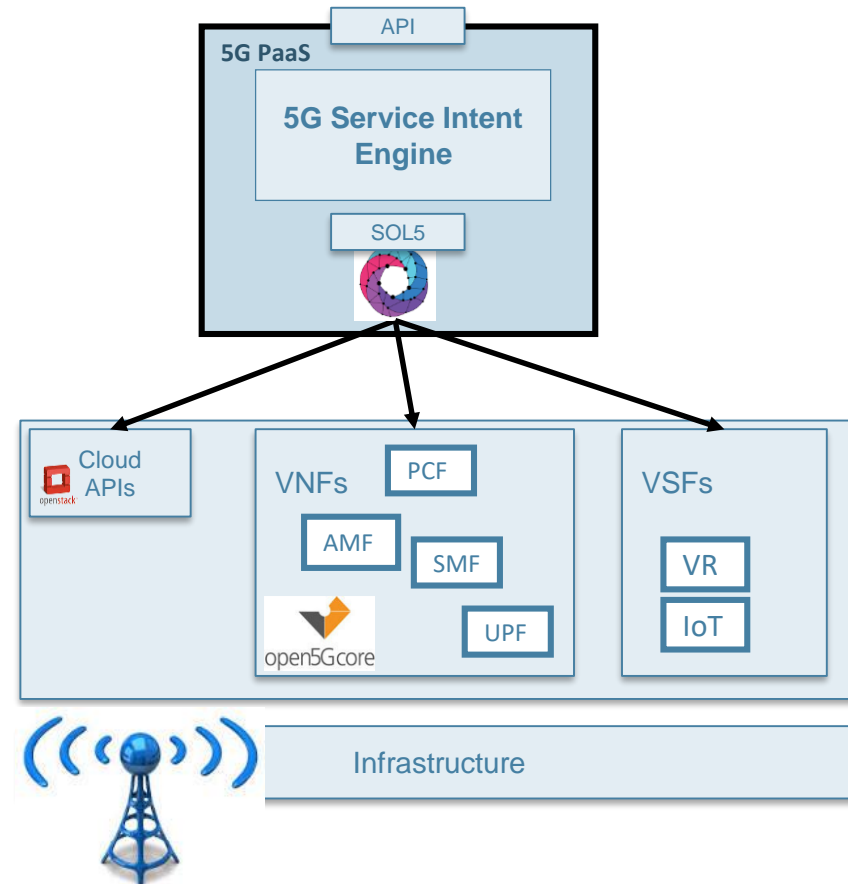
5G-AS-A-SERVICE (5GAAS)

- › Goal: enable the deployment of use cases by third parties in a fast and flexible way
 - › ...even for non-5G-experts

- › Service Intents
 - › I want encrypted VR conferencing service between AMS, ATH, KRK)

- › Decomposition of abstract user intents into NSDs, NSRs and/or Primitives

- › Instantiation, monitoring and runtime reconfiguration



TNO IN STANDARDIZATION

- › 3GPP
 - › SA1 (chairman) 5G requirements for verticals, media
 - › SA2 architectures
 - › SA4 Codec (Social VR, 5G XR study, 5G media architecture)
- › MPEG
 - › MPEG OMAF 360 video standard, projection, efficient streaming, tiled streaming
 - › 5G ad hoc group: what MPEG can do to leverage 5G capabilities



SUMMARY

- › Media (or any other vertical) and infrastructure need to understand each other
- › Potential benefits from cross-layer developments (“app-aware slice”)
- › OSM has its learning curve but can provide value (reusability, code sharing,...)

A nighttime photograph of a city street. In the foreground, a modern, curved pedestrian bridge with a glass railing and a perforated metal mesh base spans across the street. The bridge is illuminated from below, creating a warm glow. In the background, a multi-story building with a curved facade and many lit windows is visible. The sky is dark, and there are long, horizontal light trails in shades of green and yellow, suggesting a long-exposure shot of traffic or city lights. The overall atmosphere is urban and modern.

› **THANK YOU FOR YOUR
ATTENTION**

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