
CREATE
CONNECT
LIVE
INSPIRE



InterDigital Update

Edge Research Activities

+ *AdvantEDGE: Experiences with Edge Emulation*

Open Edge Compute Initiative, Fall Workshop
December 2019 | Pittsburgh

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The Living Network™

Continuing to Guide R&D and Investments



CONTENT

What type of data, for what purpose and with what security and quality requirements?



CONTEXT

What is the situation and need, and how does that impact connectivity and content delivery?



CONNECTIVITY

What network, devices and assets can be deployed to ensure a constant flow of meaningful data?

Core R&D Areas Today



5G and Now Beyond!

Core technology through to platform development and testbed deployment across all elements of the system (terminal, edge, core and internet)



Media and Video

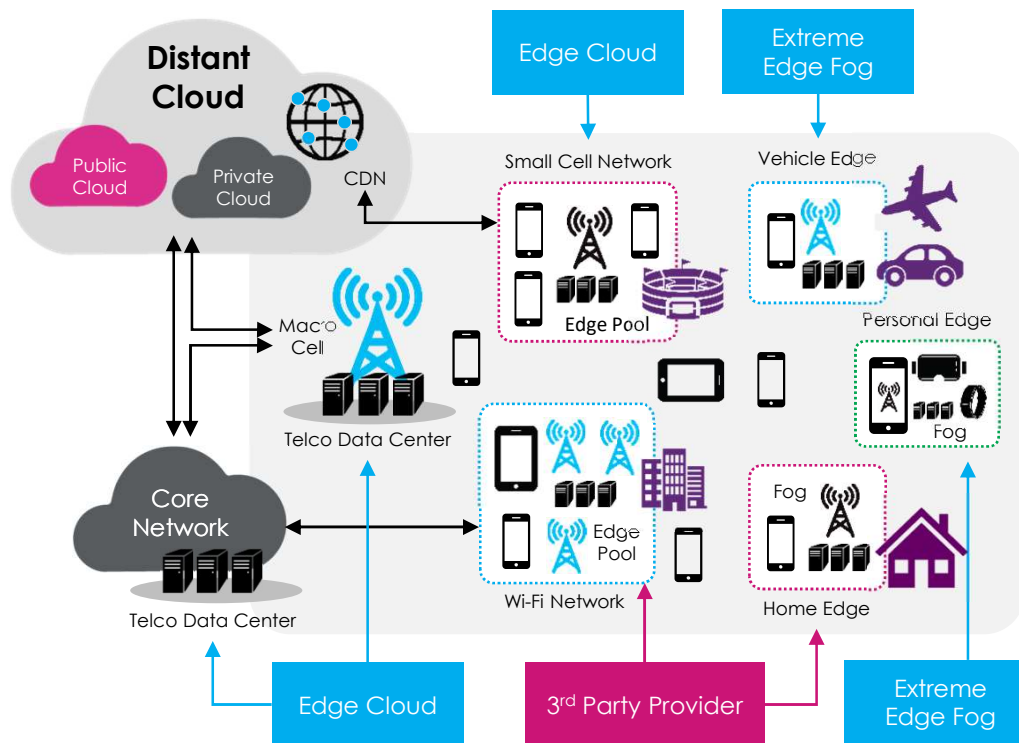
Enhancing the AR/VR experience with optimized bandwidth and low latency solutions, and one of world's largest patent portfolios in this area



Internet of Everything

World-leading oneM2M-based product platform offered to market and testbeds under Chordant brand plus research & standards

Edge Computing – a 5G Enabler



- Edge Computing embeds application resources in network equipment and devices that are closer to the end-user
- Key Benefits to 5G Networks:
 - **De-centralization** - proximity, offloading, local resources
 - **Opening the value chain** for more stakeholders
 - **Maximizing utilization** across the network
 - **Optimizing interworking across access networks**
 - **Cooperative on-demand** networking and computing
 - **Lower deployment cost and time**

InterDigital – Edge Research Summary

Active in Standards:

- ETSI MEC ISG Member
- 3GPP Edge Study Items: SA2 and SA6
- IETF Compute in the Network Research Group (COIN-RG)
- IEEE WLAN support for Edge

Edge Research Interests:

- Extending from the Telco Edge to the [Extreme Network Edge](#)
- 3rd Party / Multi-Domain; Mobility; Multi-RAT; Edge Routing; etc.

EU Projects:



Edge Emulation:



The Need for a Mobile Edge Emulation Platform

An Environment Facilitating the Rapid Development of Applications for the Edge

Edge Computing

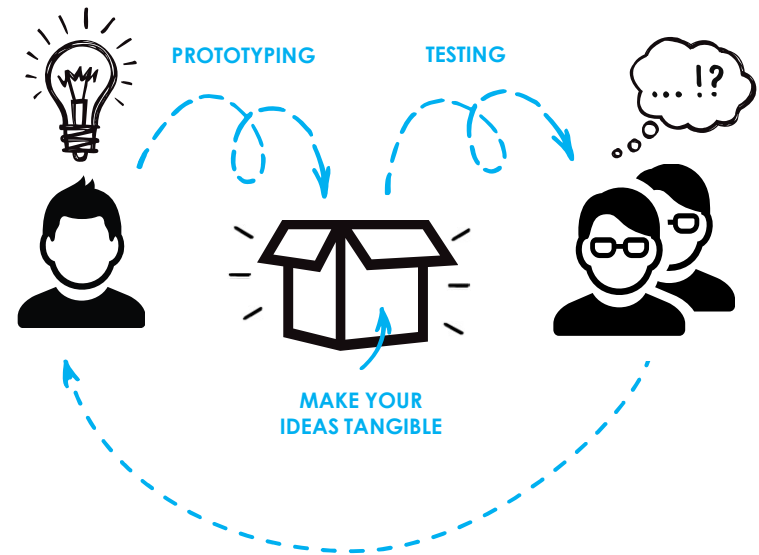
- Is a non-trivial extension of Cloud Computing
- Introduces access to **low-latency, local resources**
- Presents unique challenges

Multiple Deployment Models

- Edge vs Fog – where should an application component be placed?

Lack of Widely Available Edge Infrastructure

- Retrofitting cloud infrastructure for the edge is difficult and time-consuming
- Early development should focus on discovering edge applications and not on building infrastructure



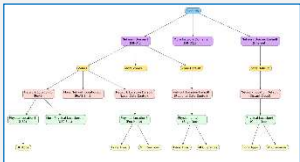
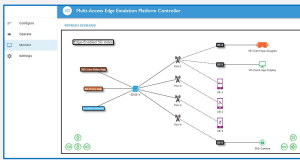
ADVANTEDGE

Mobile Edge Emulation Platform

Agile Experimentation and Validation
Environment for Edge Applications and
Services

AdvantEDGE Controller

- Control and Orchestration
- Lifecycle
- Mobility
- Network Configuration



AdvantEDGE Host

Application Layer

- Terminal Devices and Apps
- Edge Applications and Services
- Cloud Apps and Backend

Edge Service Layer

- MEC Built-in Services (Location, RNIS, etc.)
- MEC Platform and Platform

Environment Layer

- Virtualization (Containers)
- Network Topology
- Network Emulation (Latency, Throughput, Mobility)

- Containerized Environment
 - Kubernetes (K8) based
- Full End-to-End Network
 - Terminal
 - Edge (across the network)
 - Distant Cloud
- Emulated & External Clients / Applications / Nodes
- Single Host ("Edge in a box") & Multi-Host Configuration
- Scalability:
 - Small Networks (<=25 nodes)
 - Large Networks (1000+ nodes)
- Scenario Configuration, Dynamic Adaption, Real-time Monitoring, and Logging
- AI / GPU at the Edge

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Mobile Edge Emulation Platform

Physical Deployment

- Single-Host / Multi-Host / Cloud deployment capability
- Support for internal / external applications or nodes
 - Client device applications, edge applications, edge services, distant cloud applications, etc.

Edge Computing Topology

- Support for multiple node types: Client, PoA, Fog, Edge, Distant Cloud

Configurable Network Characteristics

- Latency, Jitter, Throughput, Packet loss, etc.

Edge Emulation Requirements

Traceability / Visibility

- Historic logs for post processing, real-time statistic display, visualization of network topology

Enable Edge Services

- Location service, Application relocation, RNIS, etc.
- Standardized NBI / SBI interfaces when available
 - NBI = North Bound Interface – to apps
 - SBI = South Bound Interface – to platform or access network

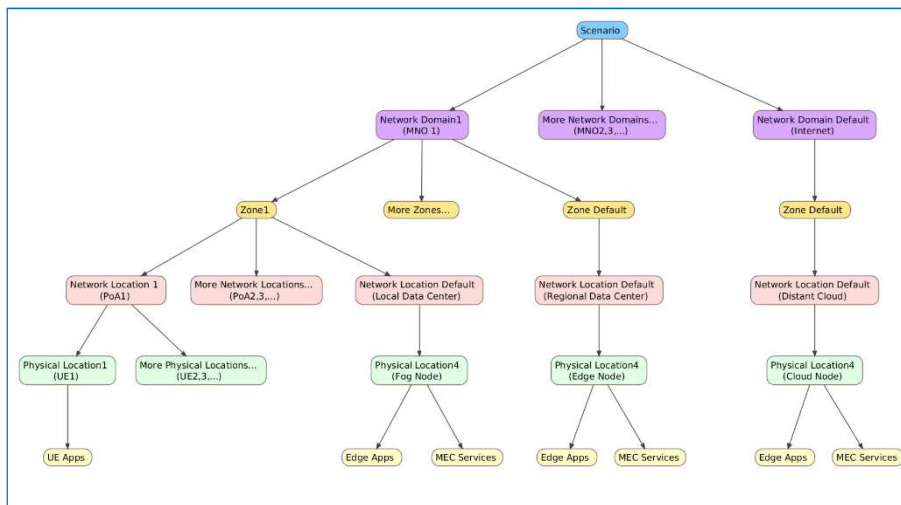
Edge Application mobility

- Edge application & state relocation across Edge nodes
- UE connection migration across Edge nodes

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Mobile Edge Emulation Platform

Layered model captures end-to-end network elements, from network domains down to individual application instances, to provide a complete "edge network" framework.



Edge Network Scenario Model

Logical Domain

- Defines the number and type of domains within a scenario
- For example: Internet / distant cloud, mobile operator domains, etc.

Logical Zonal

- A domain can be decomposed into zones with a relative distance (i.e. latency) between zones
- Each zone can be composed of varying sets of network and physical locations

Network Location

- Defines locations within a zone, where nodes may be connected
- Example: *Points of Attachment*

Physical Location

- Each node within a network occupies a physical location
- Defines number & type of nodes: UE, Fog, Edge, Data Center, etc.
- Support for internal vs. external nodes

Process

- Finest abstraction level
- Individual deployment of an application or service instance at a container level

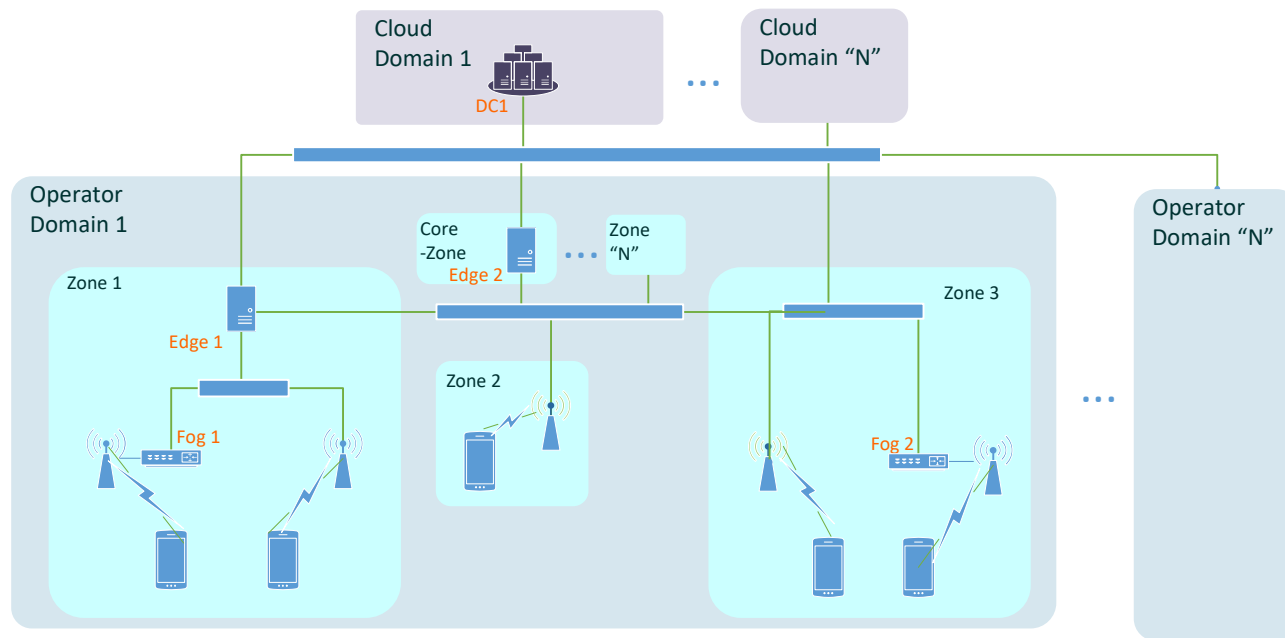
Network Behavior

- Network characteristics (latency, throughput, packet loss, etc.) programmable at several levels within a scenario
- For example: terminal link, fog/edge, inter-edge, inter-zone, inter-domain, etc.

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Mobile Edge Emulation Platform

Small General Example Scenario



Two Domains:

- Internet / Distant Cloud
- Single MNO Edge Domain

Distant Cloud:

- Single Data Center

3-Tier MNO Edge:

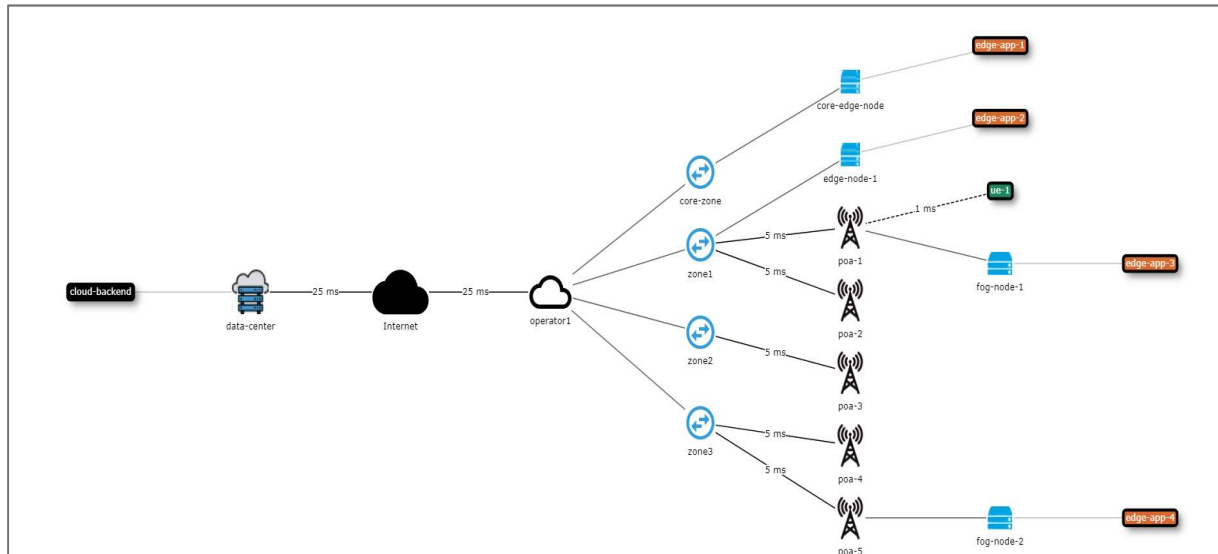
- (1) Fog Nodes at PoA Sites
- (2) Edge Node within a Zones
- (3) Core Network Edge Node

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Mobile Edge Emulation Platform

Small General Example Scenario

ID ADVANTEDGE



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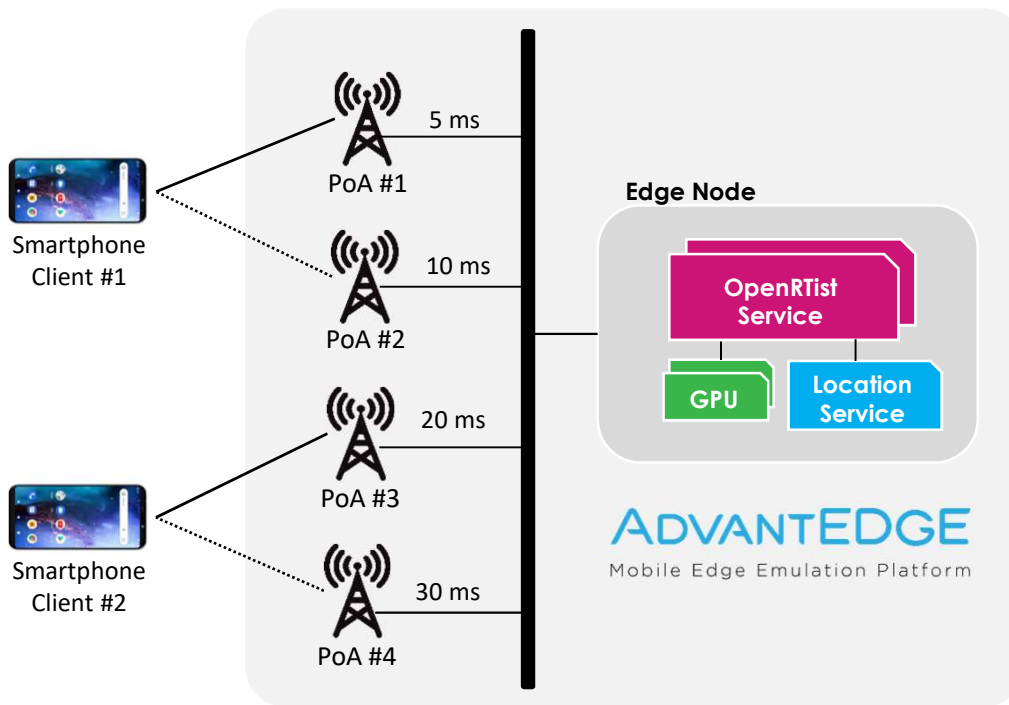
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Mobile Edge Emulation Platform

Live Video Stylization App

OpenRTist - <https://github.com/cmusatyalab/openrtist>

Stylizes Live Video Based on Famous Artwork



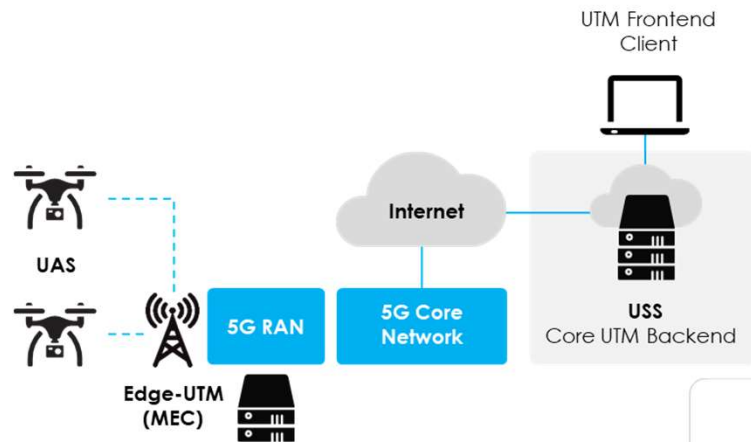
- OpenRTist App
 - Open source project from CMU
 - Live video captured on the mobile device
 - OpenRTist service stylizes the video
 - Stylized video displayed in real-time on the mobile device
- Edge Location Service
 - Artwork stylization selected based on the client location in the network
- Impact of Edge
 - AdvantEDGE emulates network characteristics across a set of Attachment Points
 - For example, evaluate the impact of latency

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Mobile Edge Emulation Platform

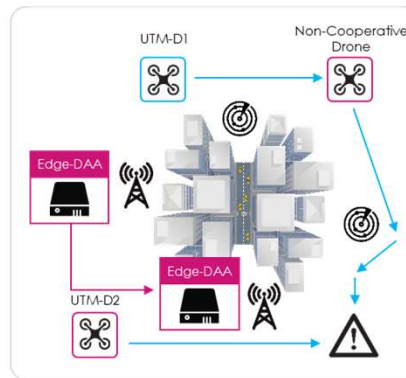
Mission Critical Automation

Autonomous Drones – UAV (Drone) Traffic Management (UTM) with Edge-enabled collaborative conflict avoidance



Edge Computing
Congress Sept 2018

MOBILE™
GSM A WORLD CONGRESS
Feb 2019



Core-UTM Backend (Cloud):

- Strategic mission planning, approval, and monitoring

Edge-UTM:

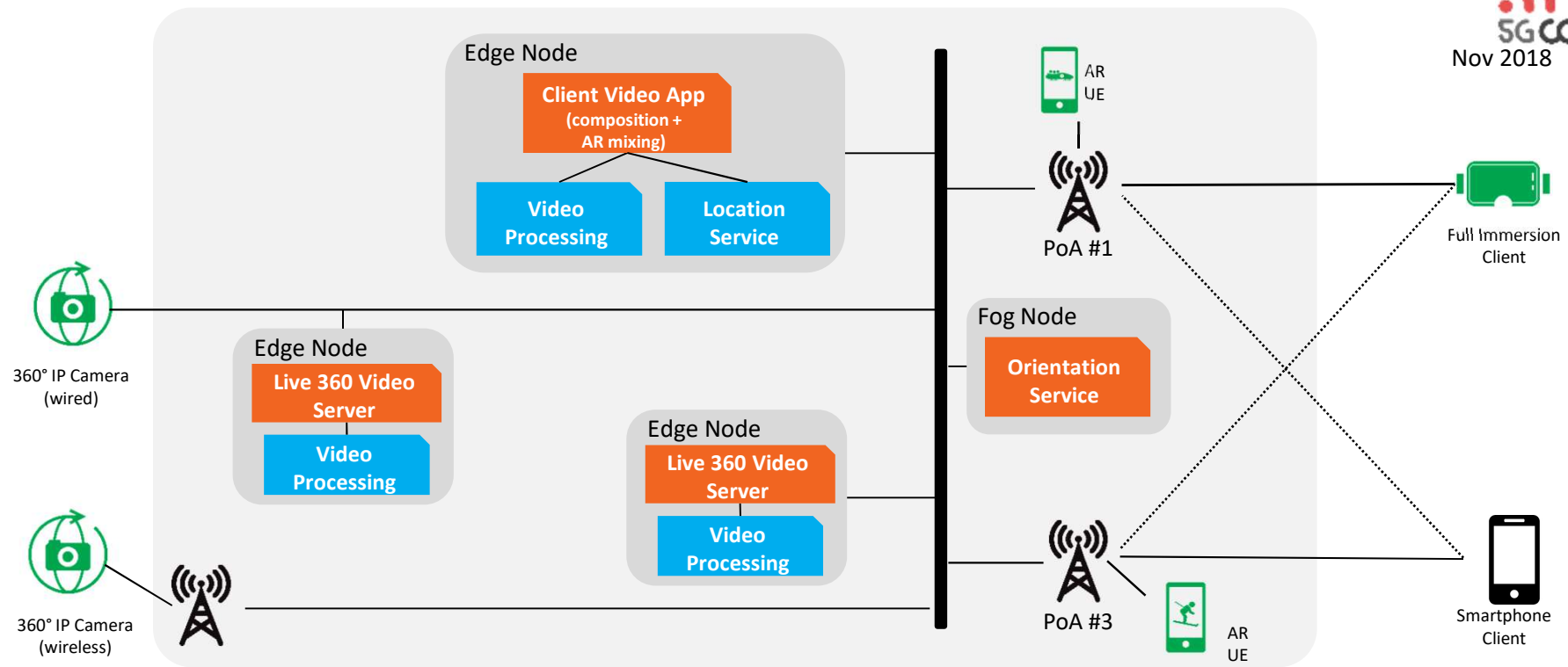
- Collaborative fusion of sensor information among UAS and ground sensors in a local area, at the network edge
- Edge-DAA function detects collisions in the local airspace and issues real-time “group” resolution advisories to affected UAS

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Mobile Edge Emulation Platform

Mixed Reality Video

Live 360° Immersive Video with localized AR



Brooklyn 5G Summit

Apr 2018

5G - READY FOR TAKEOFF

MOBILE
WORLD CONGRESS

Feb 2018

5G coral

Nov 2018

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Mobile Edge Emulation Platform

What is new?

MWC 2020 Demonstration - Beyond 5G Home

- Interactive Multi-player Game - Proof of Concept
- Requires extremely low “*motion-to-photon*” latency and full-home wireless coverage
- Realized via smart in-home multi-RAT management coupled with in-home edge compute resources



Inspired by:
Cable Labs “*The Near Future. Bring it on*”
<https://www.youtube.com/watch?v=kTeavB3IGg>

v1.3.0 – published to GitHub (November 2019)

- Emulation improvements: link bandwidth sharing
- Platform REST API documentation: wiki + run-time viewer (swagger)
- Multi-node Cluster: deployment pods to specific machines in the cluster
- Network Model Refactoring: removed redundant code, improved performance

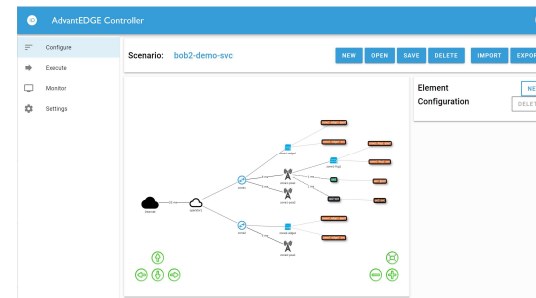
<https://github.com/InterDigitalInc/AdvantEDGE/releases>

Interested to Learn More?

ADVANTEDGE

Mobile Edge Emulation Platform

Agile Experimentation and Validation Environment
for Edge Applications and Services



Please Visit: <https://github.com/InterDigitalInc/AdvantEDGE>

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