IoT for Improving First Responders' Situational Awareness and Safety on Federated 5G Testbeds

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***Abstract*—Mission-critical services to emergency events require a coordinated response on optimizing the actions for first responders in cases such as firefighters, police agents, doctors, nurses, and paramedics as medical personnel) actions to care for sick and/or injured citizens.**

A central coordination and management team elaborates on the critical decisions and actions helping to realize the increasingly demanding complex scenarios. The implementation of those scenarios significantly rely on the capability to transport and process larger volumes of data from the field to increase the effectiveness on realizing the full awareness of the situation in the field. The adoption of 5G technologies will bring new opportunities to reduce the latency by addressing larger volumes and more complex data.

This paper describes the use case "IoT for Improving First Responders' Situational Awareness and Safety", identified in the context of 5G-EPICENTRE EU-funded project. It aims to demonstrate a mission-critical service through application experimentation in federation adopting a "testbed of testbeds" approach in which different 5G-based platforms are intelligently managed from a single control point.

***Index Terms*—5G, Testbeds, IoT, First Responders, Situational Awareness, Safety**

I. Introduction

Mission-critical services to emergency events demand a coordinated response to maximize the actions for first responders (e.g. firefighters, police agents, doctors, nurses, and paramedics as medical personnel) actions to care for sick and/or injured citizens). A central coordination is led by a team elaborating on the response decisions and actions. To enhance those task, it will be important to consider the most significant number of data sources at the field and the amount of data they produce. Such an amount of data will help to realize new increasingly demanding complex scenarios such as the ones providing full awareness of the situation in the field. By taking all the potential from the transition to 5G technologies will be possible to consider, collect and process larger vaolumes of data.

The 5G-EPICENTRE EU-funded project aims to demonstrate a mission-critical service through the application experimentation in federation adopting federating a set of 5G testsbeds to be intelligently managed, combined and calibrated from a single control point. The resulting platform from this project aims to realize the 5G vision of future network applications taking full advantage of lightweight virtualization technologies to empower and reshape the network.

Situational awareness corresponds to the perception of data and behaviour of the ongoing situation in the field of those emergency events including the conditions and circumstances they occur. By being aware will help to understand the meaning and significance of data and behaviours, and how processes, actions, and new situations inferred from these data and processes are likely to evolve in the near future, and therefore it will contribute to supporting decisions. Timely retrieving and processing the available data on the field, will contribute to enhancing the first responders' situational awareness and safety. Such data can be collected from IoT devices sensors, already available or specifically placed on the field for that purpose. Response actions can be formulated by considering all the available data from different sources to leverage and enhance central coordination capabilities and support human supervises or automated critical decisions in real-time. As the event goes on, more data are available to support management decisions and actions. The application scenarios include planning the geographical location for first responders in real-time, since they start their way towards the event field until they return home, including all the intermediary management and monitoring activities along that period. The solution to be implemented will be converted into CNF and VNFs to be deployed to the orchestration environment of the 5G-EPICENTRE facilities.

The remainder of this paper is organized as follows. Section II presents the 5G-EPICENTRE objectives and architecture. Section III describes theUse Case (UC) addressed by this paper. Section IV presents the expected results. Section V concludes the paper.

II. 5G-EPICENTRE

This section presents the 5G-EPICENTRE main objectives, its architecture and the UCs exploring their outcomes. The 5G-EPICENTRE project proposes to federate multiple 5G platforms using a Cloud-native and microservices-oriented approach.

A. Objectives

The 5G-EPICENTRE aims to achieve an integrated platform providing an end-to-end 5G experimentation addressing public safety and emergency response market players requirements. Moreover, their apps will manage 5G systems in Protection and Disaster Relief (PPDR)-based trials supporting public safety mission critical communications. Small and Medium-sized Enterprises (SMEs) and developers will be able to experiment PPDR applications providing in customized, easily repeatable, and shareable environment. Dynamic 5G slicing, application awareness and insightful Machine Learning (ML)-driven analytics activities will be supported by Artificial Intelligence (AI) means for experiment coordination and lifecycle management. Containerized network functions will to agile 5G solutions multi-access edge computing deployments in a automated and continuous manner. To implement impact-driven dissemination, standardisation and exploitation.

B. Architecture

A multi-layered approach is considered 5G-EPICENTRE architecture includes front-end, back-end, federation and infrastructure layer. The front-end layer supports the interaction processes between the platform and PPDR solution providers. The functional components of the platform are included in a back-end layer. Cross-testbed orchestration of network services and resources in a federation layer aim to provide the best experiment environment. Finally, the 5G testbed infrastructural elements of each of the federated testbeds compose the infrastructure layer. Orthogonal to those layers, and to address the security challenges of the envisioned and highly complex 5G scenarios, an Holistic Security and Privacy Framework (HSPF) is also considered.

C. Use Cases

The 5G-EPICENTRE project oversees the platform's secure interoperability capabilities beyond vendor-specific implementation. Beyond the UC addressed by this paper, EPICENTRE project also the following ones are addressing public security and disaster management:

- Multimedia Mission Critical Communication and Collaboration Platform.
- Multi-agency and multi-deployment mission critical communications and dynamic service scaling.
- Ultra-reliable drone navigation and remote control.
- Wearable, mobile, point-of-view, wireless video service delivery.
- Fast situational awareness and near real-time disaster mapping.
- Augmented Reality (AR) and AI wearable electronics for PPDR.
- AR-assisted emergency surgical care.

D. Use Case Scenarios

This UC is further documented by more specific scenarios such as "Situational Awareness", "On-demand Live High Definition (HD) Multimedia", and "Response Actions Management". "Mobitrust" is a core component providing cloud and edge computing resources supporting real-time interaction, ensuring low latency to support delay-sensitive applications and services. The actors for this use case includes "User with BK Device", "CCC Mobile Operator" and "CCC Operator" that should be previously authenticated to access the available features. "User with BK Device and "CCC Mobile Operator" may be located at the "Emergency Zone" communicating to "Mobitrust" platform through 5G Core (5GC) means. This zone corresponds to the geographical area where the emergency event occurs including the "User with BD Device" and "Command and Control Centre (CCC) Mobile Operator" locations. The Specific locations includes Emergency Zone, Non-Emergency Zone 5G Network. In the Non-Emergency Zones includes "User with Backpack Kit (BK) Device" and "CCC Mobile Operator" locations.

1) Situational Awareness: This scenario aims to provide the situational awareness of the situation on the field to the "CCC Operator" and "CCC Mobile Operator".

As functional confirmation, these operator users' needs to be aware of the situation in the field to manage and coordinate the ongoing operations. "Live "Sensor Data" and "Low Definition (LD) Multimedia" from "BK Devices" will be continuously collected from the "User with a BK Device". Permanently, the "Mobitrust" platform will monitor "Sensor Data" and "LD Multimedia" to identify incidents. After an incident has been identified, the "User with BK Device", "CCC Mobile Operator" and "CCC Operator" are notified. Proactive actions are triggered in consequence of incidents.

"User with BK Device", "CCC Operator" and "CCC Mobile Operator" should be notified within a given threshold and "BK Device" authenticates when turned on. After being authenticated, "BK Device" sends the "Sensor Data" and "LD Multimedia" to the "Mobitrust" platform. Specific incidents are identified within a time-bound (KPI).

2) On-demand Live HD Multimedia: This scenario aims to describe On-demand Live HD Multimedia from users such as "CCC Operator" or "CCC Mobile Operator" demanding further details of specific situations in the field. To that aim, they request live "HD Multimedia" from specific set of "User with BK Device". "CCC Operator" or "CCC Mobile Operator" can select the specific set of "User with BK Device" to demand live "HD Multimedia" to attend to live "HD Multimedia" and, at the same time, they receive the situational awareness. The requested "HD Multimedia" will be received within a time-bound, to be defined as a KPI.

3) Response Actions Management: In this user scenario, the "CCC Operator" aims to assign "Response" actions in case an "Alert" occurs in order to take remediation actions in the shorter possible time-bound. To that aim, "CCC Operator" should be previously authenticated. This user will be able define a set of "Response" actions and notification list to be assigned to the "Alert". A "Response" response action will include the end user name, email, SMS or phone.

Figure 1 shows a sequence diagram with the interactions between the main building blocks, described as follows:

1) "Sensor Data" and "LD Multimedia" are delivered from "User with BK Device" to the "Mobitrust" platform.
2) In the case an incident is identified, "Alert" is triggered to the "User with BK Device", "CCC Operator" or "CCC Mobile Operator".
3) "CCC Operator" or "CCC Mobile Operator" demand "Visualization" from "Mobitrust" platform providing the "Situational Awareness".

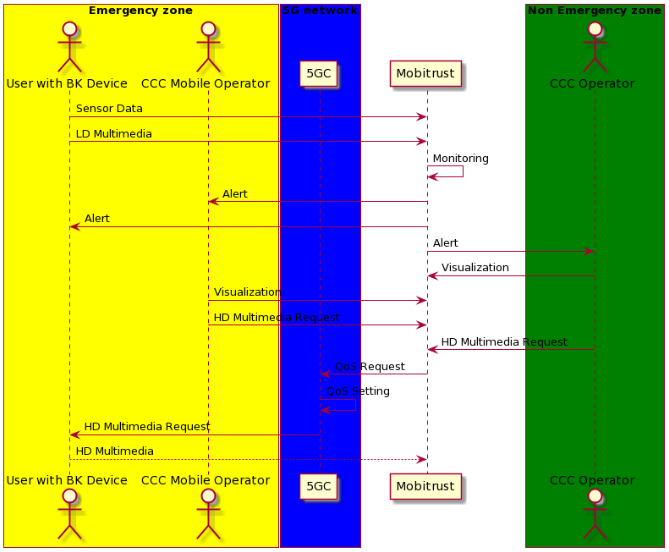

Fig. 1. Main Building Blocks

4) "CCC Operator" or "CCC Mobile Operator" demands "HD Multimedia" from the "Mobitrust" platform.
5) Mobitrust" performs "QoS Request" and "QoS Setting" to the "5GC".
6) "5GC" requests "HD Multimedia" from the "User with BK Device".
7) "User with BK Device" delivers "HD Multimedia" to the "Mobitrust" platform.

III. Mobitrust Platform

For this UC, a situational awareness platform (Mobitrust) will be used in order to meet the pre-set goal of aiding Command and Control Centres (CCC) to obtain a full awareness of field operations. Their main roles includes monitoring of agents in the field through a set of geographical/indoor positioning, environmental and wearable biological sensors, as well as real-time text, audio and video transmissions. Data is then relayed over 5G and processed in the CCC to be displayed in the platform frontend at the operator's request. Moreover, alerts triggered by AI/ML algorithms to detect man-down situations and other critical looming situations (e.g. gunshots, environmental hazards, physical threats, etc.) will be displayed. For every alert, the platform will recommend proactive actions in order to mitigate the effects it may cause. The situational awareness platform will monitor, retrieve and collect data from different types of devices, including:

- Agent bio-sensors (e.g. ECG, SpO2, respiration rate).
- Internal communication system.
- Vehicles (e.g. ambulances).
- Shared services (e.g. private websites or shared folders).

Figure 2 presents the Mobitrust Platform architecture bringing the situational awareness in PPDR operations. It presents the capabilities supporting the data and control interactions between "BK Device", "Mobile CCC" and "CCC".

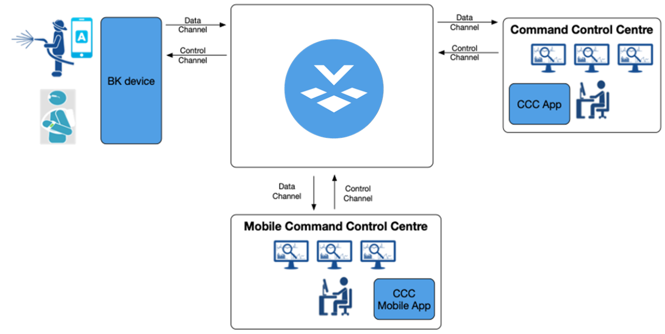

Fig. 2. Mobitrust Platform Architecture

IV. Expected Results

The implementation of this UC faces several challenges, mostly due to the limitations of current technologies. We expect to overcome them by proposing some innovations supported by 5G:

- In the context of emergency operations, the capacity to manage, and the amount of time on individual monitoring activities of each one of the deployed agents is very short. Remote centralized monitoring will contribute to improve the situation awareness on the field.
- It is not always possible to have a human operator in front of a computer terminal or next to the agent, so most times response actions are delayed. The implementation of machine learning algorithms could also assist agents by decreasing the time on the identification of looming situations and performing the response actions.
- Time-sensitive alerts require reliable and deterministic latencies. State-of-the-art networks do not provide enough latency to provide the situational awareness to the CCC (via video/audio) and assure that alerts and actions are triggered fast enough to support decisions makers.
- Non-public networks (NPN) need to be accessed transparently and securely, even when supported on public networks. This requires isolation from the rest of the network, in a VPN-style arrangement but without additional overheads and without the need for any additional software or authentication mechanisms.
- Remote monitoring involves moving sensitive information across untrusted public networks and due to privacy concerns, it is avoided. The use of a Standalone NPN (SNPN) 5G network could overcome that issue by removing the location factor, while satisfying privacy concerns due to its isolation and internal management.

V. Conclusions

The motivation for describing this UC was to demonstrate the opportunities to be provided by a new approach on federating 5G testbeds resources for the experimentation of a new kind of applications. High-demanding scenarios will be demonstrated in the context 5G-EPICENTRE platform on the top heterogeneous Cloud-native cross-testbeds to improve first responders' situational awareness and safety enabled by the data delivered from IoT devices at the field.

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