Use Case #3

Ultra-reliable drone navigation and remote control

Overview and Objectives

In the framework of 5G-EPICENTRE, NEM's MCX solution is an innovation branch, which still must pass through UC3 aims to showcase the efficiency of 5G to the PPDR community by connecting drones with the 5G network. This will allow the PPDR community to not only stream high-quality video, but also to control the drone simultaneously, altogether enjoying the low latency of the network due to advance feature in 5G, such as mMIMO, higher bandwidths and network slicing. The KPIs which will be measured in UC3 include latency, reliability, UL rate and DL rate.

Use Case Description

Within the 5G-EPICENTRE project, HHI plans to test an important UC, which addresses the topic of PPDR. Among the most prominent cases of interest to the Wireless Communications and Networks department at Fraunhofer Institute for Telecommunications is the demonstration of super reliable drone navigation and remote control by utilising the federated testbed resources.

Drones have the potential to improve public safety, as they can, for example, be deployed to fly ahead of first responders and transmit live video of a particular situation at the site. This could be, for example, a fire on company premises. By flying ahead, the drone can clarify the emergency situation before first responders are able to reach the site. This saves extremely valuable time on the scene and improves planning of the mission, so that e.g., additional personnel can be alerted and deployed, if necessary.

Efficient drone control and localisation, however, remain challenging tasks, as drone communications should be characterised by stability, wide availability, low cost and ultra-reliability, even when the drone is out of sight. As modern drones are typically controlled via remote control, their applicability in real-life situations remains severely limited. In this UC, HHI will experiment with various methods for drone control in different situations, particularly focusing on network overload situations, when the data channels are used in major events or disasters.

A particularly efficient means of controlling drones via Bandwidth-optimised communication protocols in the mobile network will be deployed in the form of VNFs on top of the 5G-EPICENTRE infrastructure, facilitating a two-way communication where commands are transmitted to the device, which in turn responds with information about its position, altitude and battery status.

The mission drone will be using a 5G network slice in order to secure ultra-reliability and will be streaming Infrared (IR) and optical video streams of the site. The fire service is to receive a prioritised data link for the use of drones. Video and telemetry data should be able to be displayed on different devices at the same time.

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The UC will demonstrate the use of a drone as part of a fire rescue service operation.

- The drone connects to the 5G testbed via 5G campus network connection using 100 MHz bandwidth at 3.7 GHz in band n78 for the transmission of telemetry and video data.
- Optionally, the drone can connect to a 5G slice within this band to ensure reliability for mission critical communications.

Scenario 1

The control centre launches the drone and sends it to the operation area. The emergency forces who arrive on the scene after the drone can access it and its video data via a tablet or other suitable UE on their way to the site to get an impression of the situation. In order to relieve the emergency services, the monitoring of the drone can be returned to the control centre at any time. The mission operation manager is in control of the drone and the video streams all the time, even on the way to the site.

Scenario 2

Optionally and additionally to scenario 1, another drone operator off-site is able to control the drone remotely from the mission control centre. In addition to the drone's automatic flight operation, this gives the maximum control over the drone and helps to guide and advise first responders with regard to the site's special conditions accordingly. This can make all the difference to save valuable time, even if only some crucial minutes, and, thereby, possibly save lives.

The interaction of the individual components is shown in the figure below.

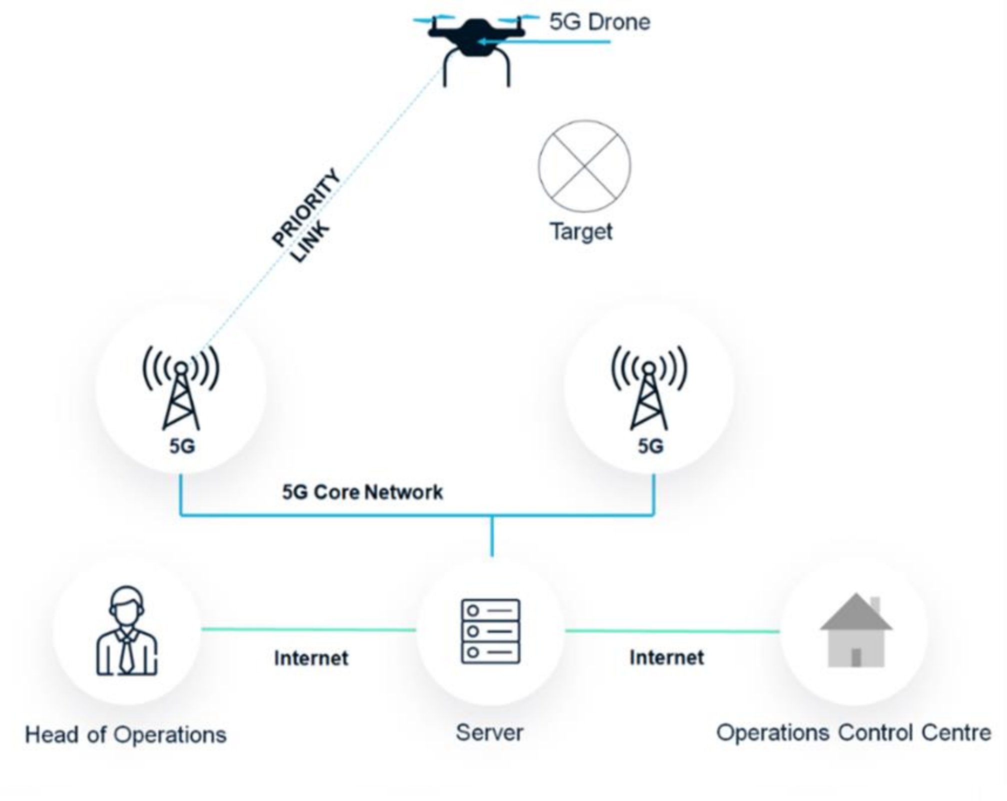

Figure 1: UC3 Interaction of the individual components (server equals management server)

The main building blocks consist of the drone with the dual camera and its 5G interface. The 5G network forms the node over which the entire communication runs. The processing of the data is done on an edge server. The access to the data and the control of the drone is done via Internet, the Server and the 5G Network as depicted in the UML diagram.

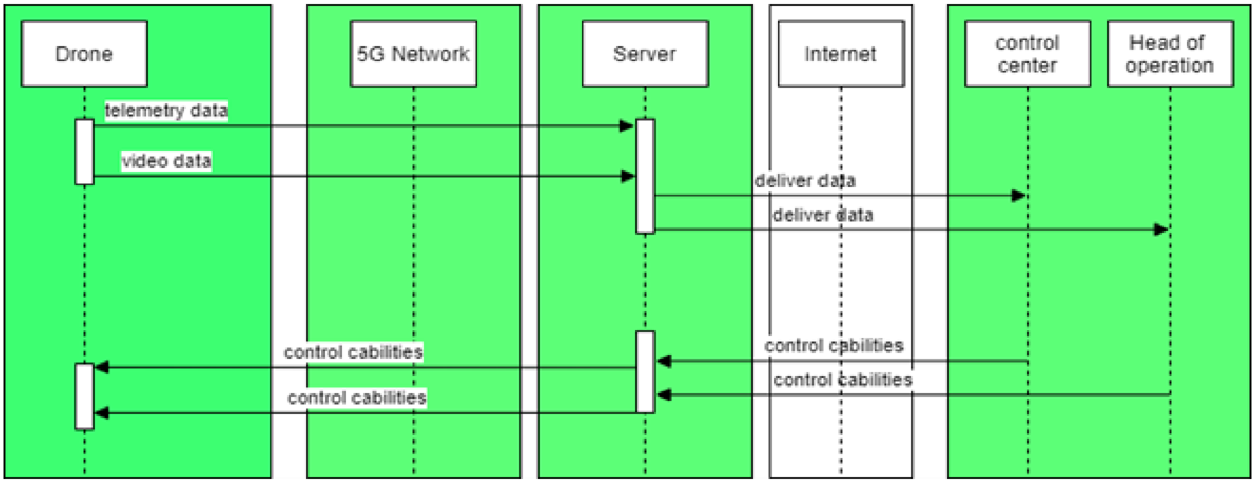

Figure 2: UC3 UML diagram

Experiment Setup/Methodology/Deployment

In UC3, a drone is used, which is coupled with a cost-efficient embedded computer, such as a raspberry pi. The embedded computer provides an interface which allows it to connect with a 5G modem and a drone controller. Then, in the context of the project, a network application was developed, which allows the drone and the application server to exchange data, such as video streaming, control link and other data over 5G. The N6 link, which connects the application server with the 5G core, enhances such communications. To control the drone, a UE, i.e., Samsung Tab S8 was used, which was also connected to the 5G network, and had the open-source software QGroundControl installed, which allows the control of the drone.

UC3 deployed its network application container on the application server of the HHI testbed, which has already N6 connection with the 5G Core. Additional SIM Cards were provided by the HHI testbed, which allowed the 5G connection between the drone, UE and testbed. A remote session with the deployed UC3 network application was made for facilitating the deployment of the UC3 in the testbed

Experiment Execution and Results

Table 1 provides an overview of the UC KPIs, and actual experimentation values.

Table 1 : UC3 KPIs

KPIs	Results expected	Experimentation results
UC 3.1	Less than 200ms E2E latency	~10-11ms
UC 3.2	90% availability of network services at the TUB campus area	100%
UC 3.3	Peak data rate of 500Mbps (DL)/120Mbps (UL)	443 Mbps/ 115 Mbps
UC 3.4	User experienced data rate of 200Mbps (DL)/30Mbps (UL)	362 Mbps/ 95 Mbps

The following results have been obtained while Drone was connected with HHI Testbed: The iperf test between Drone and 5G BTS at HHI testbed achieving an average uplink rate of 95 Mbits/s when connected to mMIMO Antenna. The iperf test between Drone and 5G BTS at HHI testbed achieving an average downlink rate of 362 Mbits/s when connected to mMIMO Antenna. In addition, the round trip time between Drone and N6 link of 5G core at HHI testbed achieving an average latency of 13 ms when connected to mMIMO Antenna.

All the above-mentioned tests performed at HHI depict the advancements of 5G such as Beamforming, mMIMO and higher bandwidth availability which allows the drone to stream a real-time full HD video (1080p) while simultaneously being controlled over 5G by a drone operator which can help the PPDR community to strategize the situation accordingly.

Conclusions

As part of UC3, measurements for the KPI values defined within the project were carried out at HHI. Various measurement scenarios were used to determine latency, throughput rates and availability. In the first scenario, the signal coverage on the Technical University campus was determined. Good coverage increases the probability of availability/accessibility of the network services. The RSRP values were measured with the Netrack[1] software on a UE and with a 5G modem and the ROMES[2] software. The RSRP values can also be measured using the modem mounted on the drone. RSRP values > -90dBm could be measured at all locations on the campus, the average value was -80dBm. In this way, 90% availability (UC3.2) can be assumed.

To determine the E2E latency (UC3.1), a continuous ping was sent from UE to UE (tablet – tablet, tablet – drone). In addition, a script was executed on the Raspberry miniPC on the drone, to retrieve KPIs, such as the RTT from the drone to the control tablet. The measured RTT values resulted in an average latency of ~10-11 ms. The scenario was set up to determine the uplink (UL) and downlink (DL) rates (UC3.3. /UC3.4). An iPerf[3] client was installed on the drone minPC. The iPerf server was located on a Virtual Machine (VM) in the 5G Berlin testbed. 10-15 iPerf measurements were carried out at different positions for UL and DL, each with a duration of 1 minute, and 60 measured values per measurement. Peak data rates of 443 Mbps for the DL and 115 Mbps for the UL were determined. The average data rates were 362 Mbps DL, and 95 Mbps UL.

For the KPIs, the average values for E2E latency and availability corresponded to the targets set for UC3. Also, the KPIs for the user experienced data rates were achieved. The targets set for the peak data rates were almost reached: the planned KPIs can only be achieved under optimal conditions for the scenario investigated, including a low RSRP and little traffic from other UEs. The data rates also depend on the UL/DL ratio of the gNodeB.

[1] Netrack Software - Definitions – Android application for measuring cell parameters.

[2] https://www.rohde-schwarz.com/products/test-and-measurement/network-data-collection/rs-romes4-drive-test-software_63493-8650.html

[3] https://iperf.fr/