Dronacharya: Enabling guided collaboration in a disconnected environment

18843: Mobile and Pervasive Computing
Carnegie Mellon University

Akshunna Vaishnav
Mentored by Jim Blakley

Background

There are often situations in the real world that require technological operation in a disconnected environment, i.e. one that does not have access to the internet at large or any form of cloud. There are three necessary components in such a situation:

- An infrastructure for network access (*JIT Cloudlet* [1])
- Computing resources (*JIT Cloudlet*)
- **Useful applications and services (this project)**

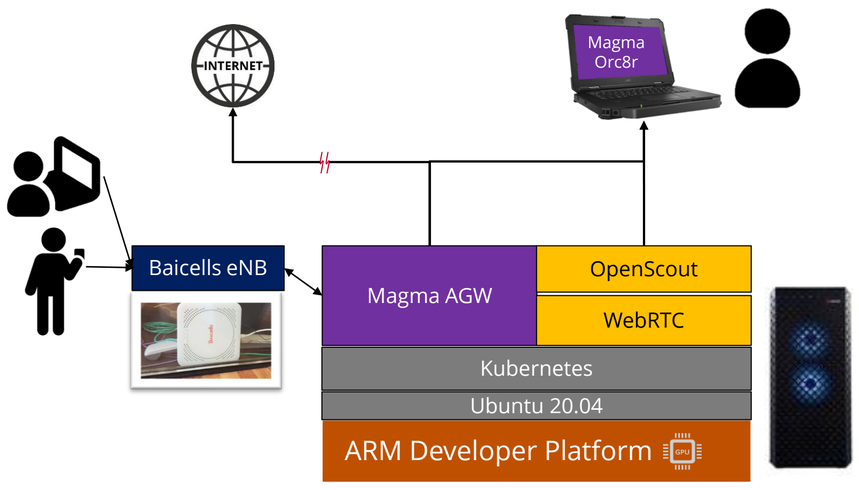
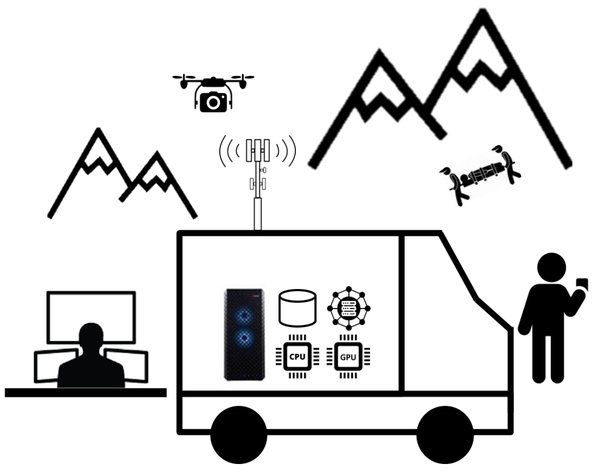


Fig. 1: An overview of Just-in-Time Cloudlet components.

In this project, I have created an application for communication, collaboration, and exploration in a disconnected scenario. Purpose: unlock communication and collaboration in use-cases for the *Just-In-Time Cloudlet*.

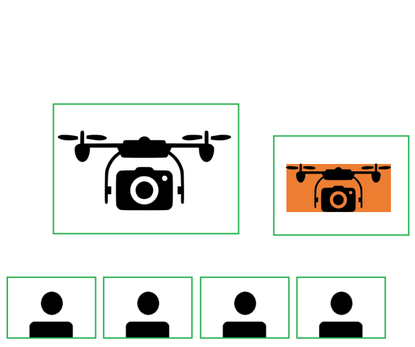
Dronacharya Use Case: Search and Rescue



Search and Rescue: allowing first responders to
1) collaborate with ease
2) locate people quickly, through the use of a drone,

when they have no pre-existing network connectivity

The Application



The application provides a familiar interface to allow users to view drone footage and communicate with each other. Drone snapshots are taken to preserve a moment that was captured.

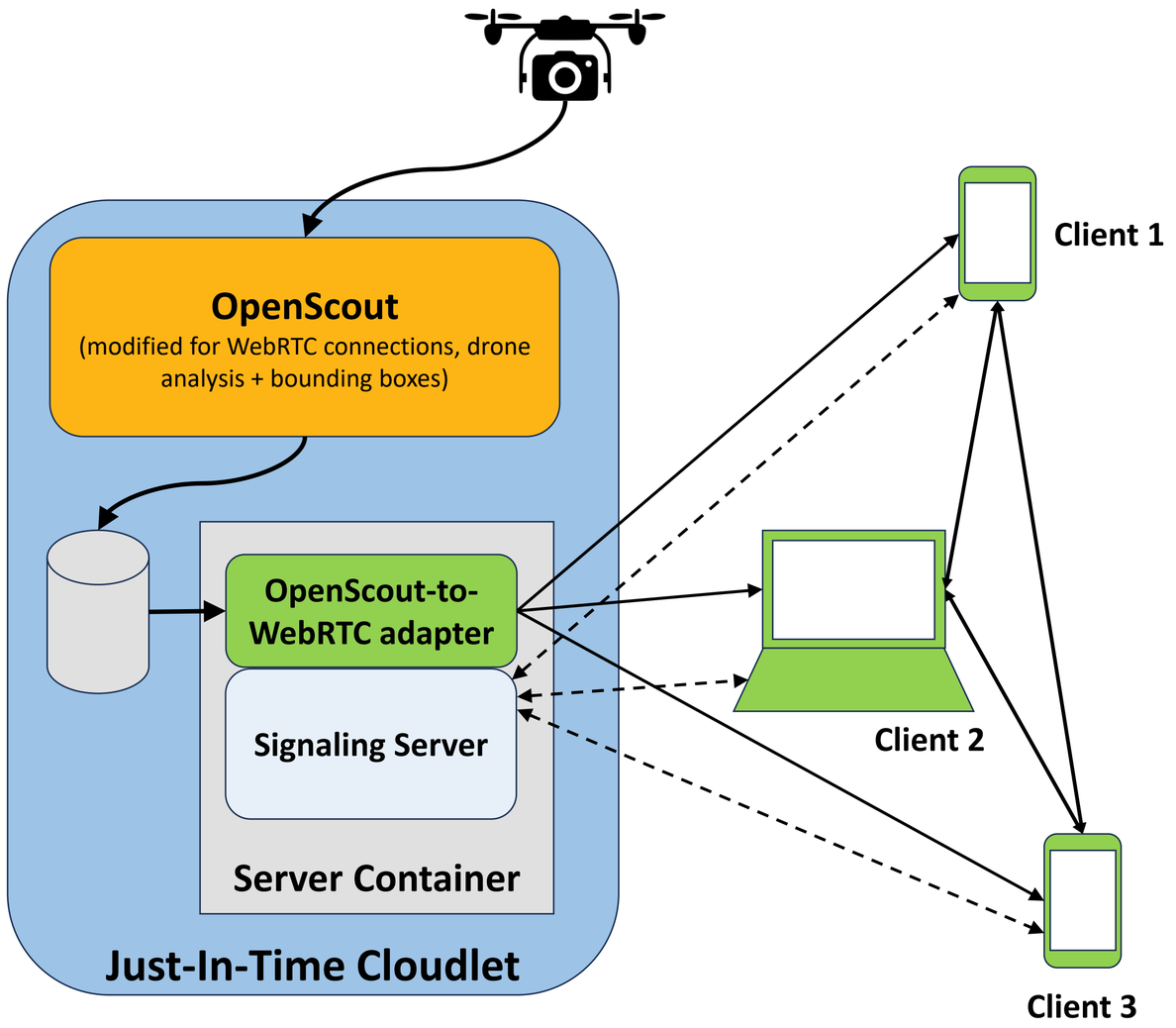
The application allows for:

- Asynchronous connect/disconnect
- Shared drone footage viewing
- Shared snapshot functionality

The application uses these technologies:

- **OpenScout** [2], the pre-existing object detection engine was used, changes were needed to transmit detected output to clients
- Industry-standard **WebRTC** [3] facilitates peer-to-peer collaboration, and requires NO cloud infrastructure, unlike Zoom, Skype, Discord, etc.

System Architecture



The application comprises of four main components:

- ***OpenScout***, drone footage extraction +analysis
- **OpenScout-to-WebRTC adapter**, to send analyzed footage
- A **signaling server**, to facilitate WebRTC peer connections
- **Clients**, who see analyzed drone footage and talk to each other

The front-end is a JavaScript-based WebApp that prioritizes user-friendliness. Web sockets [4] are used for signaling.

Demo

First responders:

A simple demo which uses image streams instead of live camera footage.

Note that the Web Application is accessible from any device through a web browser, and join-leave is completely automatic.

Drone footage can be paused, and a single screenshot of the drone footage can be taken for analysis.

Challenges + Learnings

There were a few challenges along the way:

- Limited WebRTC API/resources for Python or Android
- Moving data across Python-JavaScript abstraction layer
- Limited exposure to JavaScript, WebSockets, Docker
- Allow asynchronous join/disconnect, clients *and* drone

Through this project, I learned:

- OS-agnosticism often simpler than multiple native apps
- Cloud-native at the edge JIT Cloudlet applications are worth exploring

Future Work

Future directions for development include:

- Drone image buffer can be replaced by a service which takes OpenScout output and conveys it to WebRTC Server container.
- Video recording of the drone footage
- Containerized deployment and real-world disconnected test

References

[1] “The Just-In-Time Cloudlet” (unpublished manuscript), James Blakley, Thomas Eiszler, Jan Harkes, Mahadev Satyanarayanan, Marc Meunier
[2] OpenScout: https://www.cmu.edu/scs/edgecomputing/articles/openscout.html
[3] https://developer.mozilla.org/en-US/docs/Web/API/WebRTC_API, https://peerjs.com/docs/
[4] https://socket.io/docs/v4/client-api/