Experiment #6

Video Streaming for First Responders [EKTACOM]

Overview and Objectives

It is important to ensure that first responders on the field of a disaster have robust and instantaneous access to resilient network resources. High-bandwidth, low-latency networks can accelerate adoption of network application solutions, not only for voice communication, but also for other innovative, high-quality ICT services (such as group video calls; receiving video streaming contributions from drones; and accurate geo-localisation). Particularly with respect to image and video contributions under challenging conditions, a key requirement of the network is to ensure that robust, low-latency and direct transmission can be established, further enhanced with the capacity to simultaneously stream these contributions to multiple delivery points (*e.g.*, responders on the field; Command & Control, *etc*.).

StreamSelector4PPDR is a customised version of **EKTACOM**'s *Nomade* line of streaming solutions, adapted for PPDR users. *Nomade* is inherited from the very first software developed by EKTACOM, having been deployed on the field to the aid of journalists, and having been used widely in first-class sailing competitions in remote ocean locations, making it possible for users to transmit via satellite or mobile network to a variety of play-out platforms, including on the Internet. *Nomade* aims at offering a robust, adaptive, low-latency video transmission from an embedded camera. Further, synchronised metadata (such as location information) are supported. Extremely efficient compression and transcoding techniques are employed to limit data flow, enable better image quality, and decrease round-trip time KPIs.

StreamSelector4PPDR Network Application is the core of the streaming solution to be experimented with (with several video streaming processes that can be hosted in edge nodes or the Cloud), and two companion applications, *i.e.*, a smartphone application and a video player application. The smartphone application can only be run on selected Android smartphones.

The main component for the StreamSelector4PPDR Network Application is a video gateway, in charge of collecting live streams and routing them to their destinations. The routing is managed by an external application running on the Cloud, the *StreamSelector Register*. All of the companion applications connect to this Register, either to get the right to stream to the StreamSelector4PPDR Network Application (and also, get from the Register the necessary credential, and technical information), or to get the list of available video streams on the video player side, and requesting them to be watched.

Only pre-registered Smartphones and Video Players can connect to the StreamSelector Register, and send or receive streams from the StreamSelector4PPDR video gateway. Nevertheless, for the streaming itself, EKTACOM is using standardised video coding and streaming solutions, and, if required, streams can be sent to an off-the-shelf video player, such as VideoLAN VLC or a Command and Control (C2) video player, supporting such video coding and

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streaming standards. For the 5G-EPICENTRE experiments, this has been implemented for the video mosaic feature of StreamSelector4PPDR, described hereafter.
StreamSelector4PPDR also includes a video mosaicking capability, where all of the incoming video streams can be reduced in size, and mapped to a single "mosaic" video. This enables the C2 to have global views of all video streams from the field, and to decide which one to watch in full resolution on the main video player.
The StreamSelector Network Application contains the following services: *Video Reception Gateway*; *Mosaic*; and the *StreamSelector Register*, which is itself made from two components (*DataPlane* and *ControlPlane*). These components have to be deployed within a Kubernetes cluster, using the EKTACOM-provided Helm chart. The architecture of the solution is depicted in Figure 1.

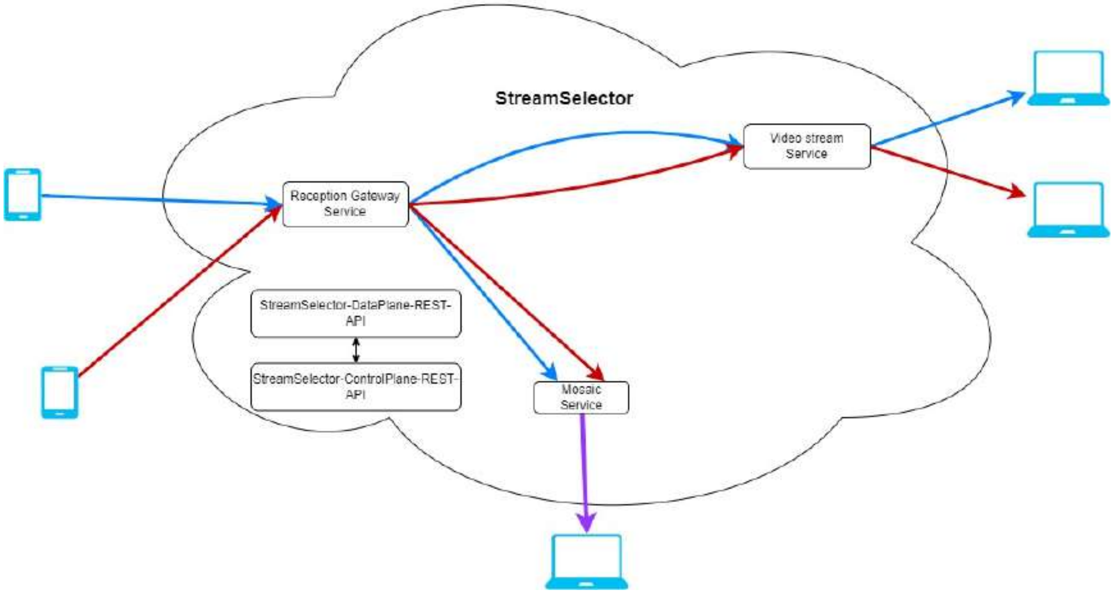

Figure 1: Components of the EKTACOM service

Together with the Network Application, a streaming smartphone application and a video player have to be deployed on user devices. In order to be able to measure KPIs, the smartphone application can be replaced by a computer application called *StreamPusher*, which streams a pre-encoded video and audio file, as if it were live streaming. This enables to stress the network with a higher bitrate.
For the purposes of the experiment, a PPDR use case scenario was defined as follows: Several first responders are on an intervention area (for example, inspection of an industrial site that can store hazardous or dangerous elements, police officers reporting live on their current situation, *etc*.), and provide a video perspective of their operational environment. The video capturing, coding and streaming are managed by a 5G capable smartphone, which has the EKTACOM smartphone application installed. Together with video, audio can be captured and streamed as well. There is an on/off icon in the user interface (UI) of the smartphone application, enabling the user to exercise control over the streaming function. Furthermore, technical and geolocation metadata are captured, and streamed synchronously, together with video and audio.
Live videos are received by the C2 centre, displayed as a mosaic video, aiming at providing a global view of the situation. Any video of interest can be selected by the operator to be displayed at full resolution. The viewing of the video is done by using the EKTACOM video player. This player is capable of collecting KPIs, such as:

- **Time-related KPIs:** latency, delay, RTT, service instantiation time
- **Throughput related KPIs:** video data bitrate, audio data bitrate, packet loss rate.
- **Availability related KPIs:** Reliability, Availability
- **User experience related KPIs:** video resolution and frame rate.

The Use Case is schematically represented in Figure 2.

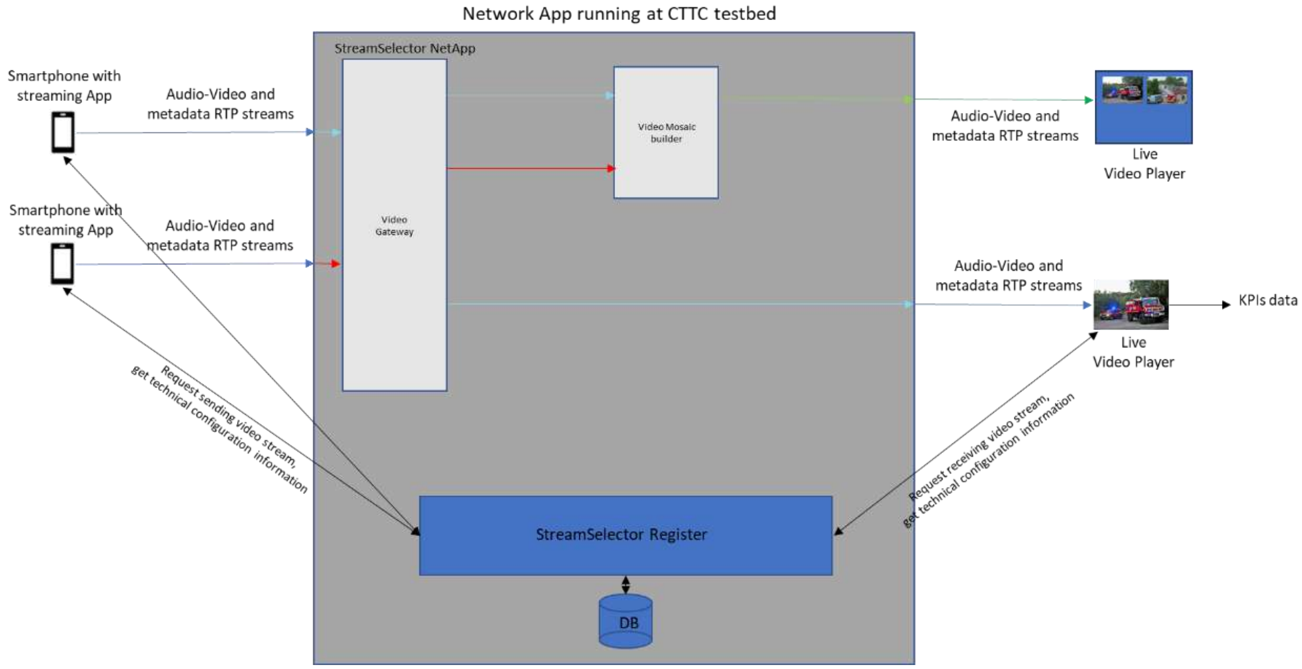

Figure 2: Components of the EKTACOM service running at the 5G-EPICENTRE Barcelona testbed

Testbed Readiness

Deployment of the EKTACOM StreamSelector4PPDR Network Application on 5G-EPICENTRE platform was relatively straightforward, facilitated by the use of the Helm chart packaging format/yaml manifest files. Following detailed coordination, the necessary components, including the Kubernetes cluster and Helm chart deployments, were successfully installed. The StreamSelector Register control plane and data plane components thus became fully operational, facilitating the collection and routing of video streams and metadata. Initial configurations for the StreamPusher and video player applications were completed. Thus, the system became capable of initiating video streams. The CTTC testbed operators resolved all encountered connectivity issues related to the Virtual Private Network (VPN) and Karmada, thereby ensuring stability in the experimentation operations. Further, collaboration with partners UMA and FORTH ensured that the 5G-EPICENTRE Portal and Experiment Coordinator were fully and correctly integrated and functional. The final steps involved conducting further tests of the vertical system through the Portal and Experiment Coordinator, to validate the end-to-end functionality and performance of the integrated solution.

Deployment

The StreamSelector Network Application was deployed on the CTTC testbed infrastructure. The deployment process comprised 4 steps which include the following:

1. Scenario selection out of the four pre-defined 5G-EPICENTRE templates, indicating different experiment characteristics;
2. Experiment information: schedule and type of experiment automation;
3. Selection of experiment artefacts: Helm chart of the vertical system/app, alongside optional additional 5G-EPICENTRE network applications or traffic simulation probes; and
4. Confirmation.

Figure 3 shows the whole process followed from the 5G-EPICENTRE Portal, to set up the experiment.

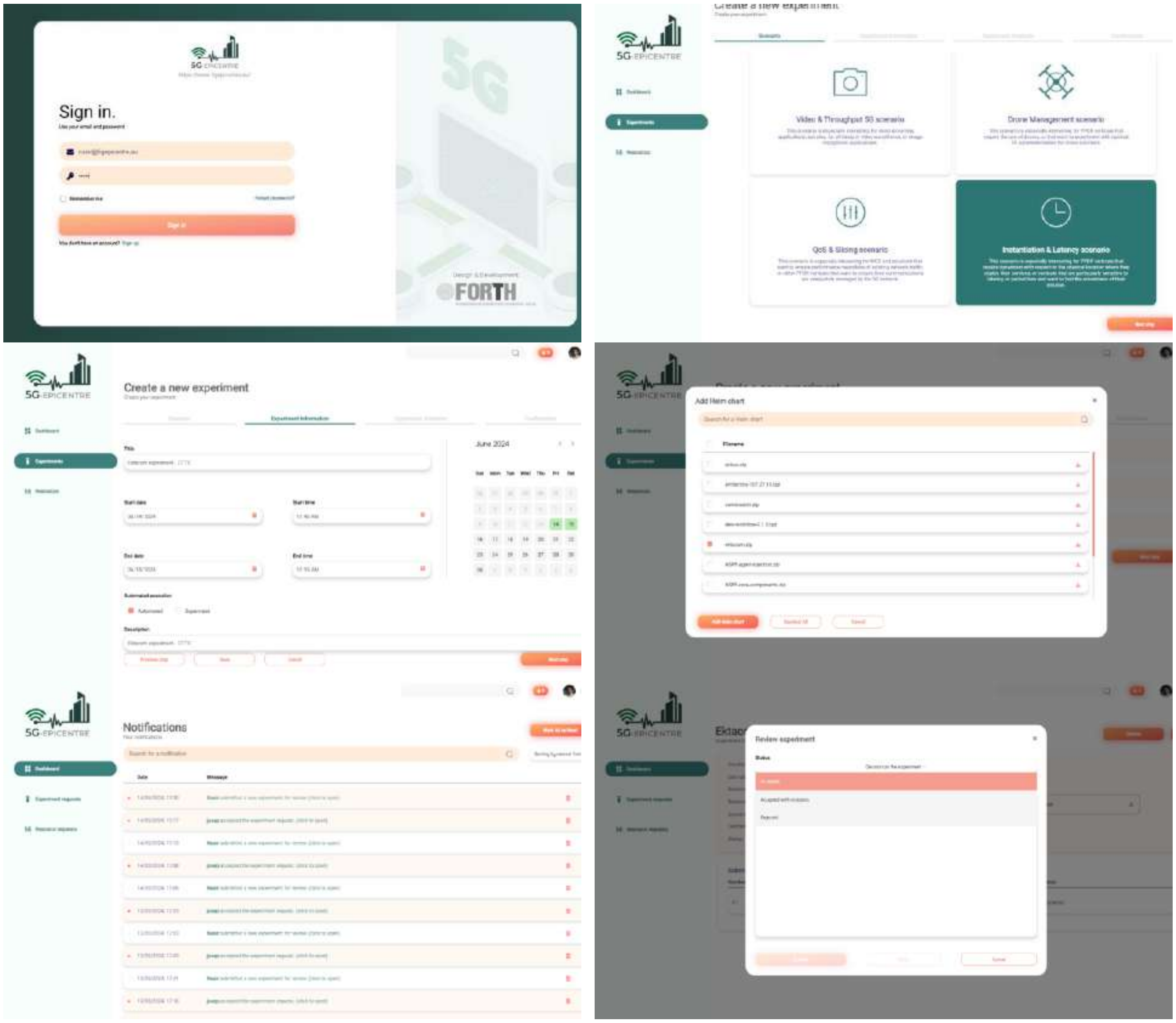

Figure 3: EKTACOM Experiment setup using the 5G-EPICENTRE Portal

Experiment Execution and Results

Deployment of the StreamSelector4PPDR solution at the CTTC testbed encompassed several stages. First, as shown in Figure 4, the system conducts essential checks and setups, such as configuration validation and resource allocation, preparing the environment for the main tasks. The 'run' phase involves executing specific tasks, like installing dependencies and initiating test scripts. The application progresses through its setup stages, indicating the steps followed to configure and validate the streaming solution. This deployment is crucial for providing first responders with high-bandwidth, low-latency network resources, enabling efficient video streaming and real-time data transmission during disaster scenarios.

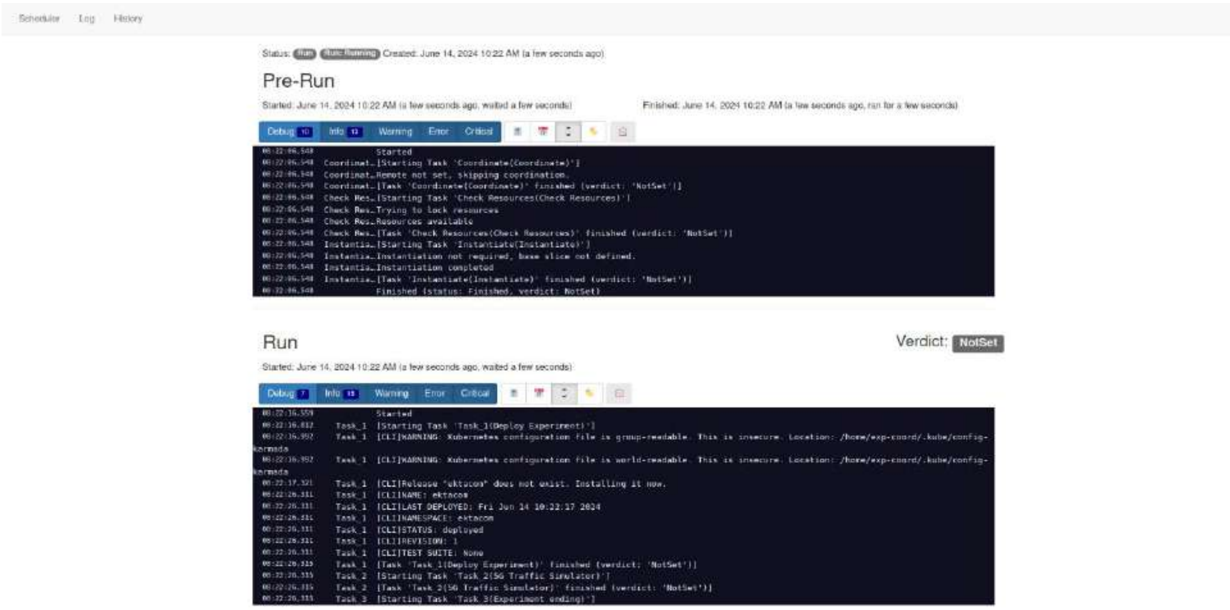

Figure 4: Pre-run and run phases, where the system conducts essential checks and setups

Figure 5 and Figure 6**Σφάλμα! Το αρχείο προέλευσης της αναφοράς δεν βρέθηκε.** detail the status and execution phases of the EKTACOM service, highlighting its active running state and management of various deployment tasks through the Experiment Coordinator. Additionally, configuration of the service within the web UI is depicted, where the CTTC cluster is set up with its management API and public access URLs. Further configurations involve establishing contracts, associated with the CTTC cluster (shown in Figure 7**Σφάλμα! Το αρχείο προέλευσης της αναφοράς δεν βρέθηκε.** and Figure 8**Σφάλμα! Το αρχείο προέλευσης της αναφοράς δεν βρέθηκε.**), detailing client information, and ensuring proper linkage between the contract and the cluster. This deployment and configuration process is fundamental for enabling first responders to transmit live video, audio, and metadata from the field. The final stages of the deployment, as shown in Figure 9**Σφάλμα! Το αρχείο προέλευσης της αναφοράς δεν βρέθηκε.**, include creating the application session, and specifying details such as type, subscription dates, number of connections, and configuration files. The EKTACOM player interface is also shown, where sessions can be selected, validated, and refreshed. The service successfully ran a video session, displaying real-time statistics such as bitrate, frame rate, and latency (Figure 10).

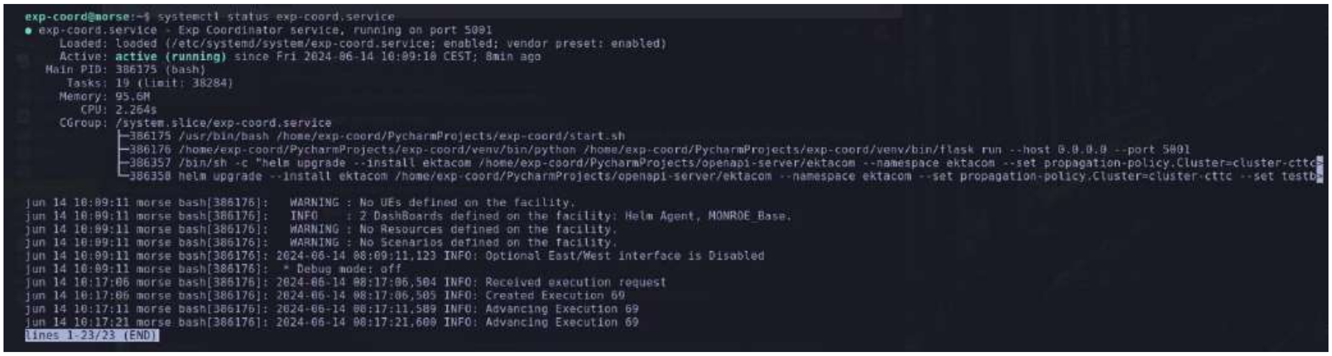

Figure 5: Status and execution phases

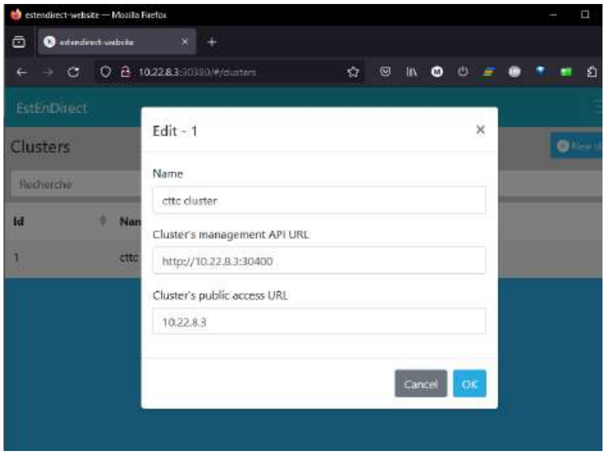

Figure 6: WebUI configuration of the service

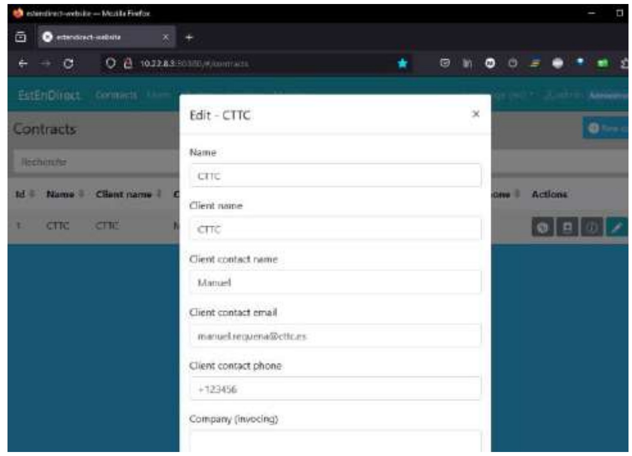

Figure 7: Configuration of the Contract connected to the CTTC cluster (1/2)

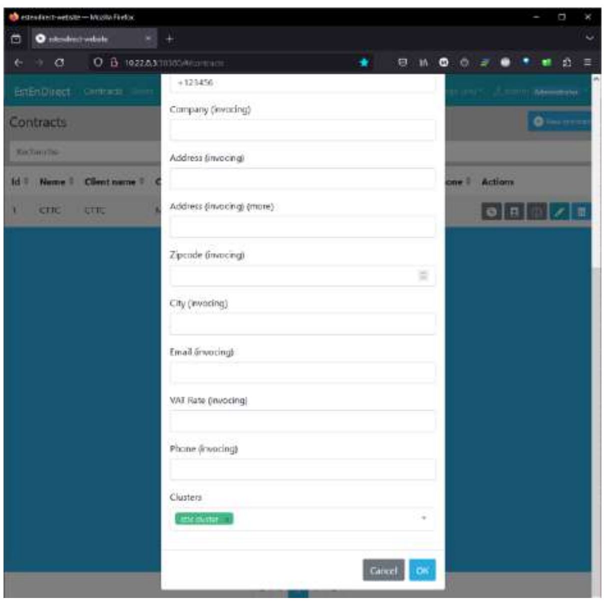

Figure 8: Configuration of the Contract connected to the CTTC cluster (2/2)

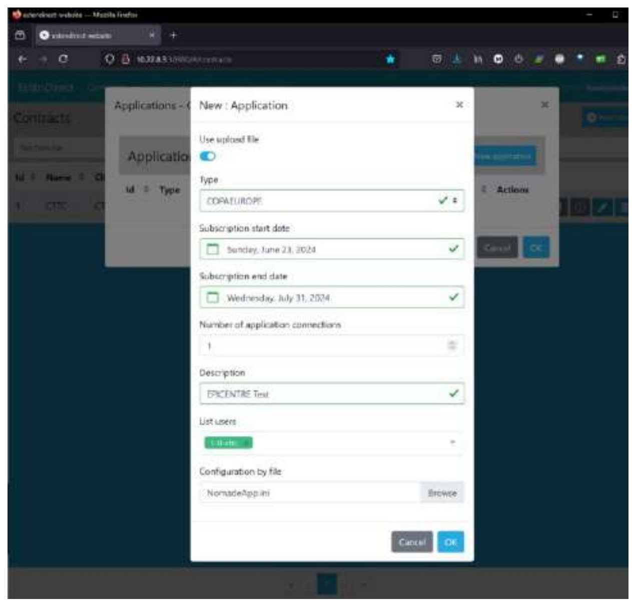

Figure 9: Creation of the Application session

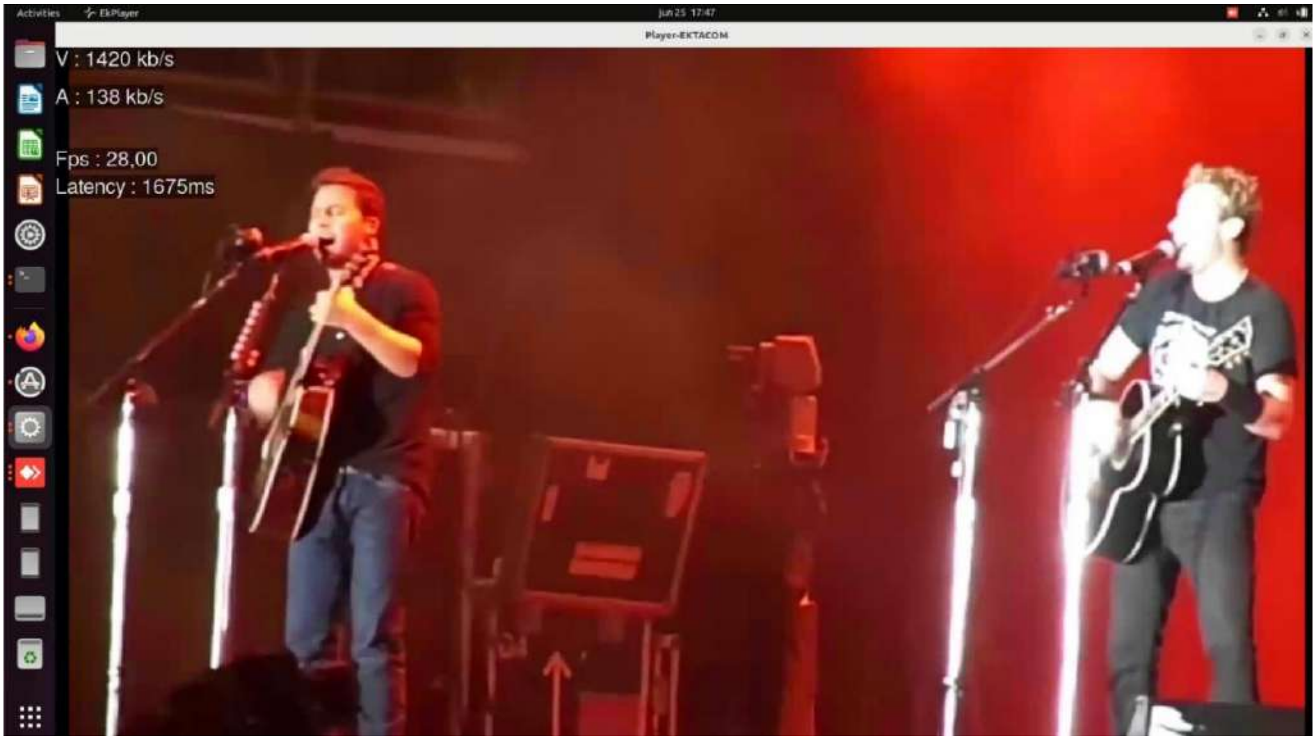

Figure 10: Player running the video session

The log displayed in Figure 11 provides detailed KPI data, specifically focusing on the Bitrate metric, which is crucial for evaluating the performance and quality of the video streaming sessions. The recorded values (for instance, 1312 kbps and 1346 kbps at 10:00:00, and 1186 kbps and 1226 kbps at 10:00:10), are within acceptable ranges, suggesting that the network is capable of maintaining a high-quality video transmission.

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  "statistics": [
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    "id": 4816,
    "key": "KBitrate_Down",
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    "unit": "kbps",
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    "updated_at": "2024-06-05T10:00:00.073Z",
    "service_type": "session_destination",
    "service_id": 6,
    "session_ids": [
     1
    ]
   },
   {
    "id": 4818,
    "key": "KBitrate_Down",
    "value": "1346",
    "unit": "kbps",
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    "service_id": 1,
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    ]
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    "value": "1186",
    "unit": "kbps",
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    "updated_at": "2024-06-05T10:00:10.045Z",
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    ]
   },
   {
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    "key": "KBitrate_Down",
    "value": "1226",
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    "service_id": 1,
    "session_ids": [
     1
    ]
   },
 …
}
```


Figure 11: Log of KPIs measured by the player

Overall evaluation

To facilitate image and video contributions under challenging conditions, one requirement is to ensure that robust, low-latency and direct transmission can be established, further enhanced with the capacity to simultaneously stream these contributions to multiple delivery points (*e.g.*, responders on the field; C2, *etc*.). EKTACOM's Nomade is a proven technology, having already demonstrated use in remote locations.

The following is statement received from EKTACOM, regarding the evaluation of the experiment results:

"Through 5G-EPICENTRE, we tested our technology in the context of PPDR, toward developing solutions for robust, adaptive, low latency video transmission, e.g., from an aerial, or ground unmanned vehicle with an embedded camera, or helmet-mounted camera. Our testing has provided us with insightful information on how to enable better image quality, thanks to available high bitrate connectivity; and allow decreasing round-trip time KPIs. 5G-EPICENTRE allowed us to validate our video gateway network application component, which includes some video processing capabilities in the context of PPDR".