INTEROPERABLE MEC PLATFORM

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Multi-Access Edge Computing (MEC)
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Outline

- What is MEC
- Drivers for MEC
- Why MSOs
- MEC Use Cases
- MEC Opportunity
- Potential MEC Framework
- MEC in MSO Network
- Next Steps

What is Multi-Access Edge Computing (MEC) Infrastructure

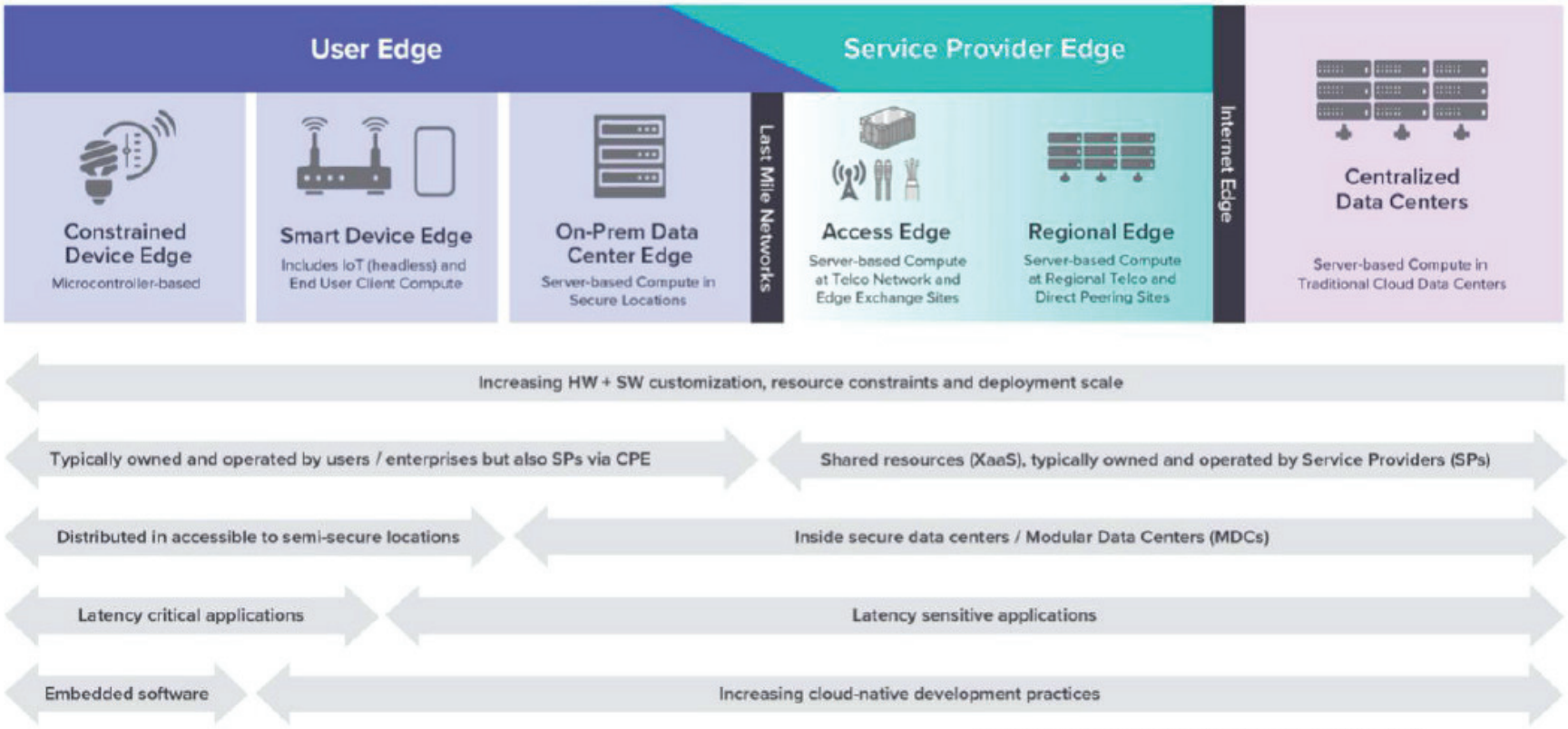
- An infrastructure deployment blueprint focused on increasing the geographical proximity between the user and/or data and the application to reduce the latency and/or transport bandwidth requirements

- An infrastructure platform that facilitates
  - discovery and use of access services by applications to process and analyze data
  - applications to register, discover and interact with each other and other network services
  - seamless relocation/transfer of user specific application context from one edge location to another nearby edge location to mirror mobility of the user

Drivers for Multi-Access Edge Computing Infrastructure

- Low RTT is important for the user experience for certain applications and services (network functions) across several vertical industries and consumer applications
- Many video intensive applications have amounts of data to be transported for processing by an application is extremely large where transport of the data is not economically practical
- Efficient use of deployed resources by short-lived applications
- Data privacy is important as enterprises consider private wireless network deployments
- Jurisdictional control of collected data requires that the data processing application be moved to where the data is
- Services based 5G functions and control/user plane separation provides the ability to create and deploy edge-centric blueprints

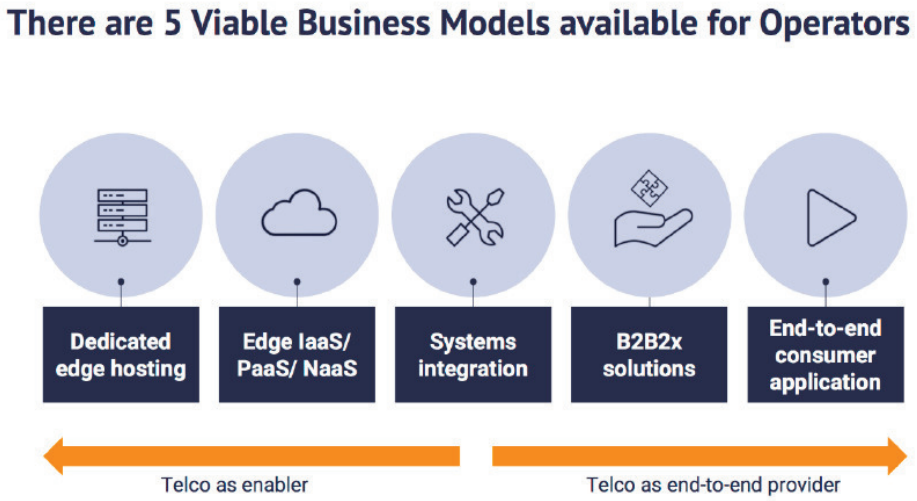
”Edge” Classification



Source: LF Edge June 2020 Taxonomy White Paper

MEC Business Models (Source: STL Partners)

- **Dedicated edge hosting**: The telco delivers and manages edge-located compute/storage resources, which are pre-installed and connected to the telco network. The customer/partner runs its software, which could be for example a virtual content delivery network (CDN) or a distributed cloud stack, on top of the telco's edge-enabled dedicated hardware resources.
- **Edge IaaS/PaaS/NaaS**: The telco in this business model operates in a similar manner to a cloud provider, providing customers distributed compute and storage capabilities, a platform for developing applications on the edge infrastructure and network services, as well as APIs and virtual network functions (VNFs) in an 'as-a-service' manner through a cloud portal as the customer interface.
- **Systems integration**: The telco builds upon an existing SI business, offering custom turn-key solutions for enterprise customers with specific requirements, which are (partially) met by MEC functionality.
- **B2B2x solutions**: The telco offers edge-enabled solutions to enterprise customers. As with existing B2B solutions, these may be for the customer's internal purposes, such as to improve existing processes, or may contribute to an end-customer offering (B2B2X). In general, these solutions will be closer to an 'off-the-shelf' product than a totally bespoke offering, thus requiring significantly less integration work than SI projects.
- **End-to-end consumer retail applications**: The telco plays high up the value chain, acting as a digital service provider for consumer applications. MEC-enabled services in this category will leverage the benefits of MEC, namely low latency, high throughput and context awareness, to provide consumers with innovative applications (e.g. VR for live sports).



Why MSOs are Ideally Situated as Enablers of MEC Infrastructure / Apps

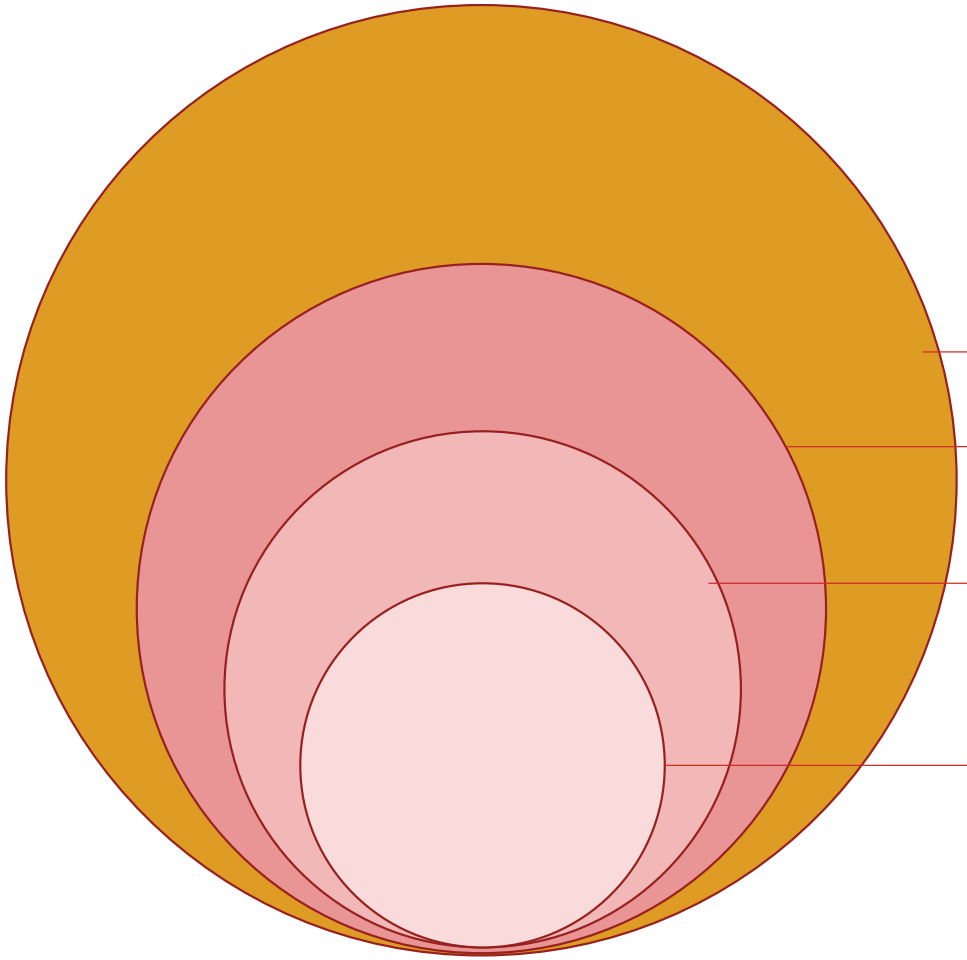
- Distributed Network Assets (Customer Premise, Fiber Node, Hub and Head-end locations)
  - Provides opportunity to deploy a truly distributed MEC infrastructure spanning its fiber nodes, hubs and head-end locations
    - Depending on the latency requirements, Fiber Nodes (FN), Hub or Head-end location(s) can be select to deploy the application workload(s)
    - In case of inbuilding solutions, the MEC infrastructure can also be considered at the customer premise

- Extensive HFC deployments
  - Facilitates higher speeds through dedicated fiber assignment / 10G for MEC deployments
  - Reduces time to market in standing up a new location
  - Enables lower cost offering

- Latency enhanced DOCSIS infrastructure
  - Enables accessibility to the MEC applications via DOCSIS and still meet the latency KPI
  - Enables flexibility with regards to use of either fiber or coax

- Inter-MSO Interconnect
  - Allows linking of MEC locations to facilitate seamless mobility experience for MEC applications (where the devices may be mobile)

Potential MEC Opportunities for MSOs



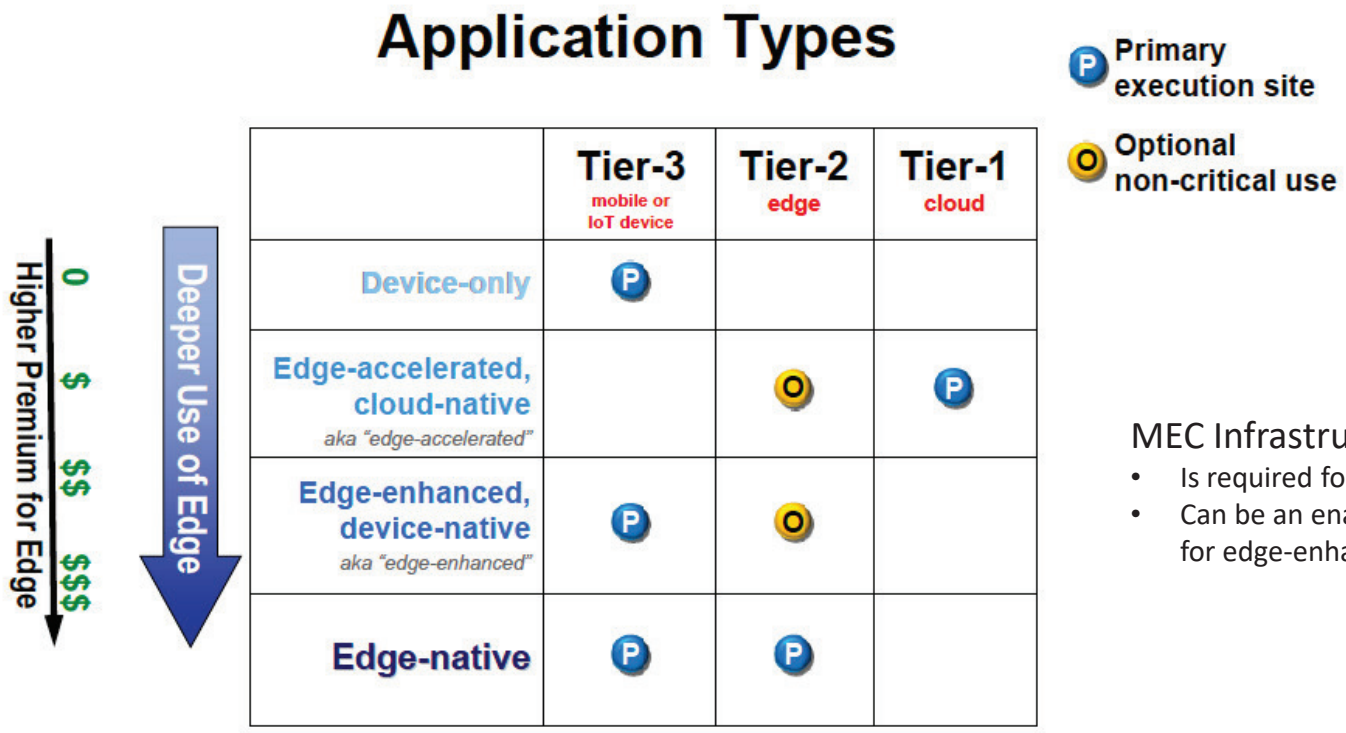
MSO MEC applications

Enhanced Services for Hosted Applications

Platform to Host Applications

Real Estate (Hub/HE) & Transport

Types of Edge Applications



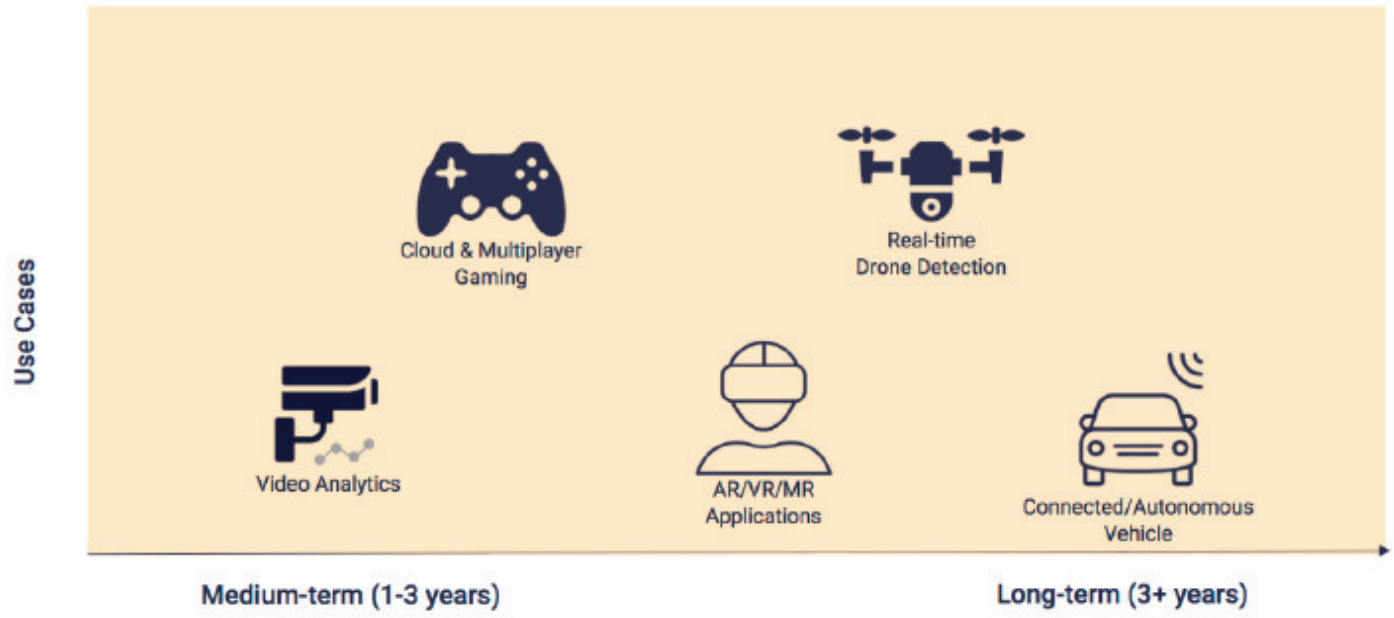
MEC Infrastructure

- Is required for Edge-native application
- Can be an enabler for improved performance for edge-enhanced device-native apps

MEC Use Case Categories

- Consumer applications
  - Video Analytics
  - AR/VR oriented apps
  - Localized Content
  - Cognitive assistance
  - Autonomous mobility
  - Gaming
- Operator or 3rd party services
  - Device location tracking
  - Radio network information
  - Registry and API
  - Security
  - Networking
- Network Performance and QoE
  - Performance optimization
  - Caching (DNS, content)

Adoption Timeline for Use Cases



Technology Enablers for MEC Deployment

- Disaggregation of RAN, core, HFC and centralized cloud infrastructure
  - Disaggregation of traditional monolithic appliances allows the operator to flexibly instantiate one or more instantiation of the network functions in optimal geographic locations where servers are available
  - The cloud is also getting more distributed by large cloud infrastructure providers

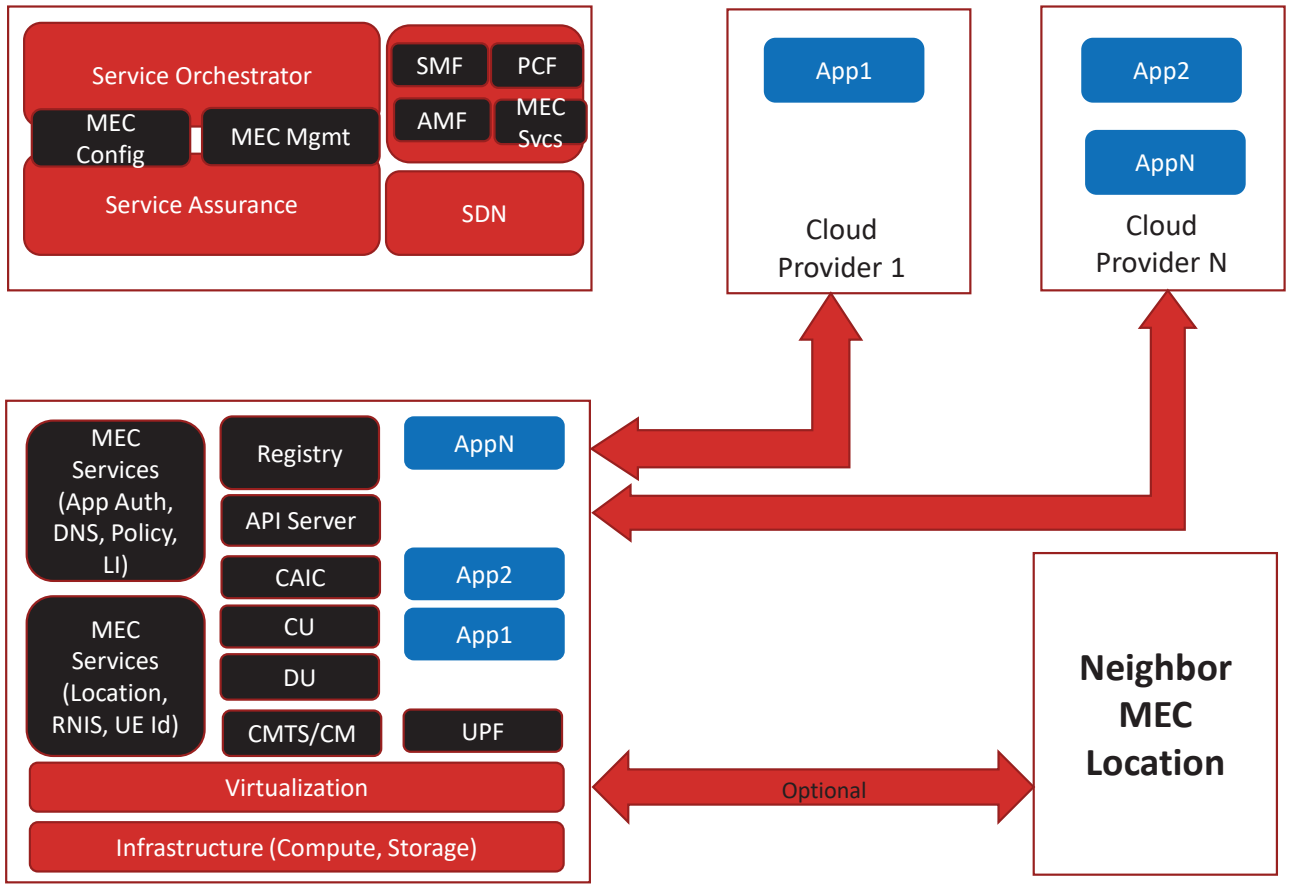
- Service based architecture and control/user plane separation
  - Ability to separate the user plane from the control plane allows flexible deployment of user plane functions all the way to the edge and minimize the latency
  - Proliferation of private infrastructure is further going to enable deployment of traditional RAN and core network functions into the edge location (on-premise)

- Local Area Data Network to restrict access to services
  - 3GPP has defined features that allows subscription to the network be enabled in only certain regions. This provides flexibility in making available MEC services on a geographic basis

- Mainstreaming of cloud native technologies
  - With the migration to 5G, cloud native technologies and virtualization are expected to go mainstream in telecommunication networks

Potential MEC Platform Framework

Potential MSO MEC Framework



Based on ETSI architecture framework

The MEC Infrastructure must be capable of being installed using MSO's virtualization platform of choice

Key Components of the MEC Framework

- MEC awareness within the service orchestration and assurance infrastructure
  - MEC topography and connectivity graph across MEC locations, UPF, applications, etc.
  - MEC service configuration
  - MEC telemetry for fault/performance management

- Centralized MEC service(s)
  - Interact with 5G functions using the SBI/NEF – for location, user id/authentication, policy, etc.

- Distributed MEC services
  - Location
  - Radio information
  - DNS
  - Lawful Intercept
  - Authentication service to authenticate applications, authorize access to the application
  - Registry/API server for applications to discover, publish and interact with MEC services and with each other

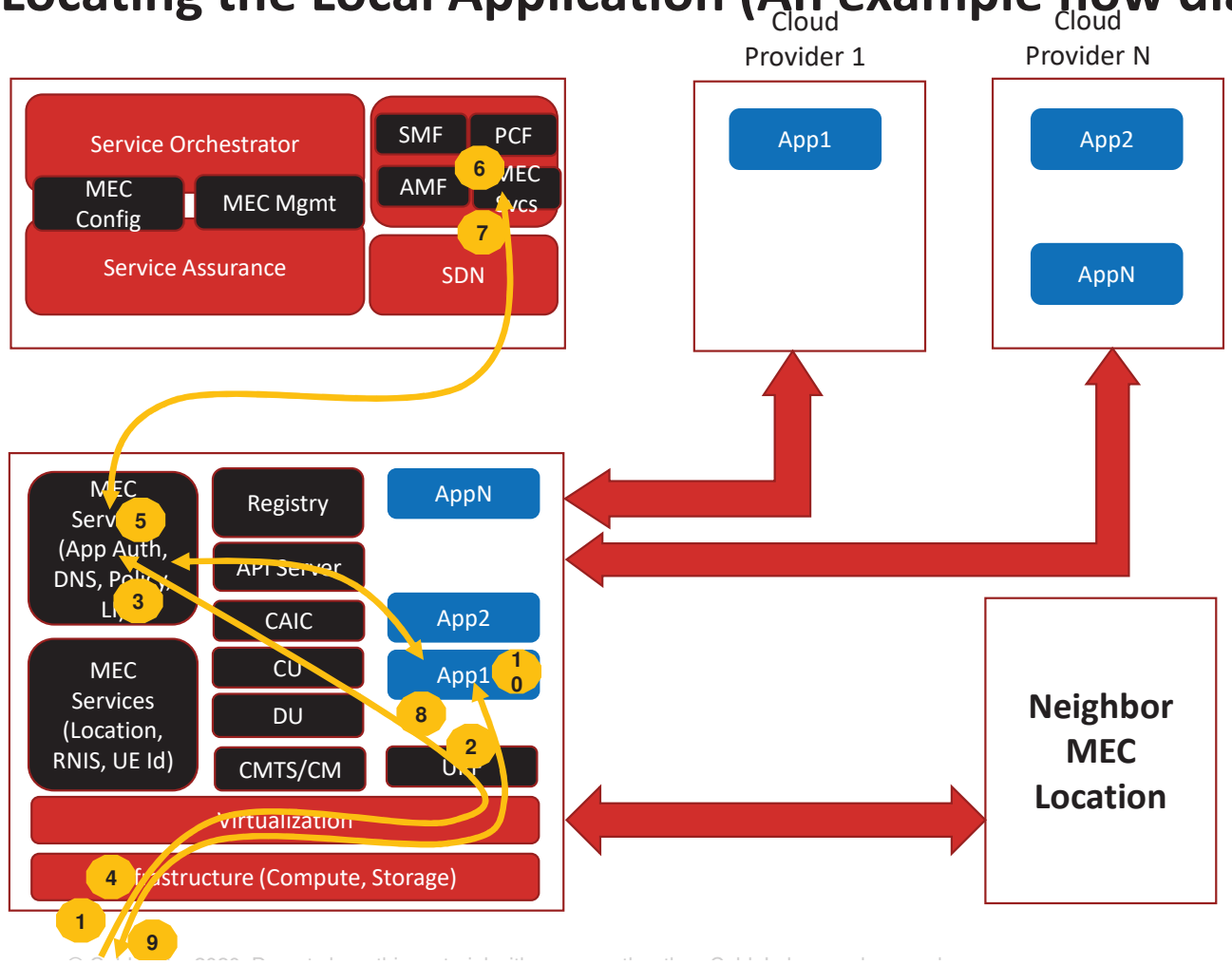
- Distributed UPFs

Key Technical Issues (Based on Use Case Description)

- How to register MEC applications in the registry?
- How to anonymize subscriber information while providing location information to a local application?
- How to authenticate application and supply tokens that applications can use to register for traffic associated with specific devices
- How to route user traffic to local instance of the application?
- How to switch the user traffic flow from central app or an app located at another MEC location to the local app?
- How to determine radio usage by individual local MEC instances?
- How to setup secured routing paths between MEC applications?
- How to setup routing paths between MEC applications across MEC locations spanning multiple operators?
- How will lawful intercept be implemented?

Some examples of how some of these technical issues can be addressed are shown as example flow diagrams in the next few slides

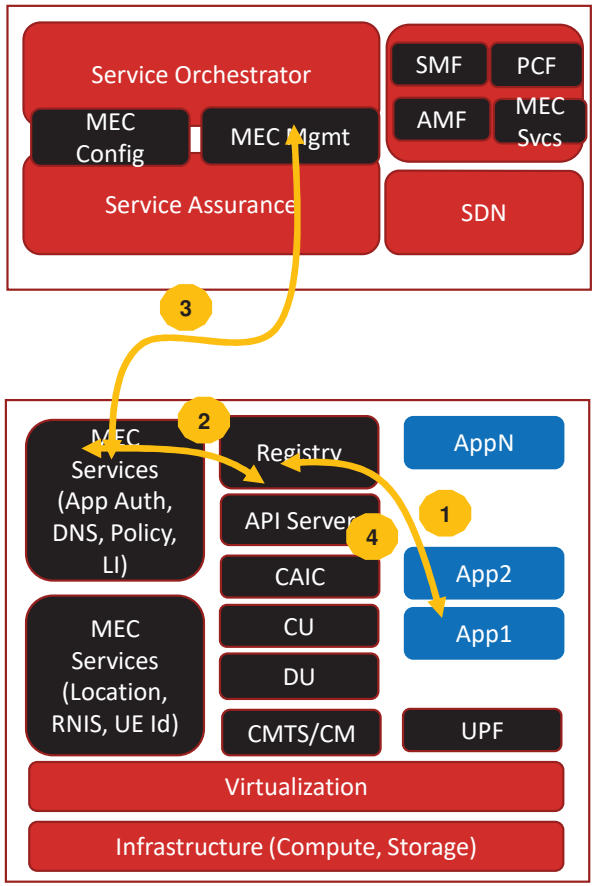
Locating the Local Application (An example flow diagram)



Note: This is an example flow to demonstrate how MEC services get used – the final flow will have to be determined after the detailed design is undertaken

1. After the device is authenticated, the device application sends a query to locate the service to register the app with
2. The UPF forwards the DNS query to the local DNS to query the auth service
3. The local DNS provides the local Auth Service IP address
4. The device sends the auth req to the auth service (Auth Service can be local or centralized)
5. The Auth Service queries the corresponding centralized MEC service to authenticate and authorize the use of the local application
6. The central MEC service queries the UDM and the PCF to validate the authorization and retrieve application specific policies
7. The central MEC service provides the authorization token (and URL of the local app) to the app in the device and the IP address of the local app via the Auth Service
8. The app retrieves the IP address from the DNS service by presenting the URL
9. The app uses the token and the retrieved IP address to access the local app instance
10. The app validates the token with the local auth

Discovering and Registering with the MEC Service (An example flow diagram)



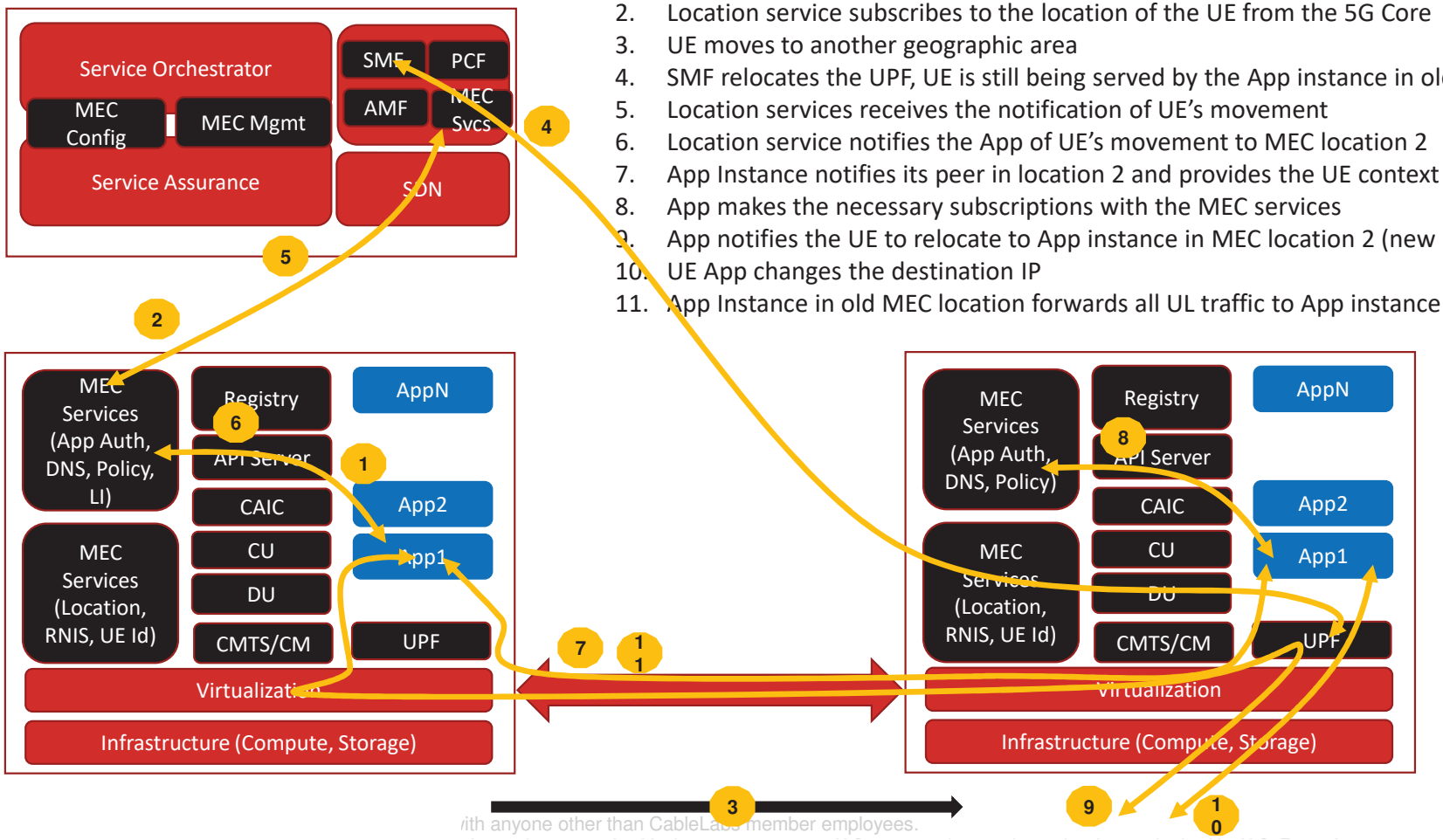
Note: This is an example flow to demonstrate how MEC services get used – the final flow will have to be determined after the detailed design is undertaken

1. Application discovers the services via the registry after presenting the appropriate credentials (similar to NRF)
2. The registry verifies the authentication and authorization via the App Auth service (similar to NRF)
3. The App Auth service retrieves the authorization token from the MEC Mgmt
4. The registry service makes available the IP addresses of the authorized services to the App

Note: the switching/fw parameters allowing interactions between the apps may have configured at the time of the app instantiation or could be set after the query in 3 is successful

Note: This is an example flow to demonstrate how MEC services get u – the final flow will have to be determined after the detailed design is undertaken

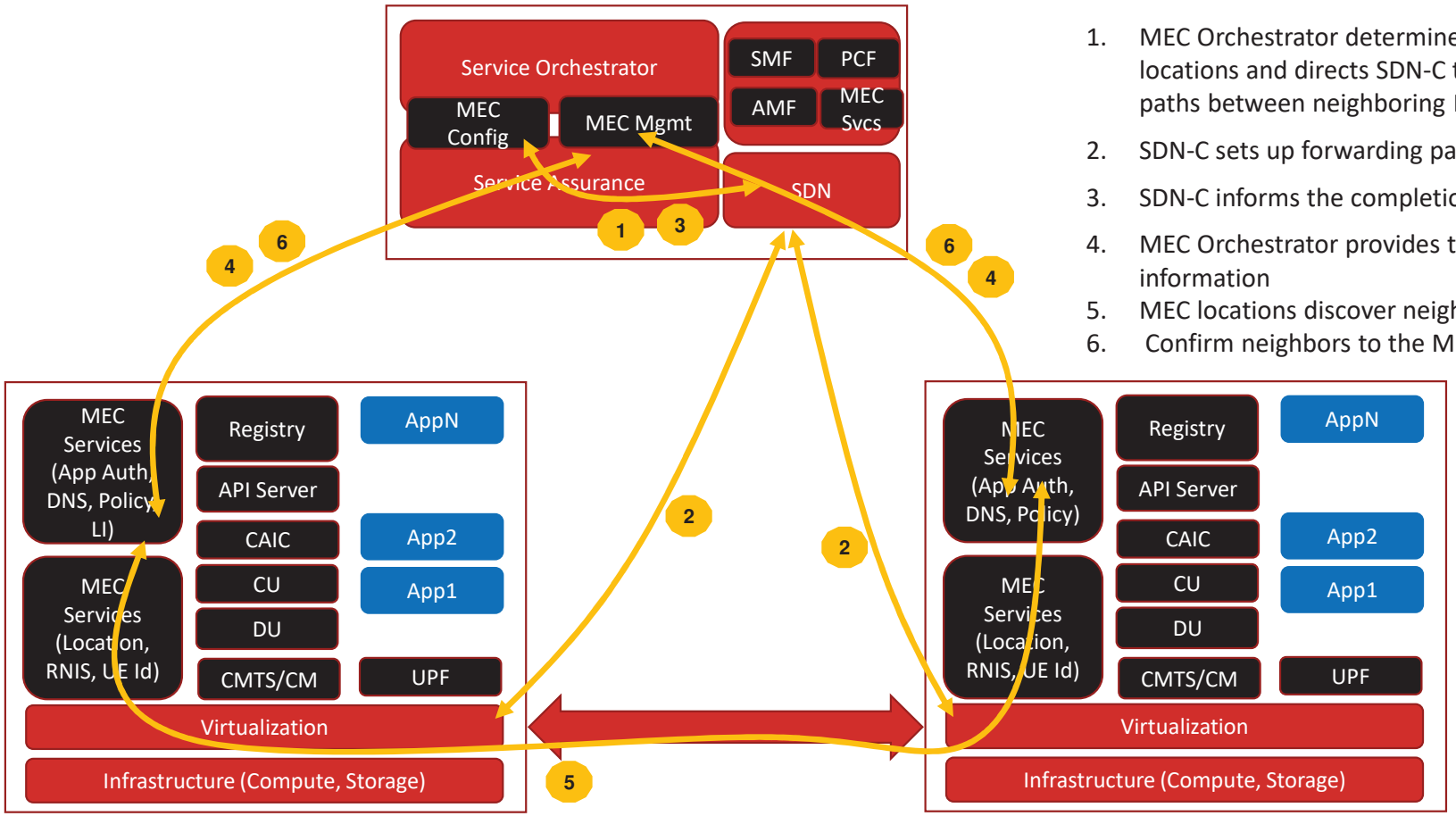
Mobility Across MEC Locations (An example flow diagram)



1. App subscribe to UE mobility
2. Location service subscribes to the location of the UE from the 5G Core
3. UE moves to another geographic area
4. SMF relocates the UPF, UE is still being served by the App instance in old MEC
5. Location services receives the notification of UE's movement
6. Location service notifies the App of UE's movement to MEC location 2
7. App Instance notifies its peer in location 2 and provides the UE context
8. App makes the necessary subscriptions with the MEC services
9. App notifies the UE to relocate to App instance in MEC location 2 (new IP Address)
10. UE App changes the destination IP
11. App Instance in old MEC location forwards all UL traffic to App instance in new MEC location

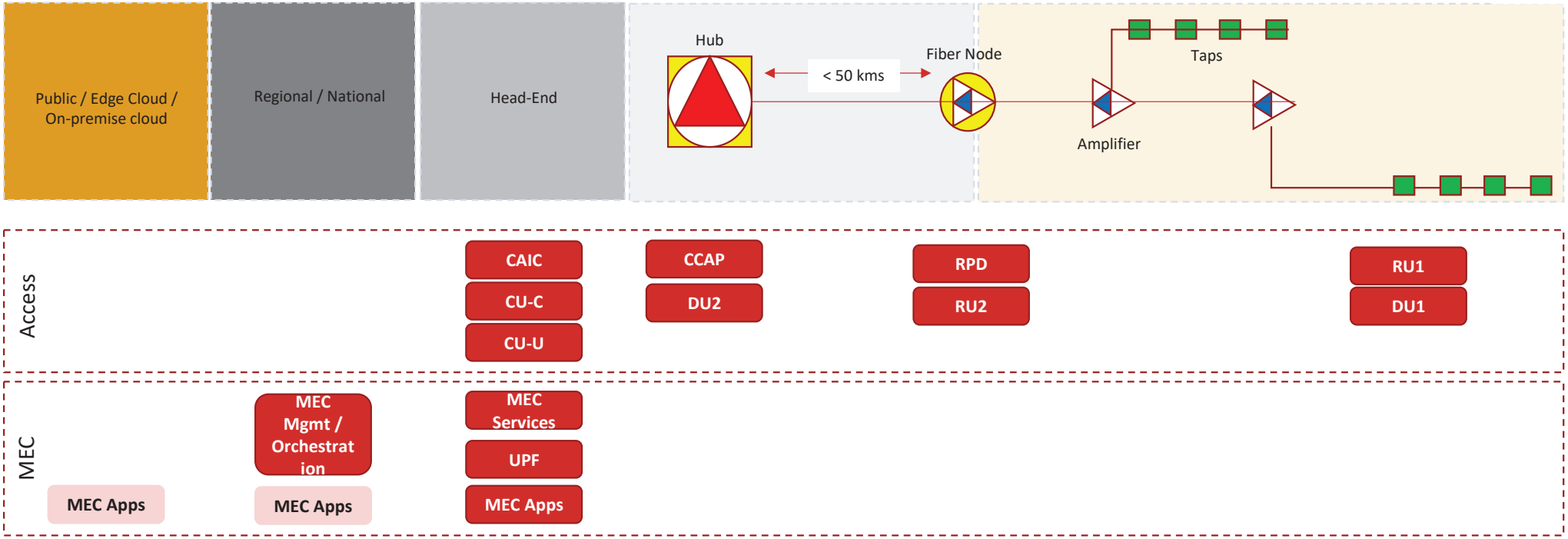
Note: This is an example flow to demonstrate how MEC services get u – the final flow will have to be determined after the detailed design is undertaken

Connectivity Across Neighboring MEC Locations (if required)



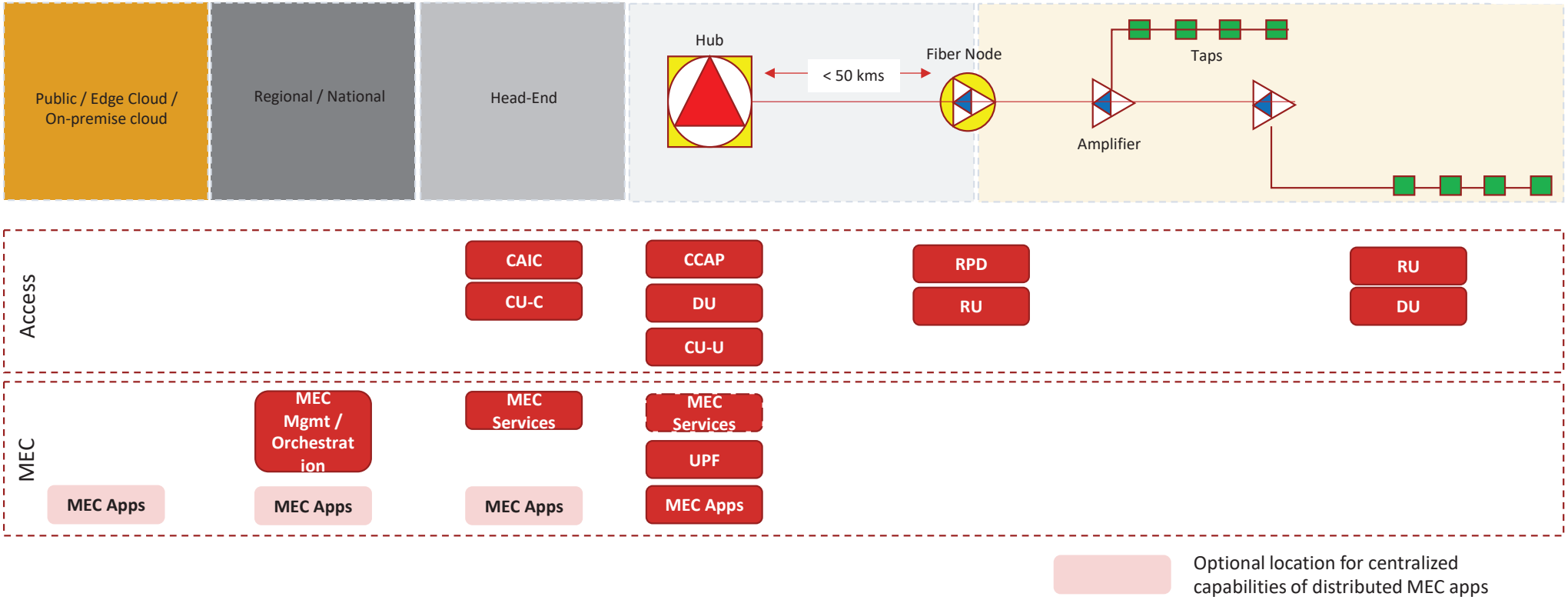
1. MEC Orchestrator determines neighboring MEC locations and directs SDN-C to set up forwarding paths between neighboring MECs
2. SDN-C sets up forwarding paths and policies
3. SDN-C informs the completion of the setup
4. MEC Orchestrator provides the neighbor information
5. MEC locations discover neighbor
6. Confirm neighbors to the MEC Orchestrator

Potential Distribution of MEC Software Workloads in MSO Network



Optional location for centralized capabilities of distributed MEC apps

Potential Distribution of MEC Software Workloads in MSO Network



Whether to deploy MEC services/applications at the head-end or the hub will depend on the latency requirements of the MEC application

Survey of MEC Players

Data Center Players	Virtualization Platform Players	MEC Platform Players	Application Support Players
Hyper-cloud providers (Amazon, Google, Microsoft)	Hyper-clouders (Amazon, Google, Microsoft)	Saguna -- provides MEC for mobile operators that can be deployed inside the access network – loosely based on ETSI's MEC framework	Azion -- products that allow application developers to build scalable and secure server-less applications at the edge
EdgeMicro -- provides edge colocation data centers	Enterprise vendors (VMWare, IBM/Redhat)	Clearblade -- provides software that lets businesses securely run and scale IoT devices in real time	Rigado -- Develops applications for smart, connected environments (buildings)
Vapor IO -- uses colocation facilities to bring cloud-like services at the base of cell site		Edge Intelligence -- provides analytics softwarre that processes data in real-time to give enterprises insights into geographically distributed edge data	Foghorn -- develops edge intelligence software for IIoT
EdgeConneX -- delivers edge infrastructure solutions via purposefully-located data centers			Akamai -- provides cybersecurity-based cloud services that protects all parties in the edge computing infrastructure

https://builtin.com/cloud-computing/mobile-edge-computing-multi-access-edge

Appendix

MEC Use Cases

Source: ETSI GS MEC 002 v2.1.1

Throughput guidance for TCP	N/w perf. & QoE	RNI service provides real-time information on throughput achievable for each device to app; App uses the information to adapt TCP and/or throughput to ensure optimal network performance and/or QoE
Local content caching	N/w perf. & QoE	Based on content request from the area of coverage, the application stores the local content to minimize transport and/or end user delay
Data analytics	3rd party service	Local application extracts meta data from connected devices to be sent to a central app; collected data is stored locally for cross-verification and to run what/if analysis
AR/VR/Cognitive Assistance	Consumer Apps	Temporary applications workload instantiation to assist users in the localized area with relevant AR/VR/cognitive assistance (e.g. shop within a mall, assembly support of furniture/equipment within home, helpbot to assist a traveller, etc.)
Gaming and low latency cloud apps	Consumer Apps	Some of the complex rendering can be offloaded to the network thereby enabling cheaper gaming consoles to be used for single or multiple player games; multi-player games based on localized players
Device location tracking	Operator service	Real-time device tracking and location data can be provided to authenticated and authorized applications to enable personalized configuration (e.g. advertisement push)
Edge Video editing/orchestration	Consumer Apps	Visual content is produced and consumed in localized area (e.g. shot tracker, multiple angle views, etc.)
Mobile backhaul optimization	Operator service	Adapting the backhaul capacity with the RAN capacity - i.e. optimizing/adapting the RAN and transport slicing resource assignment
Direct Interaction with local app	Operator service	Ability for the app on the device to connect and route traffic to the local application instance instead of one located in another location (e.g. another MEC instance or an instance located in the cloud)
Vehicle to Infrastructure	Operator / 3rd party service	After processing the data received from vehicle/pedestrian UEs and roadside sensors, the roadside application residing in MEC can generate warning signals (for all or a group of vehicles/pedestrians or for an individual vehicle/pedestrian)
Location based service	Consumer App / 3rd party service	Real-time device tracking and location data can be provided to authenticated and authorized applications to enable personalized configuration (e.g. advertisement push, information on specific art pieces in museums, etc.)

MEC Use Cases – Contd.

Source: ETSI GS MEC 002 v2.1.1

Bandwidth Alloc.	Operator service	Allows applications to request radio bandwidth over what it is configured for on a dynamic basis
Service Chaining	Operator service	Ability to leverage operator provided, 3rd party services to create a service chain, i.e. steer traffic through multiple applications
Radio Network Information	Operator service	Application can request or be notified of the radio information via an operator service. Application can use the radio information to to determine alternate mechanism (e.g. traffic splitting, activating relay nodes on near by devices and enabling device to device communication to route traffic through a less congested nodes, etc.)
Enterprise communication	Consumer apps	Enterprises can enable use of employee devices to access locally stored applications and data and ensure privacy of its data and communications. This can apply to multi-tenant buildings
Application computation offloading	Consumer apps	Provides local processing and storage for distributed application architecture and minimizing the transport cost
Video analytics	Consumer apps	Provides local processing and storage for processing video feeds and interacting with companion app located in neighboring to MEC locations to locate and track objects; the goal is to minimize backhauling video traffic from multiple video feeds to a centrally located application and introduce latency in tracking of objects that are moving rapidly
Factory Automation	Consumer apps	Provides proximity of the application to the data sources to enable closed loop automation in industrial settings, e.g. control of robot, motion of robots and autonomous mobile equipment, quality assurance of components being assembled, etc.
Lifecycle Mgmt of local applications	Operator service	Provides 3rd party application providers access to their preferred hosting platform at a MEC location and the necessary mechanism for it to discover, select, distribute its application at relevant MEC locations
Inter-operator MEC connectivity	Operator service	Provides application providers for applications instances deployed across different services providers within a geographic area to interact with each other
WTTx	Consumer apps	Provides IPTV providers to route the live TV (broadcast) through wireline from a central location; VOD and channel guide is transmitted from a local storage via either wireline or wireless; this minimizes the amount of the traffic that needs to be transported over the backhaul
In-vehicle MEC	Operator service	Facilitating routing and interfacing between one or more in-vehicle/on-person MEC instances