FUDGE-5G
FULLy DisinteGrated private nEtworks for 5G verticals

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Motivation

- **5G** is much more than the **New Radio (NR)** physical layer
- To realize the **full potential** of 5G, the **Next Generation Core Network (5GC)** is required
  - Network Functions (**NFs**), Service-Based Architecture (**SBA**), Orchestrators and Lifecycle Management
- 5G needs to accommodate a plethora of different vertical use cases under one common transport network
  - Only possible with **virtualization** and **cloud-native** solutions
- The emerging market of **5G private networks, Non-Public Networks (NPN)**, requires customized solutions

Source: SNS telecom (2018)
Project Fact Sheet

- **Project type:** H2020 Innovation Action (IA)
- **Budget:** 6.1 M€ (total budget), 4.6 M€ (funding)
- **Consortium:** 12 partners with important vendors in the 5G ecosystem and 6 high-tech SMEs (10 countries)
  - Project coordination: UPV (Spain)
  - Technical coordination: Telenor Research (Norway)
- **Project duration:** 30 months (September 2020 – February 2023)

Main 5G Components: virtualized 5GC solutions and service orchestrators

- TRL 7 (system prototype demonstration in operational environment)

Vertical use cases: 5 use cases that will be trialed in the 5G-VINNI infrastructure managed by Telenor Research in Norway with prominent stakeholders as vertical end users

- **Media** Showroom with Remote Production
- **Public Protection and Disaster Relief (PPDR)**
- **Industry 4.0** network
- **5G Virtual Office**
- **Interconnected NPNs**

Source: https://cordis.europa.eu/project/id/957242
Consortium

x12 Partners, x10 Countries

High-Tech SMEs (x6)
- ATHONET
- Cumucore
- ONE2MANY
- UBITECH
- OneSource
- FIVECOMM

Research Institute (x1)
- Fraunhofer FOKUS

Public University (x1)
- Universitat Politecnica de Valencia

Technology Vendors (x3)
- THALES
- InterDigital
- HUAWEI

Mobile Operator (x1)
- Telenor
Unified Service Based Architecture for 5G non-public networks
  - SBA for the user data plane, in addition to the control plane

5GC NFs as micro-services
  - New cloud-native 5G NFs to be deployed anywhere (edge, on-premises and cloud)

LAN-Native Support in 5G networks
  - Unified access across fixed LAN, WiFi and 5G (“all Ethernet” access), including 5G-Multicast

Interconnecting Non-Public 5G Networks
  - Not supported by current 3GPP specifications

Integration between Public and Non-Public 5G Networks
  - 5G-VINNI as public network and FUDGE-5G as non-public network

5G-TSN (Time Sensitive Networking)
  - Time synchronization on top of 5GLAN

5GC deployments on Public/Private Clouds, hybrid, etc.

Multi-vendor 5GC deployments

Subscription concealed identifier (SUCI)
High Level System Overview

Support for innovative user plane communications

Unified all-Ethernet access

Novel service routing and resource scheduling for 5GC NFs control plane traffic

Transitioning to cloud native 5GC NFs

Evolution of NFV for unified orchestration of core and vertical services

Unified orchestration of FUDGE-5G platform into range of IaaS technologies

Stakeholder-driven vertical applications
Platform Architecture

On-going work
First complete description by Feb. 2021
Media Use Case

- **NPN showcasing flexibility to concurrently serve diverse multimedia scenarios**
  - Leveraging **Network Slicing** to ensure the correct QoS across services
  - **RAN sharing with PLMN** and interoperable core parameter customization for different network slices
- **Main Innovations:**
  - **Interoperability** testing between hybrid cloud/premises deployment
  - **System Slicing** in FUDGE-5G Platform: UL-focused slice for **Content Production**, DL-focused slice for **Media Showroom**.
  - **Opportunistic Multicast** based on Name-based Routing
  - **Uplink enhancement techniques** to ensure the QoS in Remote Production

**Stakeholder:**

**Partners:**

- **NIK**
- **Interdigital**
- **ATHONET**
- **telenor group**
- **Cumucore**
- **Fivecomm**

**FUDGE-5G**
PPDR Use Case

- Non-public 5G network for first responders and protection forces
  - Work even when other infrastructure fails (earthquake, tsunami, etc.)
  - Easy to deploy and configure 5G network
  - Completely standalone or backhauled to a remote cloud

Main Innovations

- **Mobile autonomous edge** provides all-in-one 5G services in a mobile platform
- **End-to-end orchestration** enforces services from the radio up to the cloud
- **Opportunistic use of intermittent backhaul links** improves processing power with the help of a remote cloud.
- Demonstrate the coexistence of PPDR-specific NPN and non-critical PLMNs
- **SUCI** protects against IMSI catching techniques

Stakeholder: Norwegian Defense Material Agency

Partners:

- Athonet
- Telenor Group
- Onif
- One2Many
- Interdigital
- OneSource
- Thales
- Ubitech
5G Virtual Office Use Case

- Non-public 5G network with PNI and SNPN deployment:
  - PNI-NPN provides **continuous coverage** in outdoor areas, exposing internal Hospital services and devices
  - Hospital SNPN indoor coverage features **isolation for privileged devices and sensitive data**, guaranteed QoS for devices, and remote operation of medical devices in real time

- Main Innovations
  - 5GLAN environment providing an **unified Ethernet, Wi-Fi and 5G access**
  - **End-to-end Network Slicing** with focus on security and speed tolerance
  - **Vertical Application Orchestration** enabling and improving consistent QoS for apps and devices
  - **Multicast Communications** to push notifications and send alerts to specific user groups
Industry 4.0 Use Case

- NPNs will be used in an industrial facility to showcase time sensitive and ultrareliable applications using 5G.
  - Public Networks cannot meet all the requirements of an industry (usually poor coverage).
  - NPNs are dedicated to the needs of a vertical industry, instead of having to satisfy the requirements of the public.

Benefits of NPN usage:
- Strong level of security
- Time critical applicability

Main innovations:
- 5G Time Sensitive Networking (5G-TSN)
- 5G Local Area Networks (5GLAN)

Test cases:
- Remote monitoring as a service
- Remote control as a service with real-time feedback
- 5G adaptability in industrial environments
- Process control over 5G

High-level topology:

Stakeholder:
- Location: Oslo (ABB industry facility)

Partners:
Interconnected NPNs Use Case

- To demonstrate the capabilities of the FUDGE-5G platform to support seamless connectivity of devices across multiple own administrated domains

- Non-Public Network:
  - Highlighting **secured 5G connectivity** for users within a campus network
  - Standalone networks supporting **seamless connectivity to thousands of devices** and isolating capabilities in the home networks

- Interoperability testing connectivity between 5G Core deployed in three locations:
  - Berlin (FOKUS), Norway (Telenor), Valencia (UPV)

- Main Innovations:
  - **Distributed Localized Network**: Developing an end-to-end structure enabling multi-administrated local networks which will facilitate a loose roaming infrastructure without requiring special peering or backhaul (should work with any type of best effort backhaul)
  - **Distributed Authentication Framework**: Authentication and Authorization of devices in home network and also while roaming into other local EDUROAM networks
Thanks for your attention!
Any questions?
5G Components Catalogue
and initial High-Level Architecture
Platform Architecture

- Support for various SCP operations (intra-domain use-only vs always-on)
- Support for 5GLAN, 5G TSN, 5G (opportunistic) multicast and 5G Eduroam
- Innovative resource scheduling for 5GC NFs with seamless integration for SDN underlay
- Dedicated VAO piggybacking on SFV technology
- Location-aware cloud native orchestration and lifecycle management for the telco cloud: Service Function Virtualisation

On-going work
First complete description by Feb. 2021