IoT Based UAV Platform for Emergency Services

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***Abstract*— The Internet of Things (IoT) are impacting several industries and products including the Unmanned Aerial Vehicle (UAV). This paper presents the prospects of an advanced IoT Platform and WoT principles for UAV services. A Cloud service is implemented that manages the real-time video streaming and control commands for a remotely controlled drones. The goal is to implement a mission supervisor web application and a mission viewer mobile client for the UAV and integrate them into EURECOM IoT Platform.**

I. INTRODUCTION

The Internet of Things (IoT) based products and services are increasingly becoming pervasive in our lives, cities, and industries. With inexpensive Internet connection, access to high performance computing, high penetration of smartphones, connected products and IoT services are already providing solutions in mobility, energy, health care, home, and other markets. The Web of Things (WoT) on the other hand is considered as an evolution of the IoT and aims at countering the fragmentation in the IoT ecosystems [1]. RESTful web services has become the default mean of providing consumer services using IoT devices [2]. In parallel to the IoT revolution, there has been a lot of progress and improvements in making UAVs a practical solution is situations like search & rescue, wind turbine & solar panel monitoring, quick reconnaissance, agricultural monitoring etc. Now-a-days, UAVs are integrated with powerful software module for asset inspection and management. Aerial data providers like Airbus Aerial and Intel have created new businesses.

In this work, we have focused on the IoT and WoT to develop a Cloud based software platform for UAVs. The platform enables planning and monitoring the UAVs access requests, deployments, and services. The former also allows UAV operators to quickly deploy fleets of UAVs for diverse applications to monitor and respond to any emergency situations in the Smart and Digital Cities. Civilian UAVs are an important tool in the cities for emergency and prevention operations. Currently, the emergency responders are likely to face congested roads to reach an accident sight and then evaluate the scenario. It is also difficult to understand if humans are trapped somewhere if there is fire and smoke in the environment. UAVs are useful in such scenarios as they can be flown to the emergency spot quickly. On-board thermal camera or infrared camera can detect humans trapped in blazes and the information can be relayed to firefighters who know exactly where to launch the rescue operations. To accomplish these objectives, our first UAV prototype experimentation is targeted to emergency services.

The main contribution of the paper is to extend the EURECOM-IoT Platform[1] features to create an advanced platform for UAVs. The IoT and WoT based UAV platform also integrates advanced functionalities to tackle the complexity of coordinated UAV based operations. This in turn accounts for an effective utilization of available resources. The platform also provides web services for real time monitoring (using both thermal and normal cameras), live video transmission, video analytics (object detection in real time), mission planning &management tools, mission supervisor web application, and mission viewer mobile client application.

Rest of the paper is organized as follows. Section II summarizes the current literature on UAV platforms and features of EURECOM IoT Platform. Section III describes extensions of the Platform, its features for supporting UAV use cases. Section IV concludes the paper with future directions.

II. STATE-OF-THE-ART

Although UAVs or drones based research cover multiple domains, but we found limited research performed at the intersection of IoT and UAVs. The paper [3] concentrates on stable, reliable drone control and management using the oneM2M IoT common service layer for global interoperability. An interworking proxy entity (IPE) is developed to connect the drone management system with the oneM2M system. The authors also presented the oneM2M resource mapping considering Mobius (an open source implementation of oneM2M) common service entity and the Drone IPE as an application entity. The authors of [4] have explored the possibilities of using drone based communication systems for both wireless power transfer and communication simultaneously. They have presented their system design and experimental results with air trials. A prototype drone for air and water quality measurement is discussed in [5] while an IoT Platform for drones is presented in [6]. However, the later presents just a basic architecture with software configurations. Apart from the above, a robotic drone as a tele-presence platform is presented in [7]. There is a significant gap in current literature for an advanced IoT Platform for UAV operations and management. Below is a description of the current features of EURECOM IoT Platform which has been extended for supporting UAV based emergency services.

[1] `https://iotplatform.eurecom.fr/n/log_in`

A. *EURECOM IoT Platform*

Cloud based high level architecture of the EURECOM IoT Platform is shown in Fig. 1 [8]. It has been utilized in solving Smart Home and Connected Car [9] research questions. The architecture follows the principles of oneM2M IoT and W3C Web of Things (WoT). The microservices based web services (also called micro elements) are portrayed in Fig. 2.

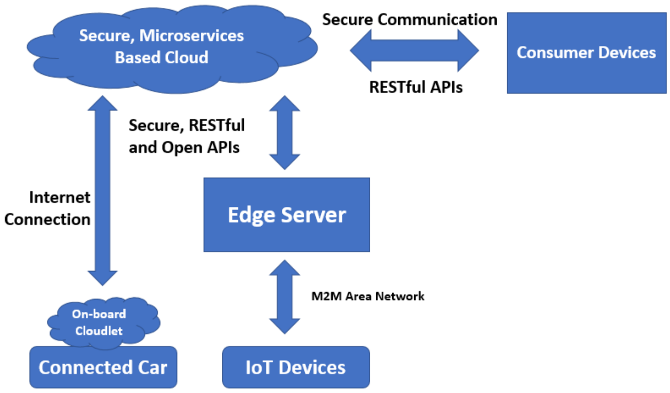

Fig. 1. High level architecture of EURECOM IoT Platform.

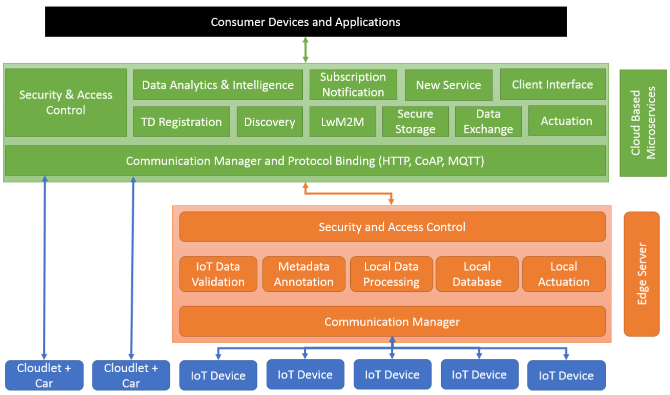

Fig. 2. Micro elements of EURECOM IoT Platform.

The software Platform web services are exposed through north and south interfaces. The south interface is dedicated to the IoT devices and an Edge Server. The Edge Server is an edge computing node providing local data validation, metadata annotation using Sensor Measurement List[2], local data processing, storage, and local actuation capabilities. The south interface also exposes a communication manager which provides protocol binding to HTTP, CoAP, and MQTT. It allows devices to connect using any of these communication protocols and is one of the novel aspects of the Platform [2].

The north interface supports the interactions with consumer devices like web browsers and mobile devices. This interface exposes web services including discovery, LwM2M for data management, access to sensor data, subscription, notification. Security features are embedded into the web services by design.

[2]https://tools.ietf.org/html/rfc8428

III. IoT Platform Extension for UAV Operations

Through this work, we plan to support several emergency operations using UAV - (i) early assessment of incidents in roads and/or structures, delivery of small medical equipment as early support to ambulance response, (iii) fast response to civil-triggered alerts for the emergency responders (e.g. police, firefighters, ambulance), (iv) support to missing people search, (v) incident prevention and surveillance in crowded events, and (iv) preventive monitoring of infrastructures. The IoT Platform must support Cloud based web services for data harvesting, distribution, real-time analytics, and resource management. Due to multi stakeholder nature of the emergency services, a set of multi device HMIs are to be supported through both web and mobile applications. A custom middleware is also necessary for optimized UAV-to-Cloud communication and real time video analytics for automatic assessment of emergency situation. To accomplish that, we require an architecture with loosely coupled software modules. Microservices are the apt choice here which ease software module integration, future extensions, and rapid scaling of the web services.

The northbound interface of the EURECOM IoT Platform are extended to include UAV operations specific web services. The newly introduces web services are for the purposes of real time video analytics, UAV mission definition, and telemetry monitoring shown in Fig. 3.

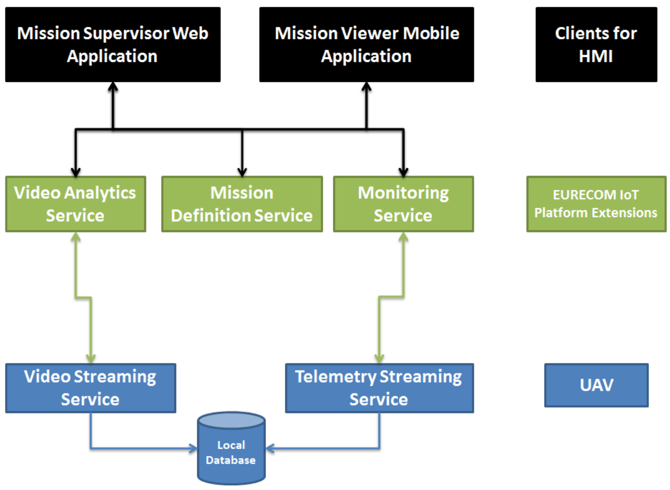

Fig. 3. Extensions to EURECOM IoT Platform.

A. *UAV as IoT device*

The upgraded architecture considers the UAV as an IoT device which is streaming telemetry data over MQTT and video from thermal and normal cameras using web socket. Both telemetry and video data also stored in a local database for backup and off-line processing. This is a significant step towards offering Drone-as-service for future business cases.

The telemetry messages are formatted using JSON schema for the ease of processing at the server side. Following is an example -

{"position":{"latitude":40.407956,"altitude":740.400024, "longitude":-3.835798}, "attitude":{"yaw":-0.008569,"roll":-0.118375,"pitch":0.083307}, "speed":{"y":0.049647,"x":-0.510497,"z":0.117688}, "time":1528203107285,"battery":32}

B. Platform extensions

The first microservice introduced in the Platform is for mission definition. This is the web service which receives a civilian and/or smart city infrastructure triggered alert with a GPS coordinate where the UAV is requested. The request is automatically treated for mission definition and drone assignment service. Depending on the received GPS coordinate, a trajectory is defined through a mission design service. A drone pilot is assigned from the ground service. All such mission definitions and related information are stored in a databased in the Cloud.

The second microservice introduced is telemetry monitoring service which integrates an MQTT broker since the telemetry data is transferred over MQTT. The MQTT topic telemetry is defined to be[3] where the MISSIONID, TASKID, and DRONEID are generated when a new mission is created. These parameters can also be retrieved using the north interface. To provide a secure exchange of data, the MQTT is operated over TLS. The clients support *mqtts://URL* format to subscribe to the topic and receive telemetry data. It is also possible to send control message to the UAV payload using the same MQTT broker. In that case, additional topics are to be defined and the UAV will subscribe to those topics.

The third microservice is about providing real time video analytics capabilities to the Cloud. To detect people and cars in emergency situations (even during fire, smoke), both normal and thermal cameras are used for video acquisition from the UAV. The video is then transmitted to this web service over web socket. An implementation using WebRTC is also possible. Object detection including humans and cars are well studied in the state-of-the-art [10], [11], [12]. Our work concentrates on developing the web service that can perform object detection in real time and send the enhanced video to the client. This communication is performed using web sockets as well.

C. Web and Mobile Applications

Due to multi stakeholder nature of emergency services, the extended Platform supports multiple client HMIs. A web application is developed for the mission supervisor. This application is monitoring and managing all UAV missions by means of -

- mission plans
- live and enhanced video streams from normal RGB and thermal cameras.
- event notifications from ground services
- situational awareness and video analytics support

An example mission supervisor web application is shown in Fig. 4 and the client is mainly used by the Platform administrator.

[3]d112/telemetry/mission/MISSIONID/task/TASKID/drone/DRONEID

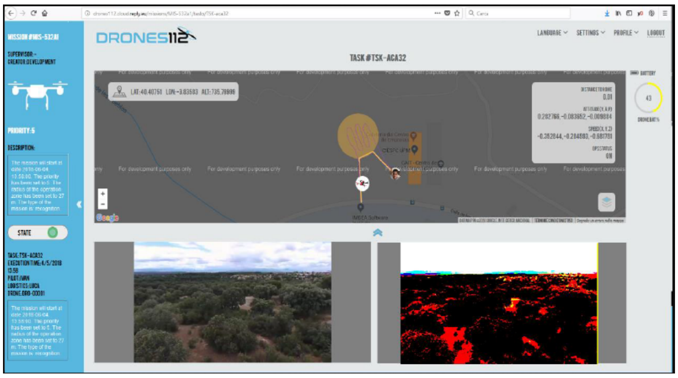

Fig. 4. Mission supervisor web application.

Another mobile application for Android powered devices is developed for emergency service providers (e.g. police, ambulances, and fire fighters). The application retrieves the enhances video from the IoT Platform and telemetry data of the UAV. This allows the emergency responders to understand the scale of the situation and plan the reinforcements ahead. To receive the telemetry data, Eclipse Paho Android service[4] is utilized.

IV. Conclusion

This paper motivates the utilization of the UAVs for emergency purposes. The emergency services are identified and we have presented our ongoing work to extend the EURECOM IoT Platform. Three new microservices are introduced to the Platform to to support real time video analytics, mission definition, and telemetry streaming for UAV operations. The upgraded IoT Platform and client applications are undergoing real world trials for performance evaluation.

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