Towards affordable high-performance 5G networks

A production-ready UPF based on RARE

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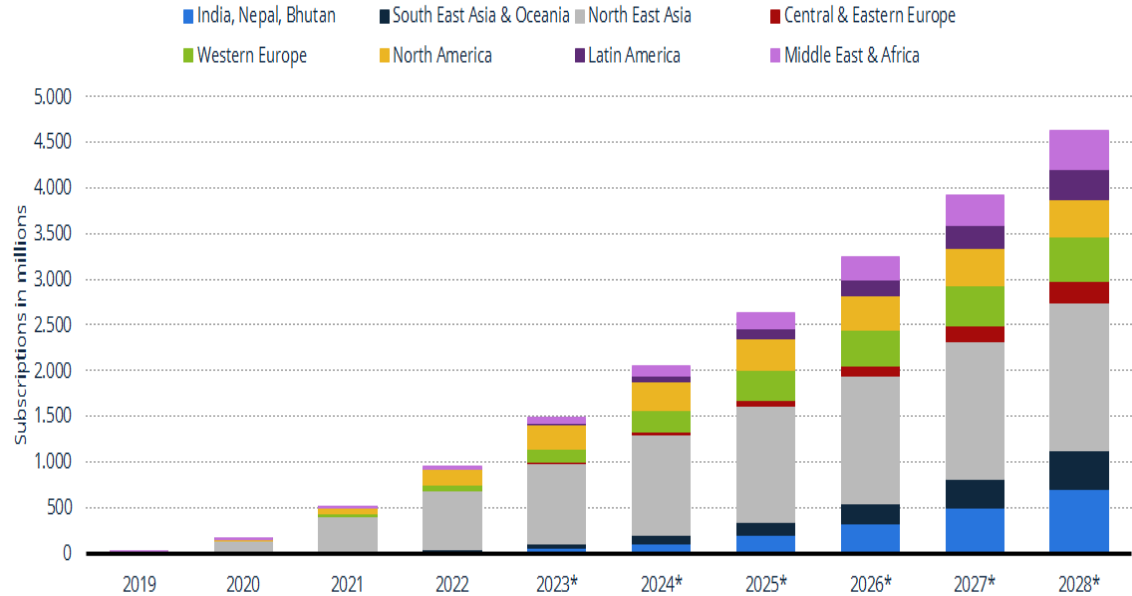4. Scenario under consideration
5. Conclusions

5G: vision

Mobile broadband is the fundamental technology for interconnecting communities and individuals

5G will continue growing with more that 4.4 billion subscribers predicted by 2027*

- The impact of mMTC

5G mobile subscriptions worldwide

■ India, Nepal, Bhutan ■ South East Asia & Oceania ■ North East Asia ■ Central & Eastern Europe
■ Western Europe ■ North America ■ Latin America ■ Middle East & Africa

Notes: *Forecast
Source: Ericsson (2022), statista
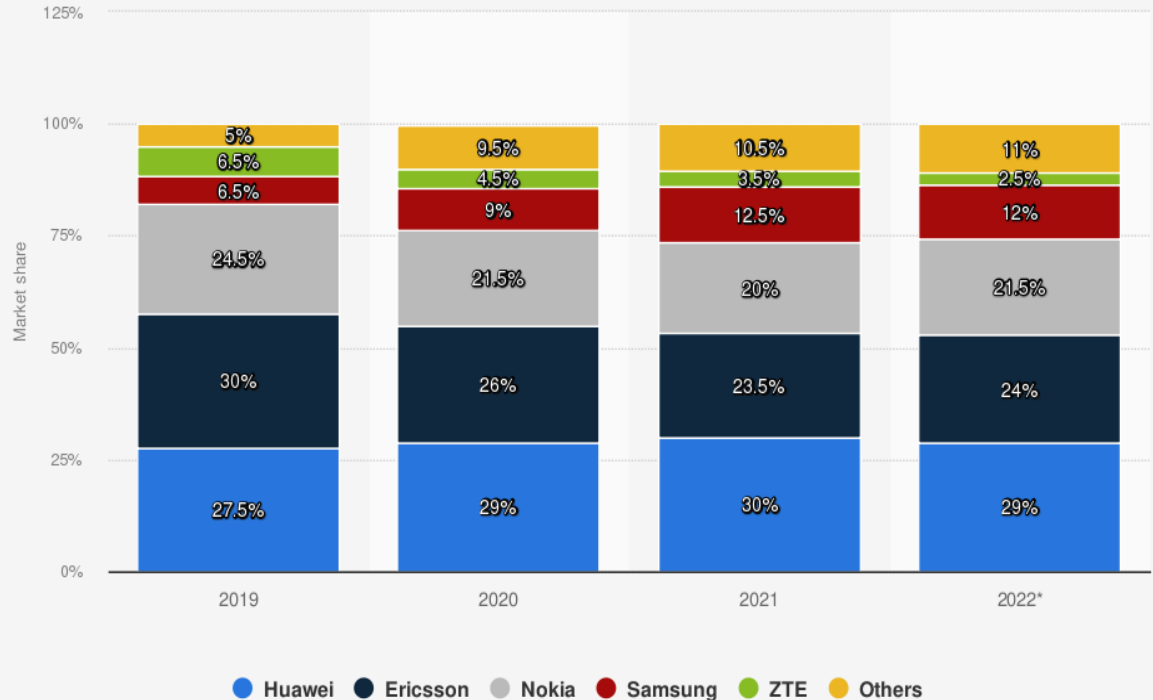
5G: vision

Five tier one vendors

- High CAPEX/OPEX

The market share is growing for "Other" vendors

- Open-source solutions
- Startups
- More customizable and affordable products

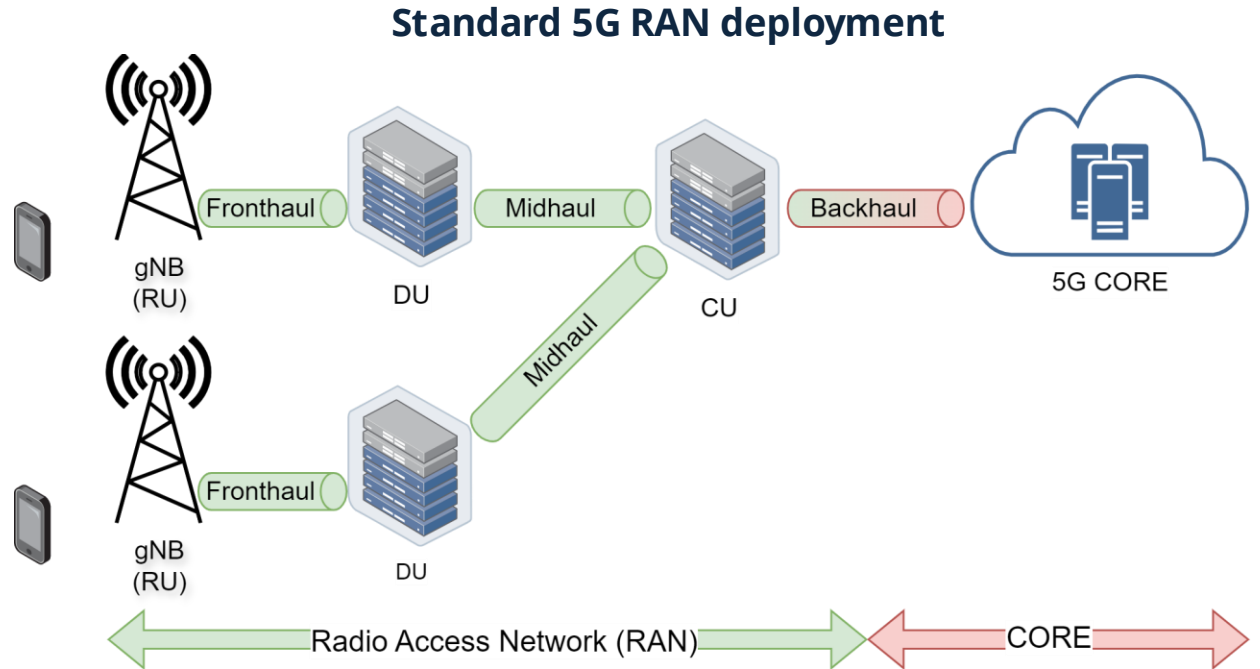## Mobile base station vendor market share worldwide from 2019 to 2022

	2019	2020	2021	2022*
Others	5%	9.5%	10.5%	11%
ZTE	6.5%	4.5%	3.5%	2.5%
Samsung	6.5%	9%	12.5%	12%
Nokia	24.5%	21.5%	20%	21.5%
Ericsson	30%	26%	23.5%	24%
Huawei	27.5%	29%	30%	29%

Legend: Huawei, Ericsson, Nokia, Samsung, ZTE, Others

Source
TrendForce
© Statista 2024

Additional Information:
Worldwide; 2019 to 2022

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5G: architecture

Radio Access Network

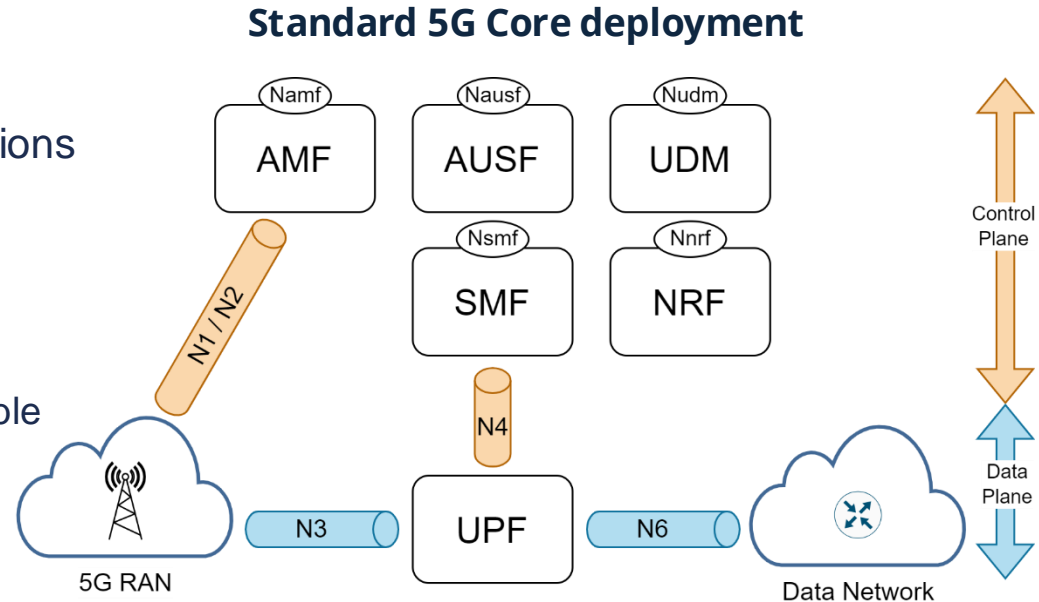- Base station (gNB)
- Function split (DU-CU)
- Fronthaul/Midhaul links

Standard 5G RAN deployment

gNB
(RU)

Fronthaul   DU   Midhaul   CU   Backhaul   5G CORE

Midhaul

gNB
(RU)

Fronthaul   DU

Radio Access Network (RAN)   CORE

5G: architecture

5G core

- Service Based Architecture (SBA) framework

- A set of interconnected Network Functions (NFs) to provide:
  - the control plane functionality
  - common data repositories

- NFs
  - Self-contained, independent and reusable
  - Expose services through well-defined interfaces: REST, QUIC

Standard 5G Core deployment

Namf — AMF
Nausf — AUSF
Nudm — UDM
Nsmf — SMF
Nnrf — NRF

N1 / N2
N4
N3
UPF
N6

5G RAN
Data Network

Control Plane
Data Plane
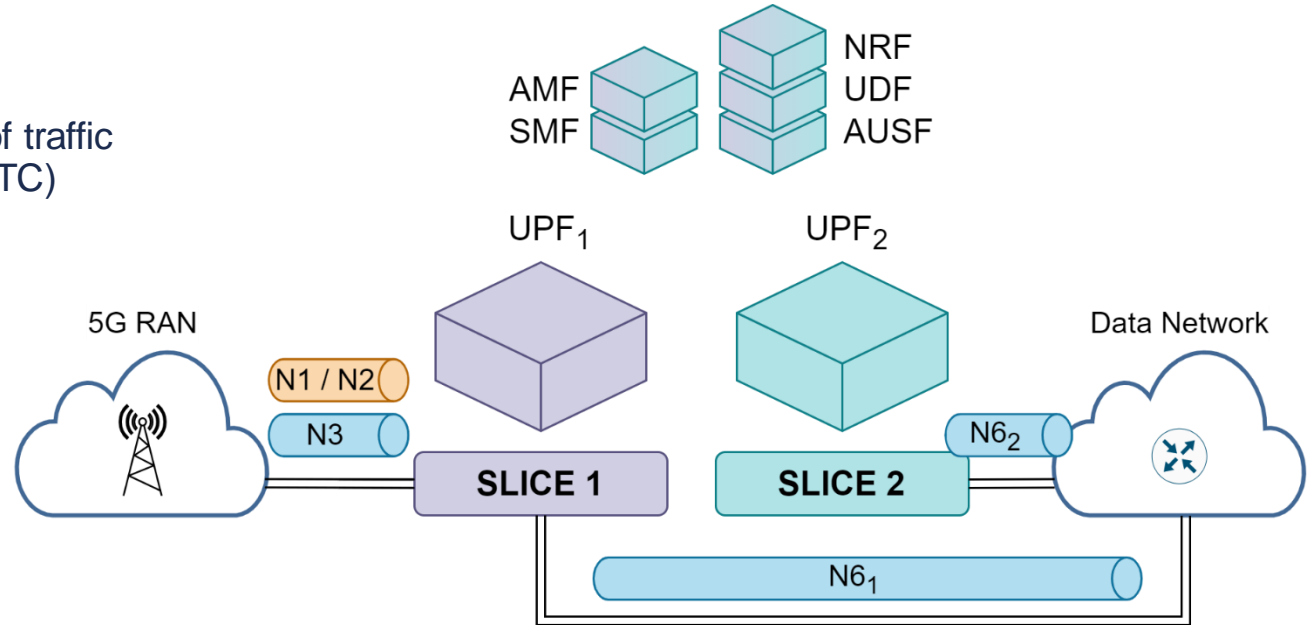
5G: deployment

Example of 5G deployments

- 5G containerization
    - NFs at different locations
    - Not all the configurations are possible
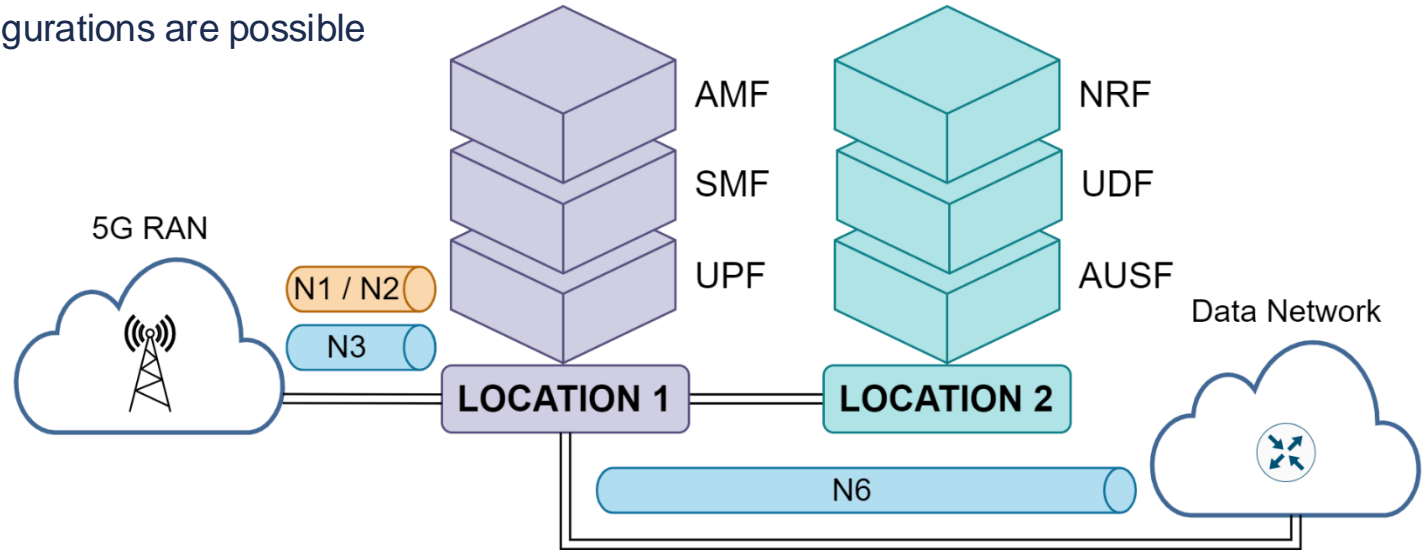
5G: deployment

Example of 5G deployments

- 5G slicing
  - Duplication of NFs
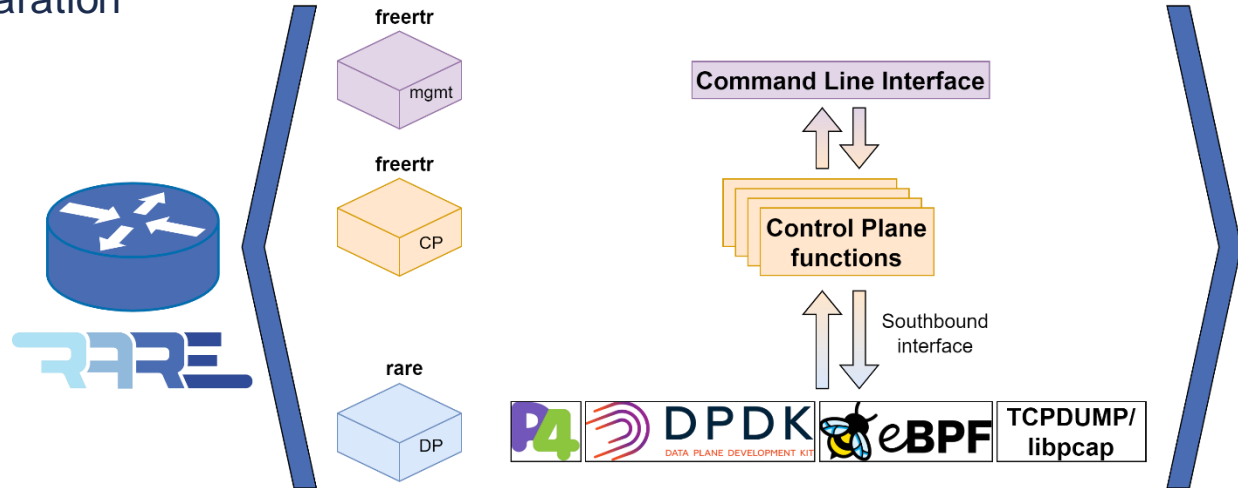 - Each slice for a type of traffic (URLLCc, eMBB, mMTC)

RARE router

Router for Academia, Research & Education (RARE)

- Production ready routing and switching functionalities
- **GEANT 5th programme**
- Control and data plane separation
  - Control plane: *freertr*
  - Data plane: *rare*
    - Programmable data plane
    - P4, DPDK, XDP, libpcap

RARE router

Functionality

- Routing & forwarding
  - IP, LLDP, VLAN, MPLS, BGP, OSPF, BFD
- Tunneling
  - GRE, L2TP, VXLAN, GTPv1, IPsec, MACsec, wireguard, openvpn
- Management
  - Telnet, SSH

Performance

- Tested at **100 Gbps** (Tofino ASIC)
- Tested at **400 Gbps** (Tofino2 ASIC)

UPF implementation in RARE

- Target
  - Provide a standalone UPF

- Motivation
  - Affordable UPF solution
  - Enhance the performance between the RAN and the Data Network (DN)
    - More users
    - Higher data rate
    - Lower delay/jitter

UPF implementation in RARE

Implementation

- **N4** interface: **PFCP** protocol (tested)

- **N3** interface: **GTPv2** protocol (ongoing)

- **N6** interface: **IP** protocol (already available)
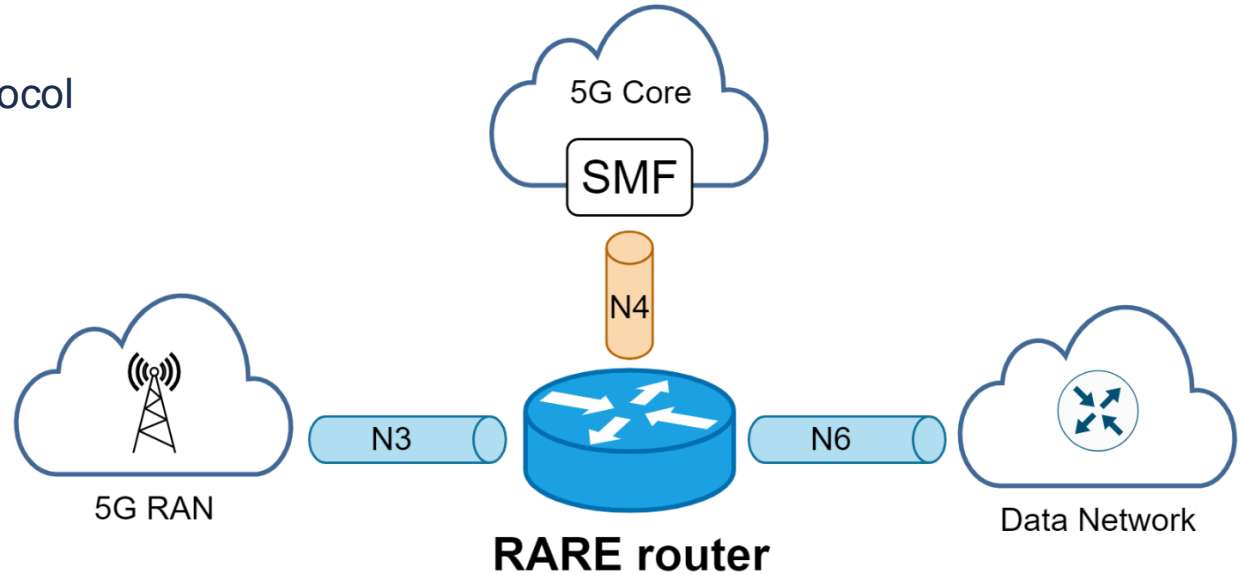
Scenario under consideration

Smart Networks for Everything
(**SmartNets4E**[1])

- An infrastructure for network research

- Three nodes interconnected at 100G

- Research resources for 5G/6G in different verticals
  - Advanced manufacturing (CFAA node)
  - Health, education, transportation and mobility (BILBAO node)

- Integrated into the ESFRI SLICES-RI

- Collocated with GEANT's PoP (LEIOA node)

[1] https://i2t.ehu.eus/en/resources/smartnets4e
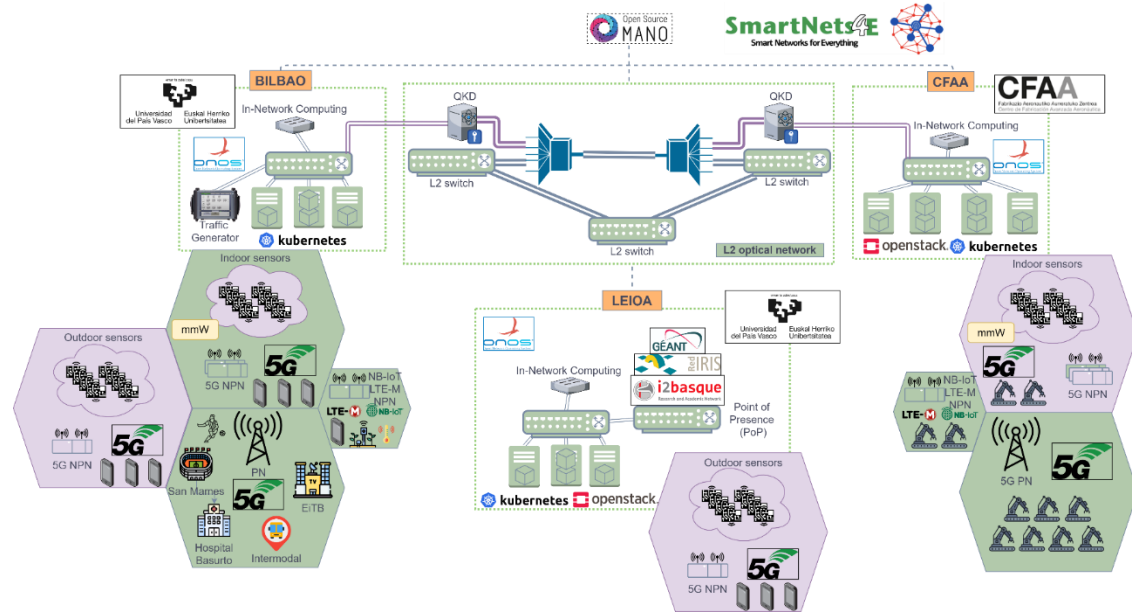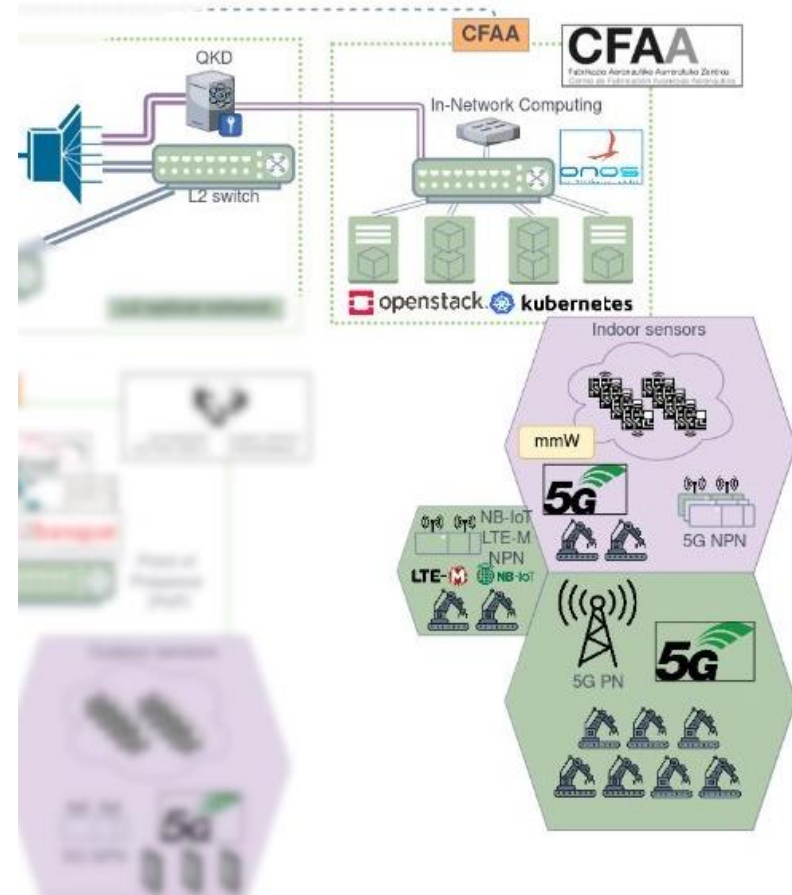
Scenario under consideration
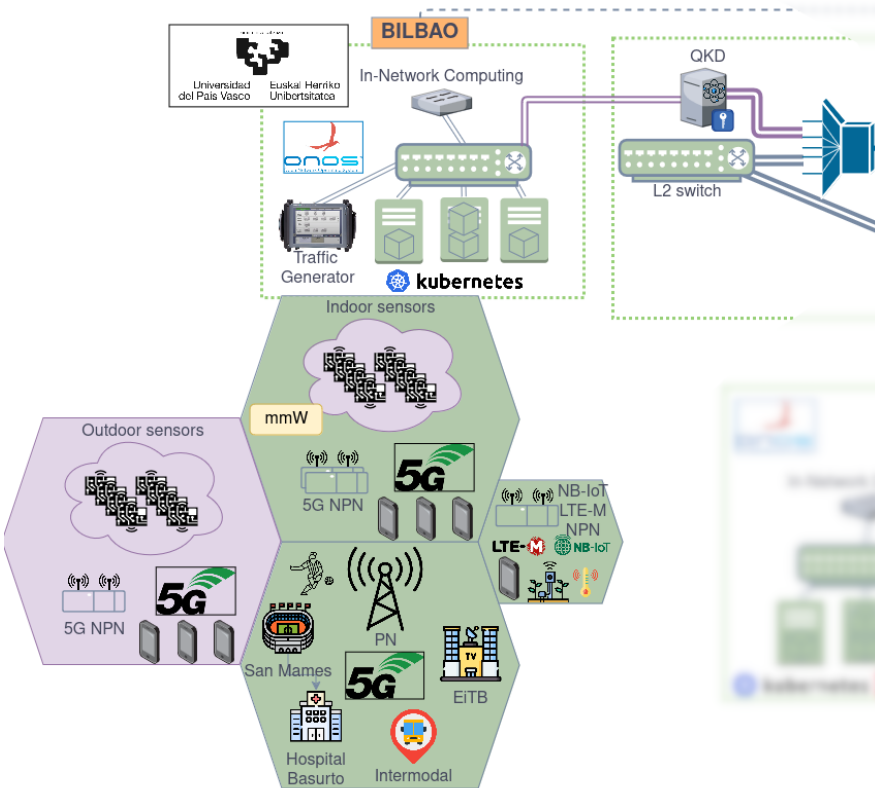
SmartNets4E: **BILBAO** location

- Computing nodes

- Commercial and experimental 5G NPN

- Quantum Key Distribution (QKD) equipment
  - Secure communication between CFAA and BILBAO

- Network analysis and testing equipment:
  - Traffic generator
  - Impairment generator

- Experimental P4 network

Scenario under consideration
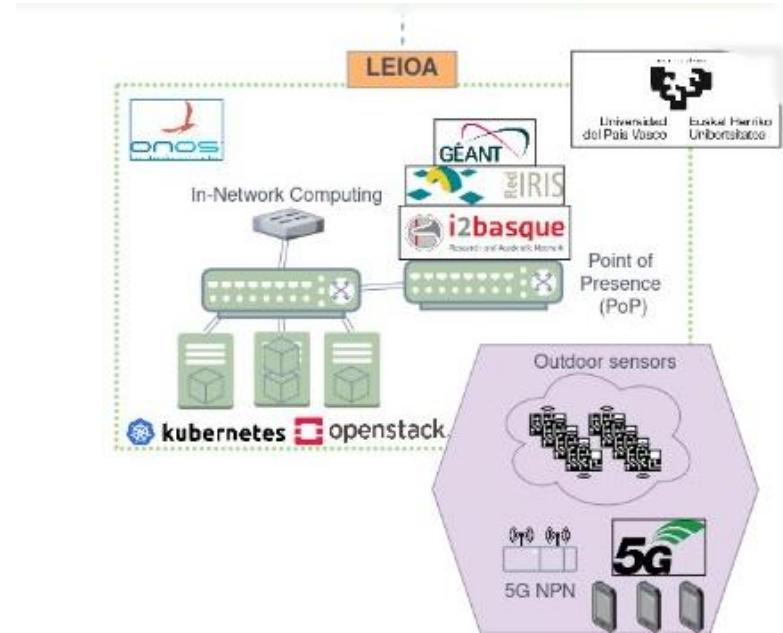
SmartNets4E: **CFAA location**

- Advanced manufacturing R&D

- Indoor commercial 5G NPN (mmWave)

- Experimental 5G NPN
  - LTE-M and NB-IoT support

- IIoT sensor network

- Quantum Key Distribution (QKD) equipment
  - Secure communication between CFAA and BILBAO

Scenario under consideration

SmartNets4E: **LEIOA location**

- Interconnection site
  - GEANT PoP
  - RedIRIS PoP
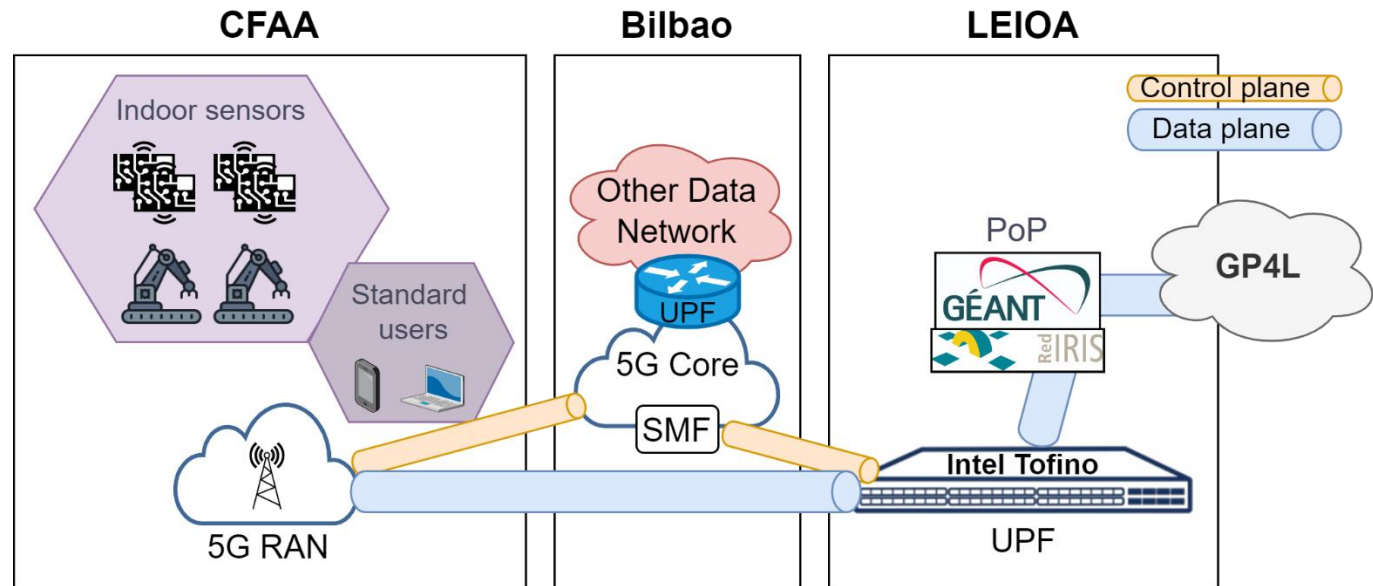- Computing nodes
- Outdoor commercial 5G NPN
  - Campus network

Use case

The role of RARE-UPF

- The scenario in our research infrastructure

Use case

Video:

- SmartNets4E : the 3 locations of the experimentation facility
- 5G and RARE infrastructure
- PFCP implementation in RARE

Conclusions and next steps

Conclusions

- High-performance user plane for 5G core network

- Multi-UPF scenario

Next steps

- Performance tests

- Implementation of other 5G entities: SMF, N3IWF, etc.

- Remote access and management tools

Thank you
Any questions?

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