Use Case #6

Wearable, mobile, point-of-view, wireless video service delivery

Overview and Objectives

UC6 consists of a camera system installed on a transport vehicle (in this case the Boston Dynamics Spot), the network applications (proxy, AI-Analyzer, image-data simulator, mqtt publisher and data publishers) and the End-User device applications to show up the image- and meta-data.
The communications between camera, network applications and end-user devices are done over the 5G-Network at HHI.
In demonstrations, the use case showed AI-Object recognition in camera images on a monitor. Controlling of type of used AI-Net is possible through GUI. Because of demonstrating indoors, in this demonstration Object-recognition was used instead of a fire-detection-network.

Use Case Description

OPTO is specialized in development, design and manufacture of sophisticated individual and complex large-scale solutions for measurement, monitoring, and control technologies. OPTO's UseCase (UC) uses drones for an in-depth analysis of specific emergency situations that may arise. The solution offered by UC6 focuses on camera-based systems with image data transfer over networks. It will process the image using Artificial Intelligence (AI), customized for the PPDR-Sector, generating an image flow from a camera-based system connected to the 5G network, transferring the data via a Virtual Network Function (VNF) AI Analyzer to an 5G connected handheld display device. The AI-Analyzer, hosted in 5G-Core-Serverlandscape, is annotating detected objects in the image flow stream, which can be displayed at the 5G connected handheld display device (see Figure 1). This means that the solution of this UC is a drone application focused on image processing and brings new needs to 5G experimentation in drone contexts.

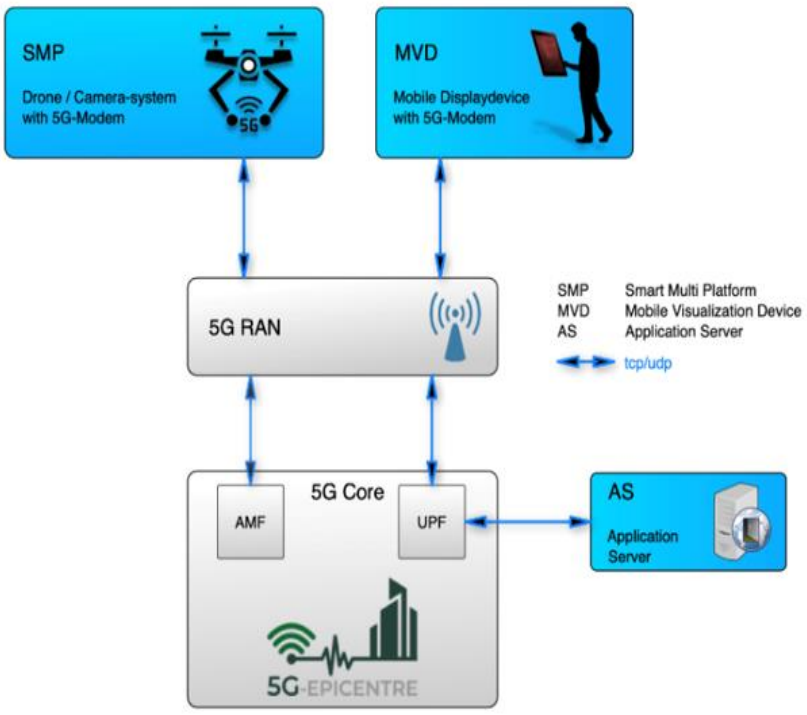

Figure 1: Description of the integration with 5G-Core

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Experiment Setup/Methodology/Deployment

OPTO installed a Graphics Processing Unit (GPU)-based VNF (Proxy, Detector, mqtt provider, GUI) in HHI's 5G-Testbed in Berlin, reachable from customer UE devices, showing results on a monitor in demonstration area. The measured KPIs are listed in Table 1.

Table 1: UC6 KPIs

KPIs	Results expected	Experimentation results
UC 6.1	Reduce reaction-time for personnel deployed on the field by 20%	Reducing possible reaction-time by >20%.
UC 6.2	Near real-time information to ECC operators / personnel deployed on the field (< 1000 ms)	Near-Real-Time information delivery with an image rate of 20 frames per second (50ms) has been achieved.
UC 6.3	Automatic in start of flight to disaster location.	Boston Dynamics Spot robot, controlled by an PPDR Firefighter to reach a fictitious indoor disaster area.

Experiment setup/methodology

To achieve the planned functionality, we used a professional Ximea USB-Camera connected to a NVIDIA Orin NX GPU-Board to build up the camera system. The NX-Board takes the raw camera image data, it processes it (white balance, sharpness, colours, etc), encodes jpg images at a framerate of 40fps and publishes the image data via 5G to the 5G network applications.

To receive the camera published data and to host the network applications we use a gpu-powered server (NVIDIA RTX3080), which is necessary for the AI analyser functions. This server is integrated as part of the HHI 5G ecosystem. This server is also publishing the image- and meta-data to the end-user devices.

The camera system was installed on a Boston Dynamics Spot to demonstrate the wide usage possibilities of the camera system, and possible use cases for PPDR firefighters. The robot was controlled by a firefighter to reach a fictitious disaster area and was provided by HHI.

Figure 1 : Boston Dynamics Spot (provided by HHI), carrying the camera Systems, controlled by a Firefighter.

Figure 2 : Detail on Boston Dynamics Spot installed Ximea Camera-System with 5G-Modem and NVIDIA Orin NX GPU-Processing Component.

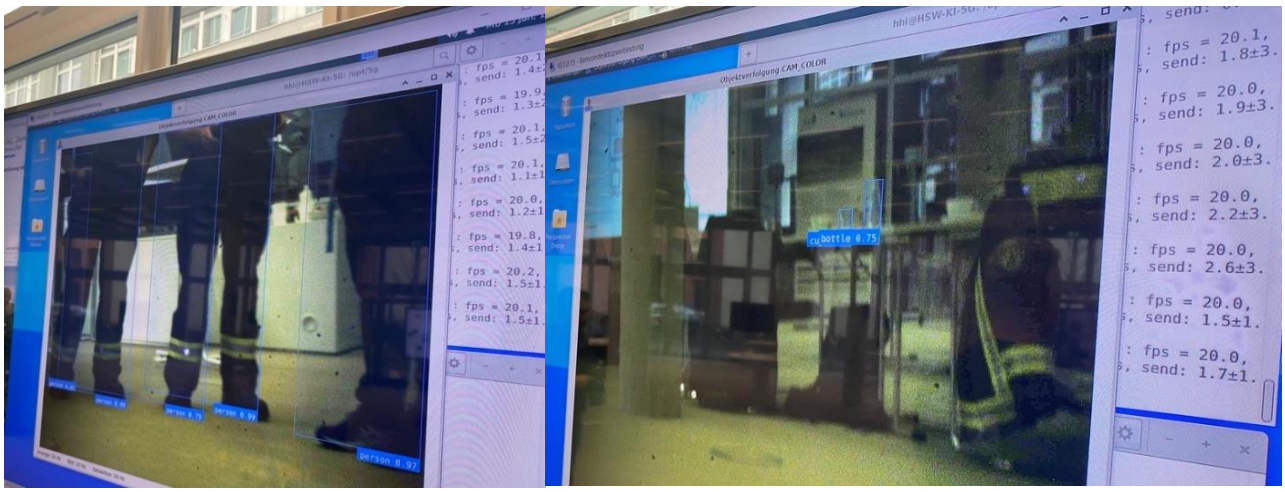

Figure 3: End-User Device showing object recognition on PPDR firefighter demonstration with prediction of object type and confidence

The graphical front end is built up for Linux Ubuntu Desktop 20.04 and for mobile Apple Devices (iOS iPhone, iPadOS, MacOS). The following screenshots show the Apple iOS / iPadOS app developed in this project:

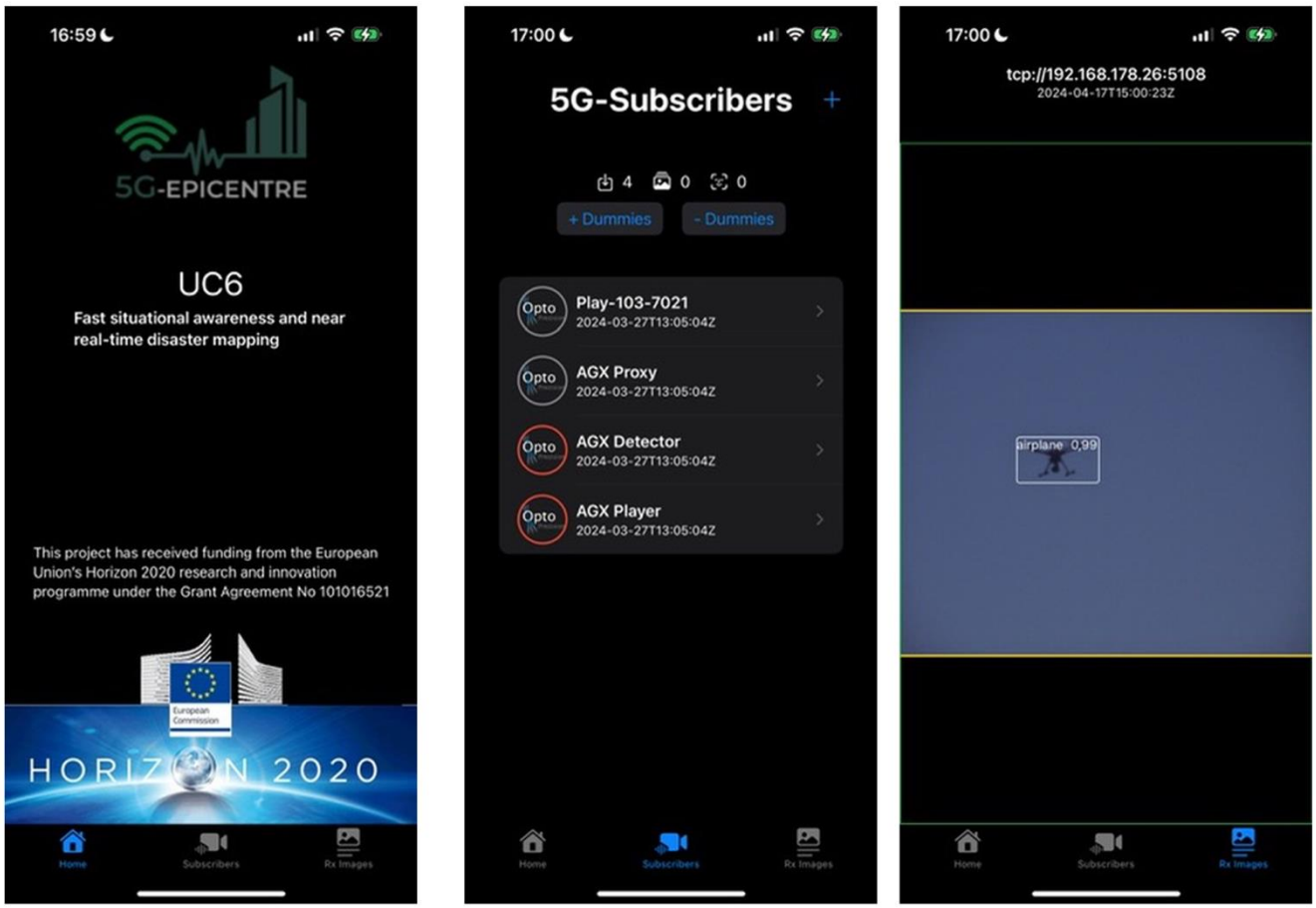

Figure 4 : Screenshots of the End-User App running on iPhone

The deployment is done by containers that run on the gpu-powered server with direct connection to the gpu cores and memory. The OS must be Linux Ubuntu server at least version 20.04. At least 192GB RAM and 16 cores are recommended. The server must have network connections to the end-user devices and the camera system.

Overall evaluation

UC6 was able to achieve an overall framerate of 20fps from the camera (encoding and sending via 5G) to the VNFs (proxy, detector, publisher) and the end-user devices, which allowed a fluent streaming of images from the disaster area to the PPDR personnel in the field and operations center.
Regarding KPI 6.1 UC6 was able to show the reduction in time to get an overview of a situation in comparison to having a person to be walking into the disaster area and sending image data manually or without annotations.
Furthermore, the results can be viewed by more than one person that is in the disaster area and in the con-trol center in near real-time. This speeds up the delivery of information to all involved people and raises the communication quality, because all involved people have the same information base.
The achieved results are considered to be Good and show that the 5G-network at HHI is able to deliver relia-ble and stable services with good performance.

Conclusions

UC6 reached all its KPIs and was able to showcase video transmission and AI object recognition in the simulated disaster area at HHI Testbed Berlin. The images collected from a camera mounted to the Boston Dynamic Spot were transferred to the VNF Proxy, and analysed with AI for Object Recognition. Then the results were published on a Monitor as live images and object boxes with object type and probability prediction. All communications took place over 5G. The AI is running in the 5G Core as VNF.
OPTO successfully showcased UC6 in the HHI Testbed Berlin at two events with PPDR-Customers:

- Firefighters Berlin; and
- Saxony Police Headquarter.

Overall, the HHI Testbed gave good performance and reliability without any concerns.
The experiments performed can be summarized as in the following breakdown:

- Hardware Configurations and Issues
  - The utilization of specific hardware configurations, such as Android tablets and custom AR visors, was essential in the testbed setups.
  - Issues related to the Android system in the custom computing unit prompted researchers to adapt and use Android tablets instead, ensuring smoother operation.
- Software Deployment
  - Various software components were deployed across the testbeds to facilitate different functionalities.
  - These included Android applications for AR visualization, video streaming, and KPI acquisition, as well as web applications deployed on Kubernetes clusters for remote monitoring and control.
- Communication and Connectivity
  - Communication between different components, such as AR visors, computing units, and remote command and control centre, was established through audio-video channels.
  - The results align with the predefined KPIs, underscoring the robust performance of the 5G networks in both the UMA and HHI testbeds.
- KPI Compliance
  - Results obtained from the tests demonstrated compliance with the KPIs outlined in the experimental setups.
  - These KPIs encompassed various aspects such as time to detect incidents, time to present AR information, and overall system responsiveness.
- Testbed Variability

The conducted analyses across the testbeds showcase the feasibility and effectiveness of the implemented systems in meeting the specified objectives. By addressing hardware issues, deploying appropriate software solutions, and ensuring seamless communication and connectivity, the experiments successfully demonstrated the capabilities of the proposed UC7. Moreover, the observed compliance with predefined KPIs underscores the reliability and performance of the systems under test. These findings highlight the potential for further advancements and applications in fields requiring augmented reality, remote monitoring, and real-time communication. Moving forward, continued research and development efforts can further refine these systems, potentially leading to broader adoption and utilization in various practical scenarios.