Background

- Cable technology's evolution
  - from Converged Cable Access Platform (CCAP)
  - to Distributed Access Architecture (DAA)
  - to Flexible MAC Architecture (FMA)

- Why would Cloud be the next?
  - Lower operator's total cost of ownership (TCO)
  - Increase operations efficiency
  - Leverage modern services (e.g., Data Lake, Machine Learning, IoT and predictive maintenance, …)
  - Gain business agility

- Telecom industry has started its journey to Cloud.

Agenda

- Flexible MAC architecture overview

- Approach to FMA cloudification

- Cloud infrastructure and services for FMA cloudification

- Cloud FMA use case exercise

- Conclusions

Flexible MAC architecture overview

Background

- FMA concept began after a number of discussions among technical staff from Cox Communications and the AT&T Foundry.

- FMA was designed with the idea of all components being able to work in a physical and virtual environment through standardized interfaces.

- Objective: allow for the decomposition of functions and their strategic placement in the operator network or public cloud.

- FMA working group developed and published the first FMA System Specification in 2020.

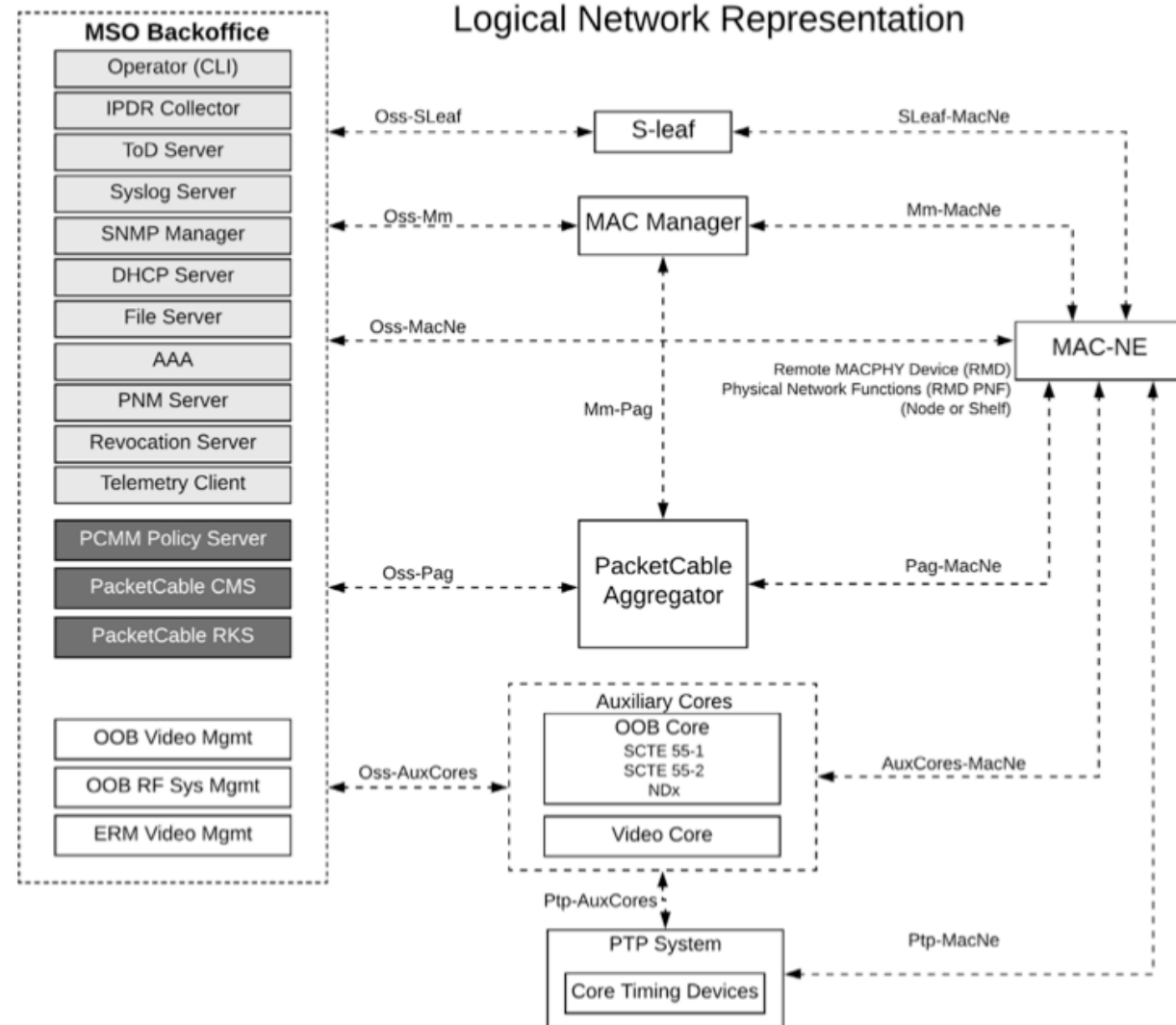# Flexible MAC architecture overview (cont.)

FMA evolution in three phases

Phase 1 – Support key components necessary to bring RMDs into existing operator networks without causing disruption to legacy EMS and NMS platforms

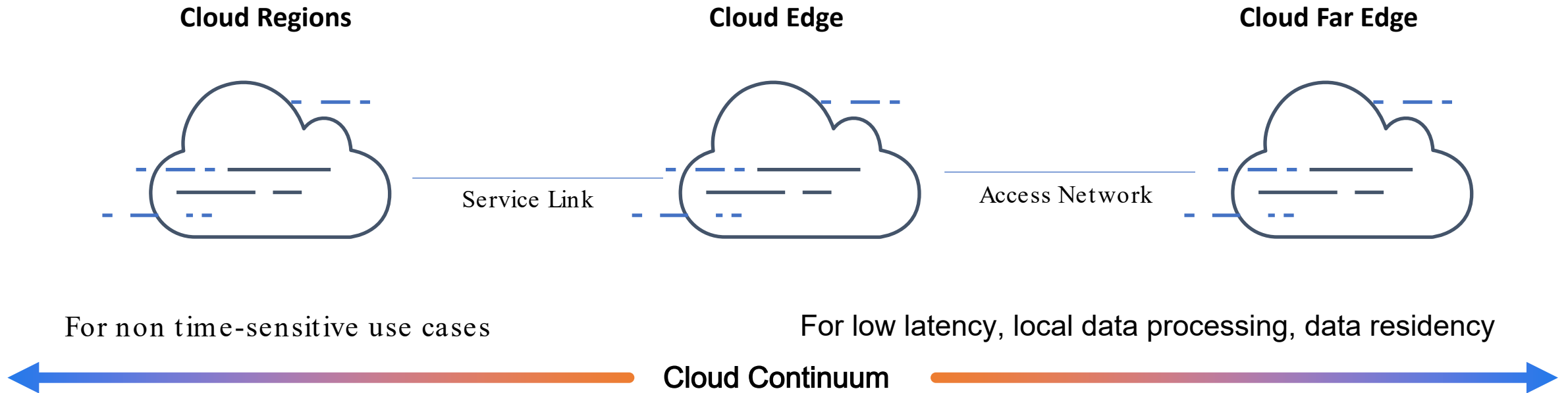Phase 2 – Allow for continued use of Remote PHY devices in the FMA network management paradigm

Phase 3 – Add support for the Remote MAC Core concept with physical and virtual MAC support

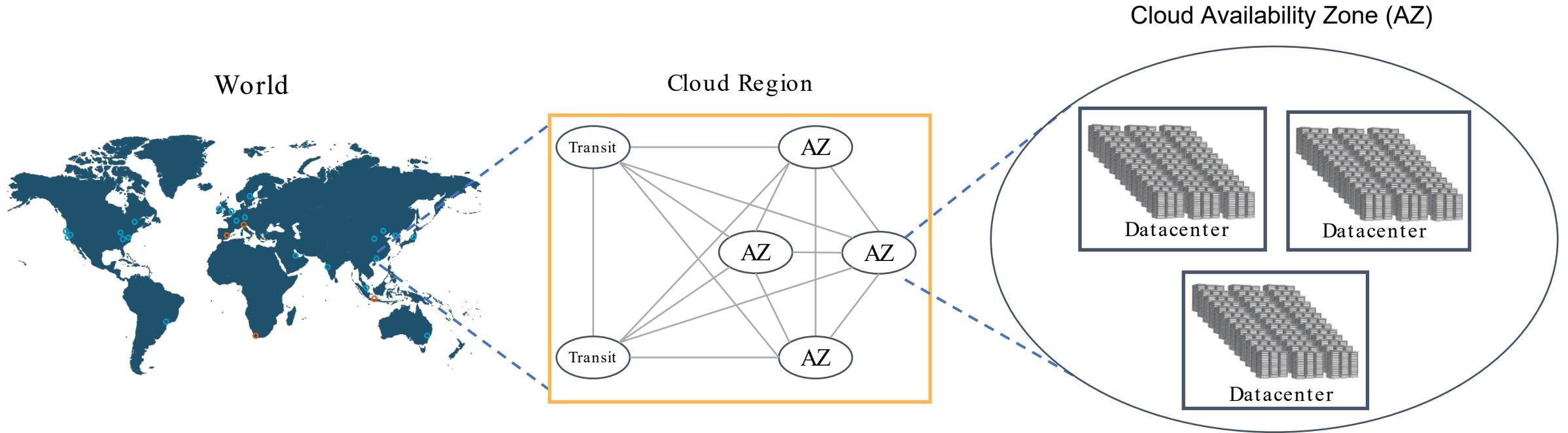# FMA Phase 1
reference architecture

Approach to FMA cloudification

- Cloud continuum

Cloud Regions   **Cloud Edge**   **Cloud Far Edge**

Service Link   Access Network

For non time-sensitive use cases   For low latency, local data processing, data residency

Cloud Continuum

Introduction to cloud infrastructure*: Region

Cloud Availability Zone (AZ)

World

Cloud Region

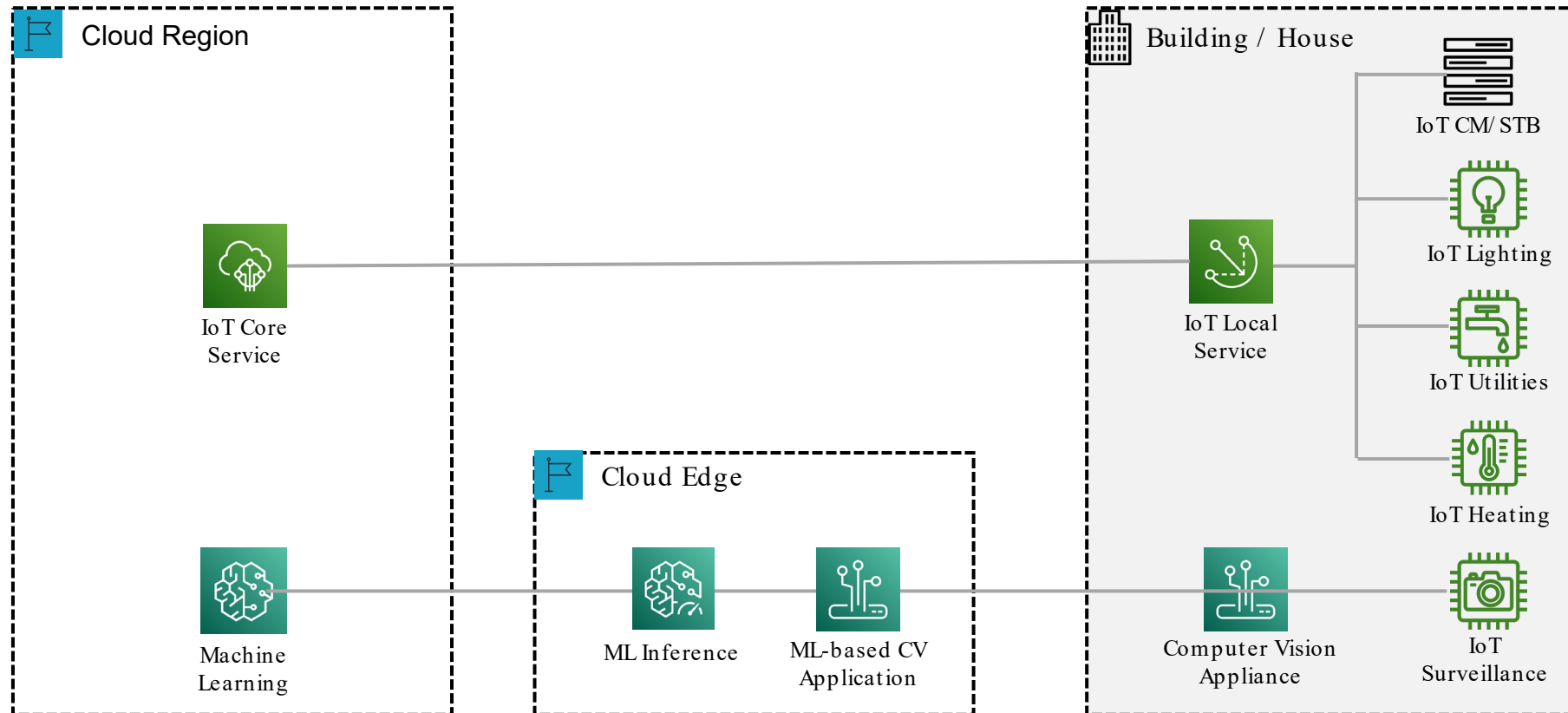Transit — AZ — AZ — AZ — Transit — AZ

Datacenter   Datacenter   Datacenter

* This presentation uses Amazon Web Services (AWS) as an example of a cloud infrastructure. Please note that similar architectures can be built with other cloud providers.

Introduction to cloud infrastructure: Edge
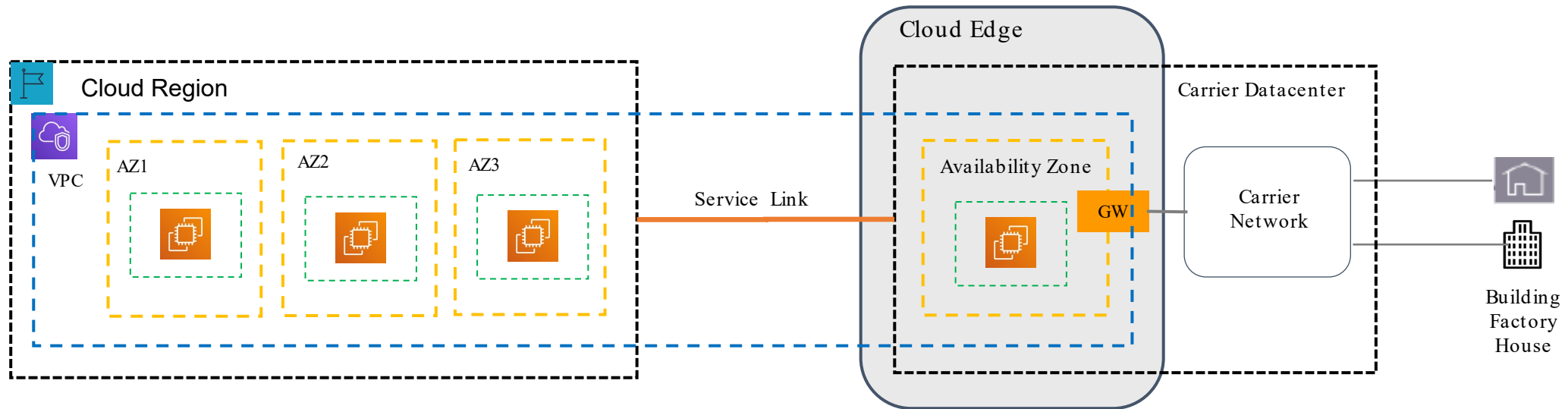
Introduction to cloud infrastructure: Far Edge

What determine allocation of FMA functions in cloud

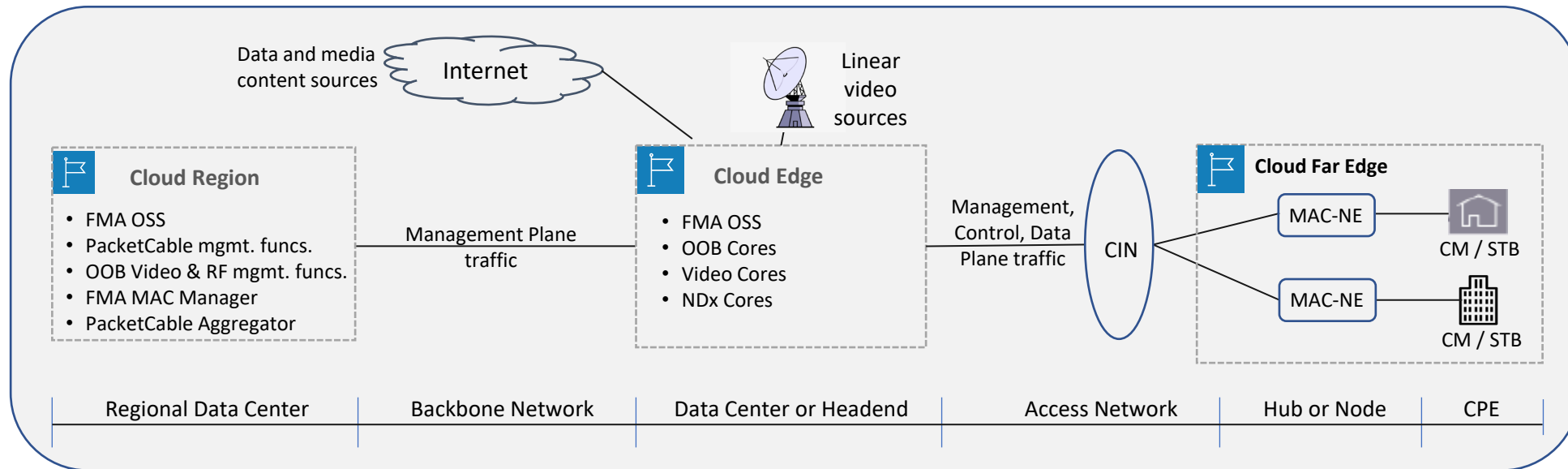| FMA System	FMA Functionality	Plane	Latency Tolerance*	Operation Locality
MSO Backoffice	OSS - IPDR Collector, Syslog Server, SNMP Manager, DHCP Server, File Server, AAA, PNM Server, Telemetry	Management	Medium - High	Backoffice
	PacketCable management - PCMM Policy Server, PacketCable CMS, PacketCable PKS	Management	High	Backoffice
	Auxiliary Core Management - OOB Video Mgmt, OOB RF Sys Mgmt, ERM Video Mgmt	Management	High	Backoffice
MAC Manager	Manage MAC-NE through FMA protocols	Management	High	Backoffice or Headend
PacketCable Aggregator	Scale PacketCable Multimedia Backoffice element to RMDs	Management	High	Backoffice or Headend
OOB Core	Manage and control legacy set-top boxes (STBs) as RMDs in substitution of SCTE 55-1 and SCTE 55-2 OOB Cores	Management Control	Medium Low	Headend or Hub
NDx Core	Support Narrowband Digital Forward (NDF) and Narrowband Digital Return (NDR) capabilities	Control Data	Low Low	Headend or Hub
Video Core	Provide video EQAM processing functions, except video PHY and QAM-related processing in RMD	Control Data	Low Low	Headend
PTP System	Clock synchronization across RMDs	Control	Low	Headend
MAC-NE (RMD)	DOCSIS MAC and the upper layer protocols, QAM, digital to/from analog conversion for RF/Ethernet or PON transmission	Management Control Data	High Low Ultra low	Hub or Node

- Timing characteristics
- Operation locality

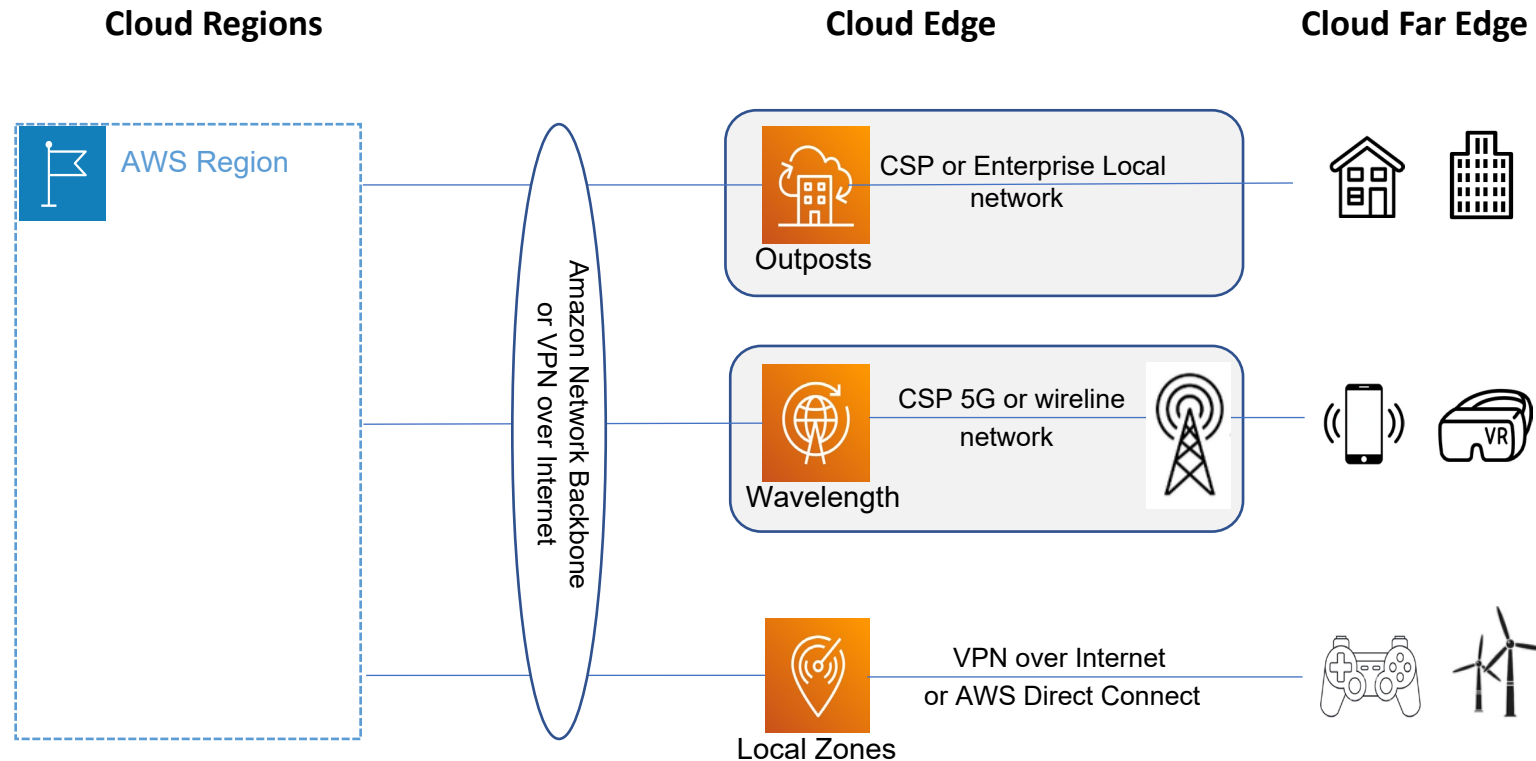# Approach to FMA cloudification (cont.)

- FMA System Architecture
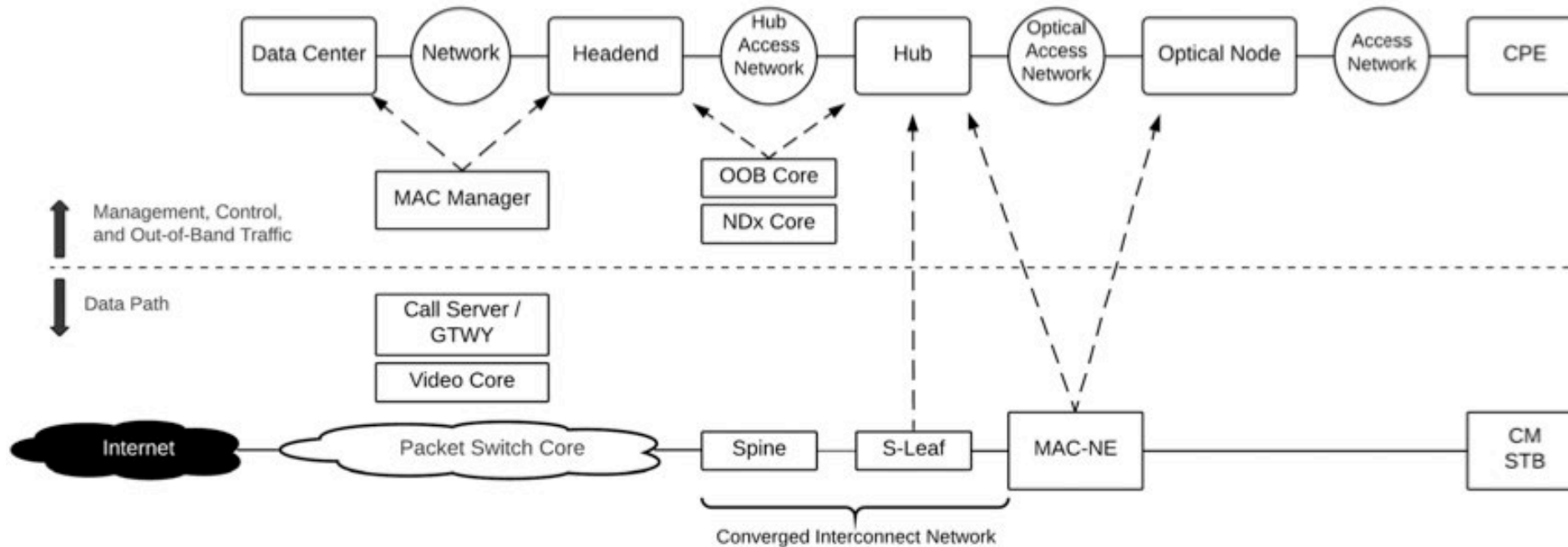
Approach to FMA cloudification (cont.)

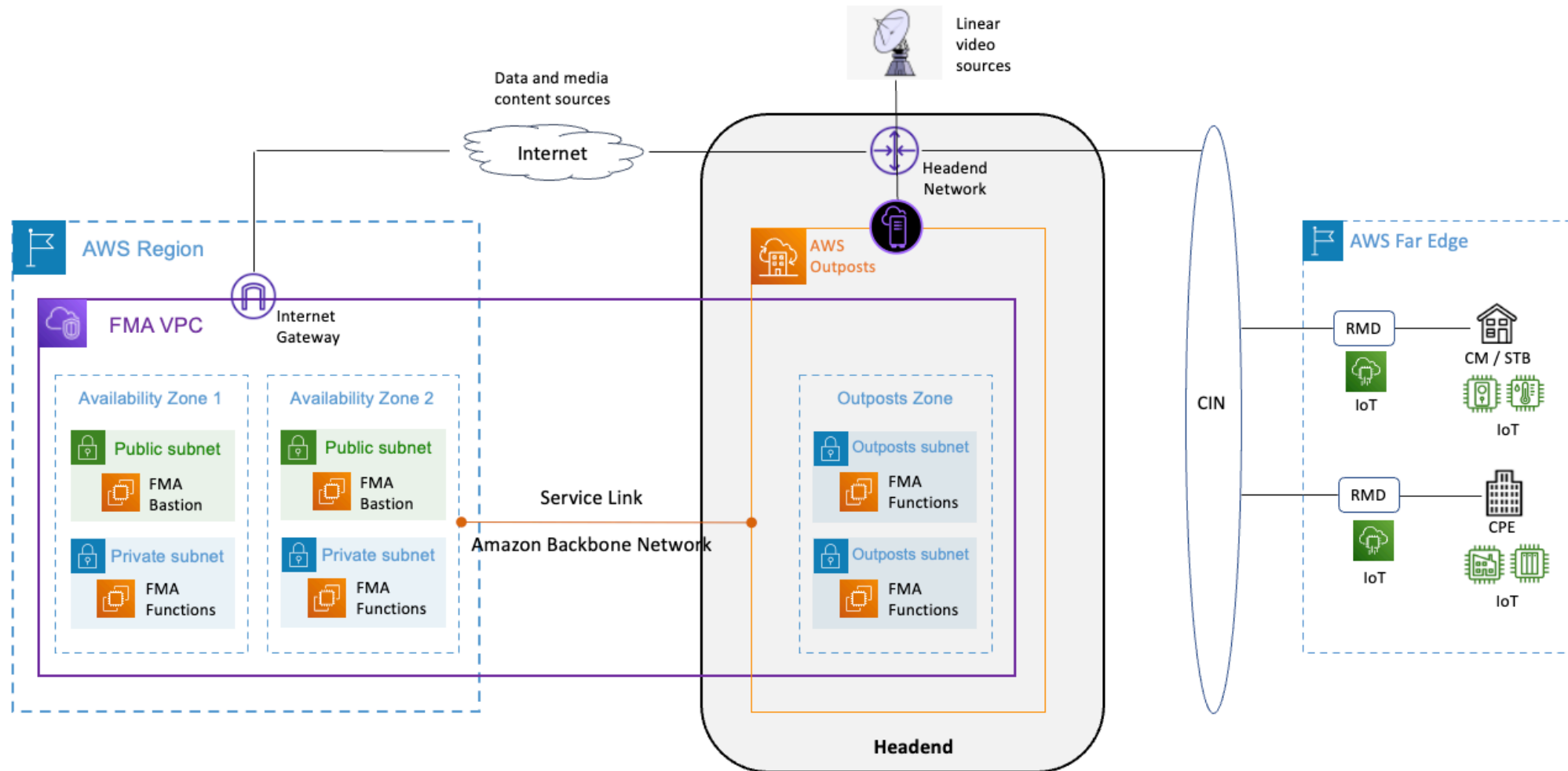- FMA cloudification architecture pattern

Cloud edge services

- Different types of cloud edge technology

Cloud Regions **Cloud Edge** **Cloud Far Edge**
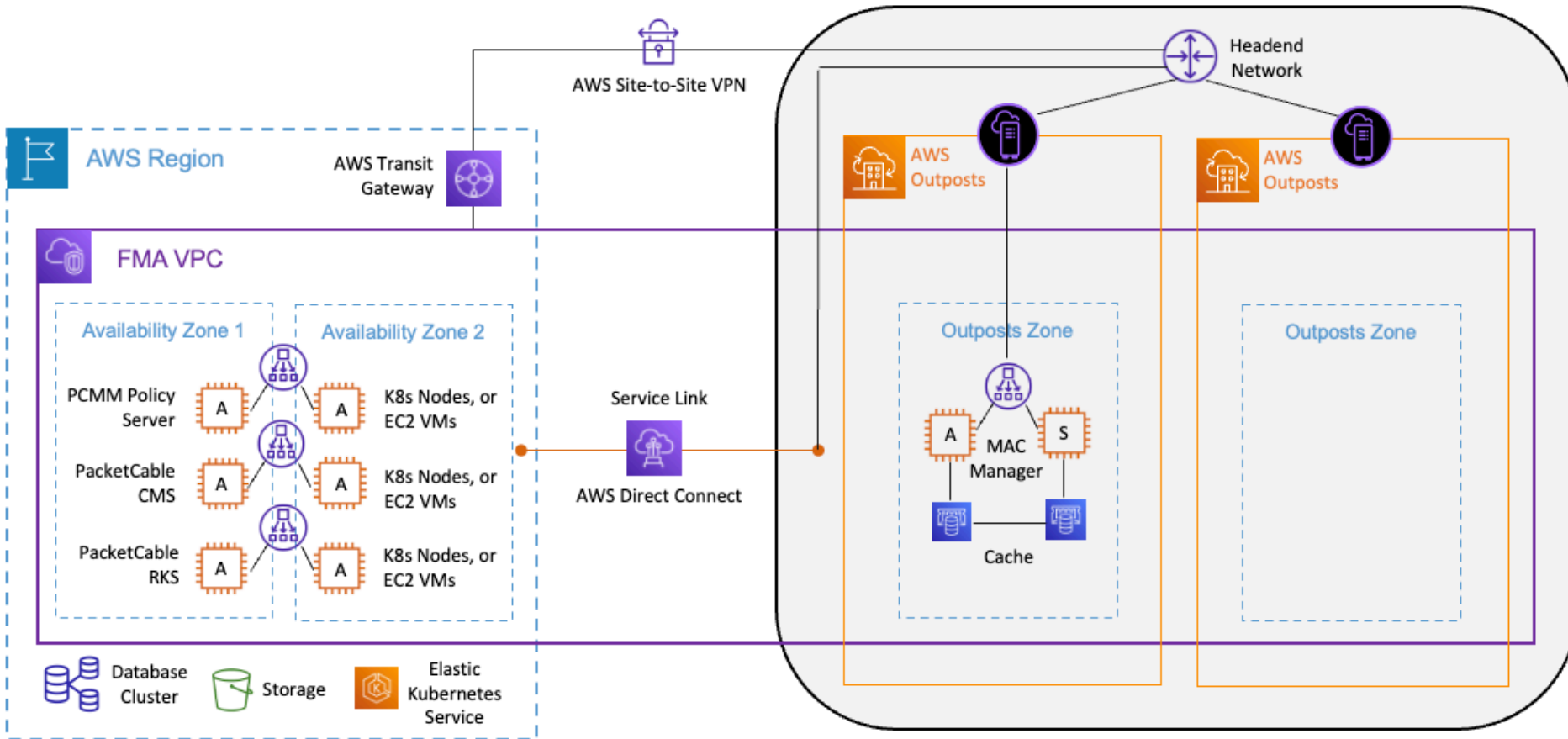
AWS Region

Amazon Network Backbone or VPN over Internet

Outposts — CSP or Enterprise Local network

Wavelength — CSP 5G or wireline network

Local Zones — VPN over Internet or AWS Direct Connect

Cloud edge: service selection for FMA

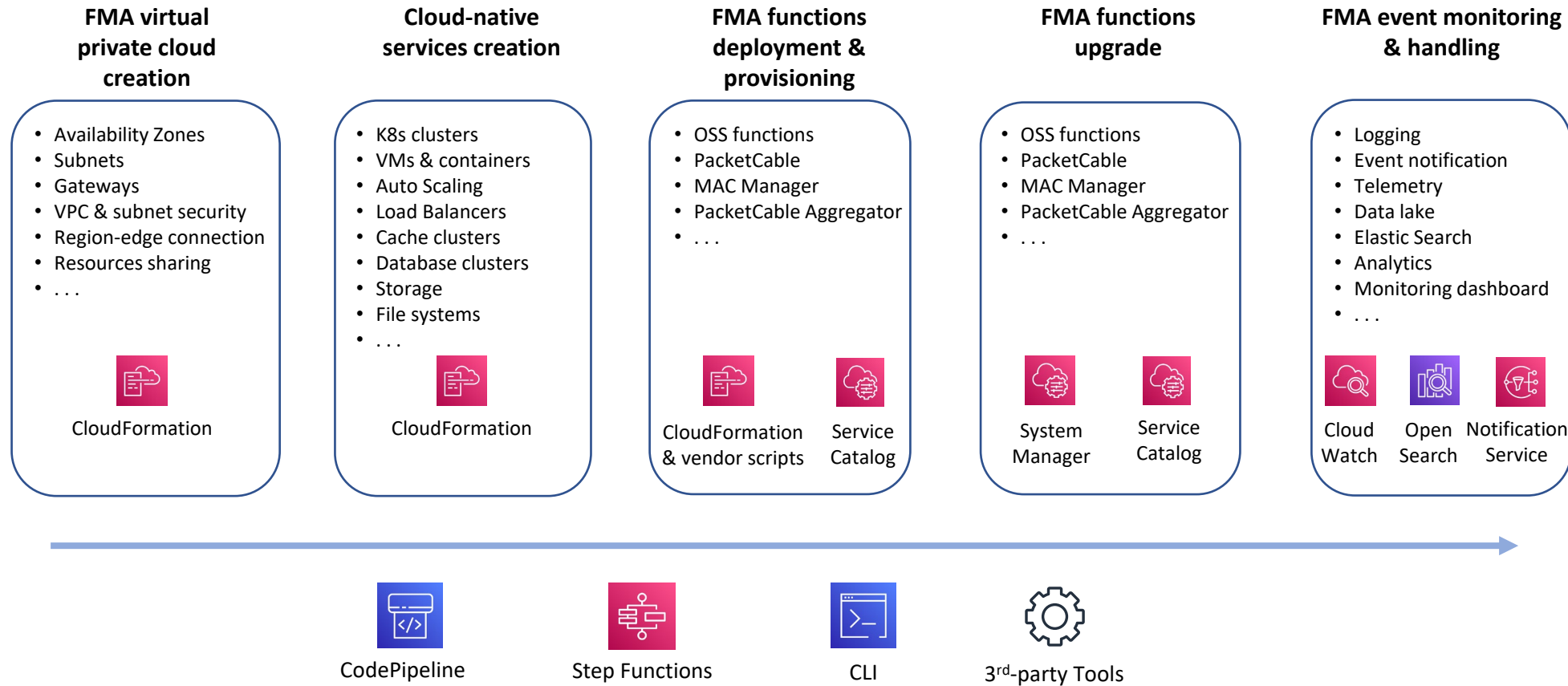| Type of Cloud Edge Service	Cloud Edge Architecture & Deployment location	Use Case	Type of CSP	Management Responsibility
Outposts	On-premises networks or in CSP networks	• Private Multi-Access Computing (e.g., smart factory, healthcare operations, real-time ML and analytics) • Private Mobile Network • MSO network	• Telecom operators • MSOs	• Cloud infra. & cloud services: AWS • Local network: CSP or on-premises operator
Wavelength	In CSP networks, especially 5G mobile networks	• Public Multi-Access Computing (e.g., intelligent vehicles, real-time retails)	• Mobile network operators	• Cloud infra. & cloud services: AWS • Local network: CSP
Local Zones	In AWS infrastructure	Public Multi-Access Computing (e.g., real-time gaming, interactive live video streams)	N/A	• Cloud infra. & cloud services: AWS • Local Zones connectivity: CSP or enterprise

FMA cloud architecture
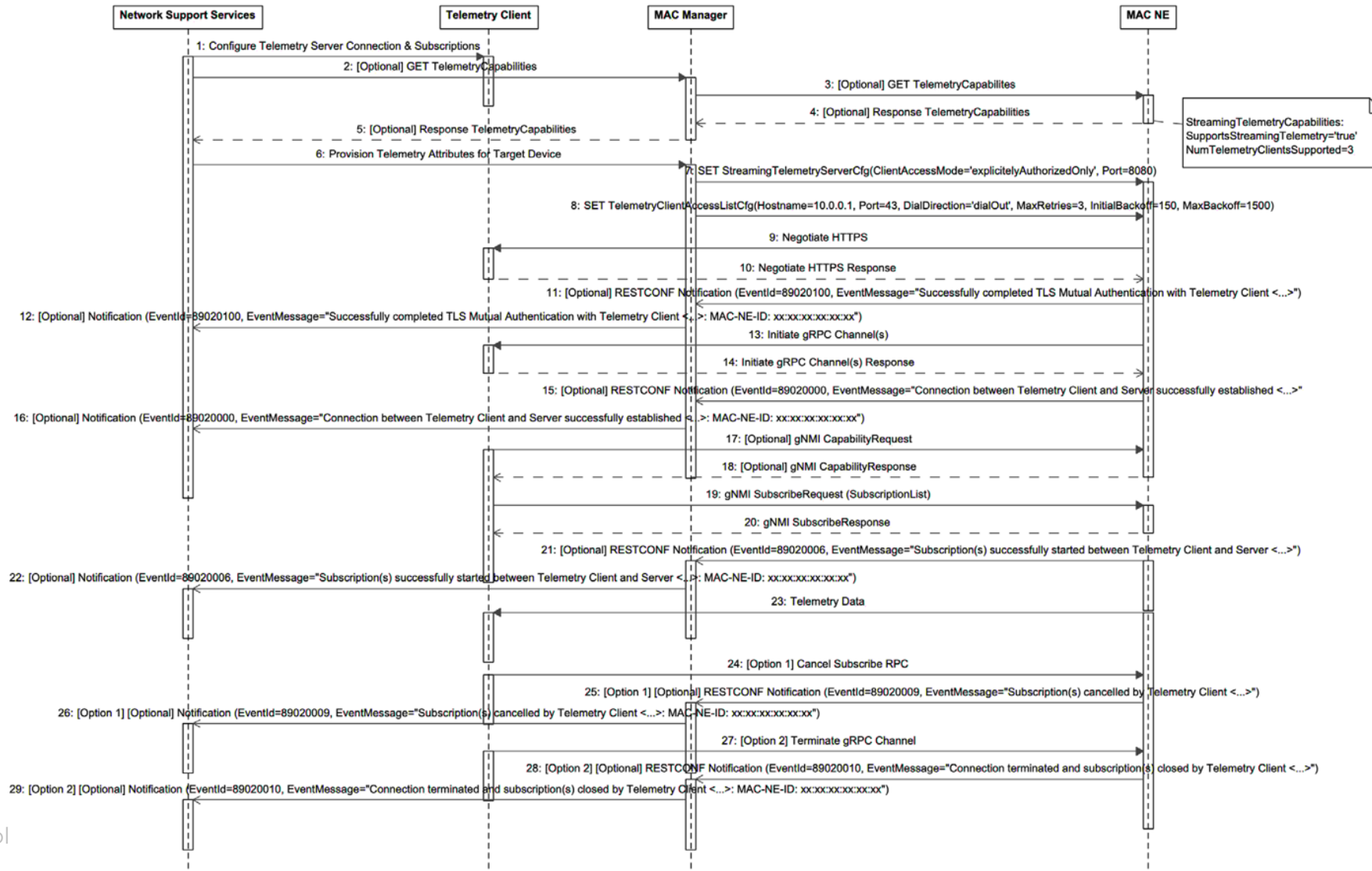
FMA cloud solution patterns

FMA cloud operation automation

FMA virtual private cloud creation

- Availability Zones
- Subnets
- Gateways
- VPC & subnet security
- Region-edge connection
- Resources sharing
- . . .

CloudFormation

Cloud-native services creation

- K8s clusters
- VMs & containers
- Auto Scaling
- Load Balancers
- Cache clusters
- Database clusters
- Storage
- File systems
- . . .

CloudFormation

FMA functions deployment & provisioning

- OSS functions
- PacketCable
- MAC Manager
- PacketCable Aggregator
- . . .

CloudFormation & vendor scripts

Service Catalog

FMA functions upgrade

- OSS functions
- PacketCable
- MAC Manager
- PacketCable Aggregator
- . . .

System Manager

Service Catalog

FMA event monitoring & handling

- Logging
- Event notification
- Telemetry
- Data lake
- Elastic Search
- Analytics
- Monitoring dashboard
- . . .

Cloud Watch

Open Search

Notification Service
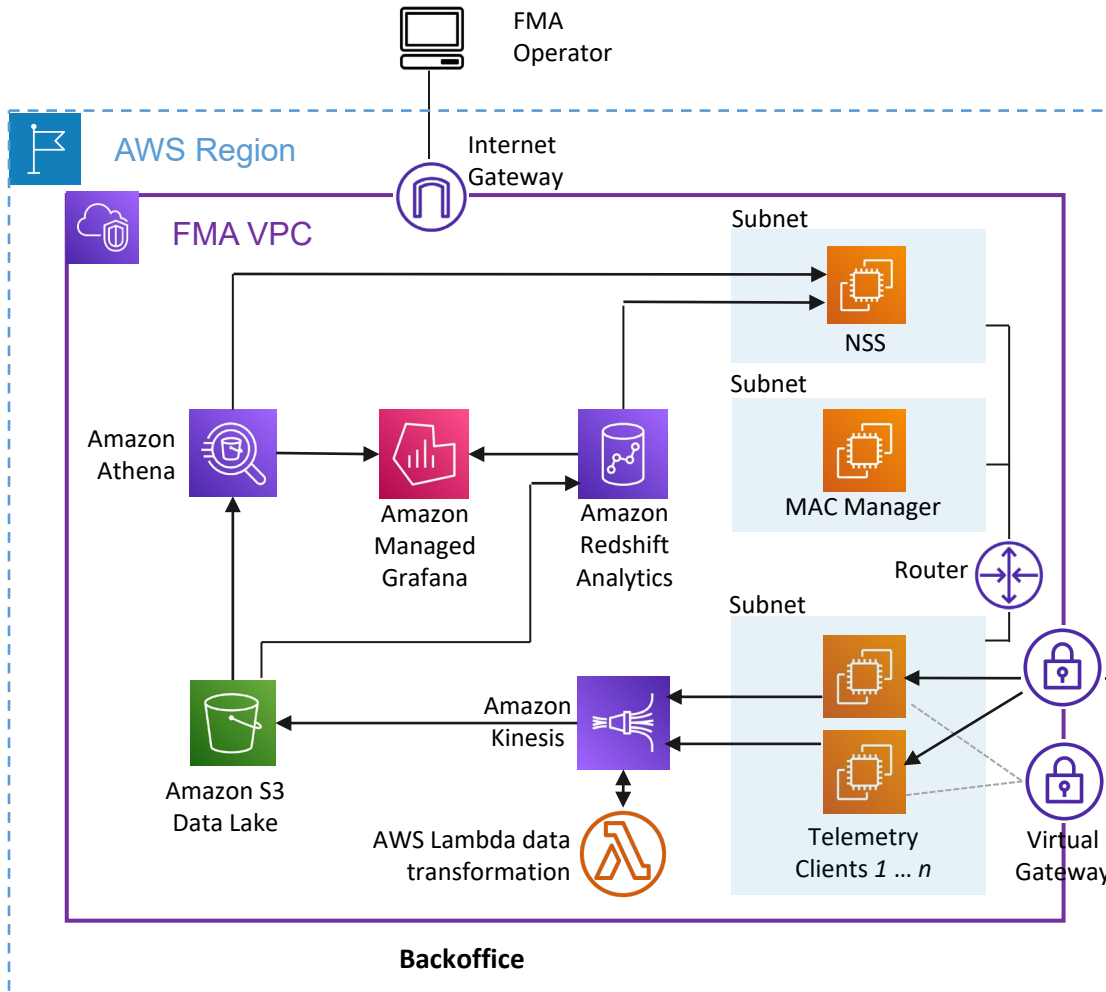
CodePipeline

Step Functions

CLI

3rd-party Tools

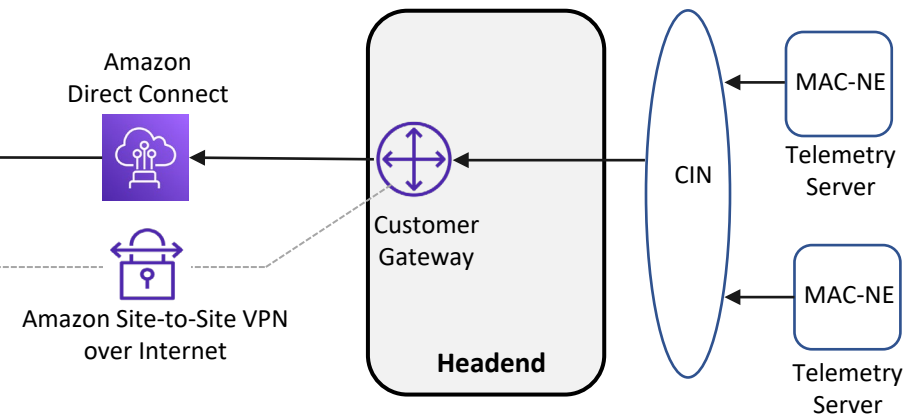# Cloud FMA Use Case Exercise: Streaming Telemetry

CM-SP-FMA-OSSI-I02-220602

Streaming Telemetry: Functional Work Flows
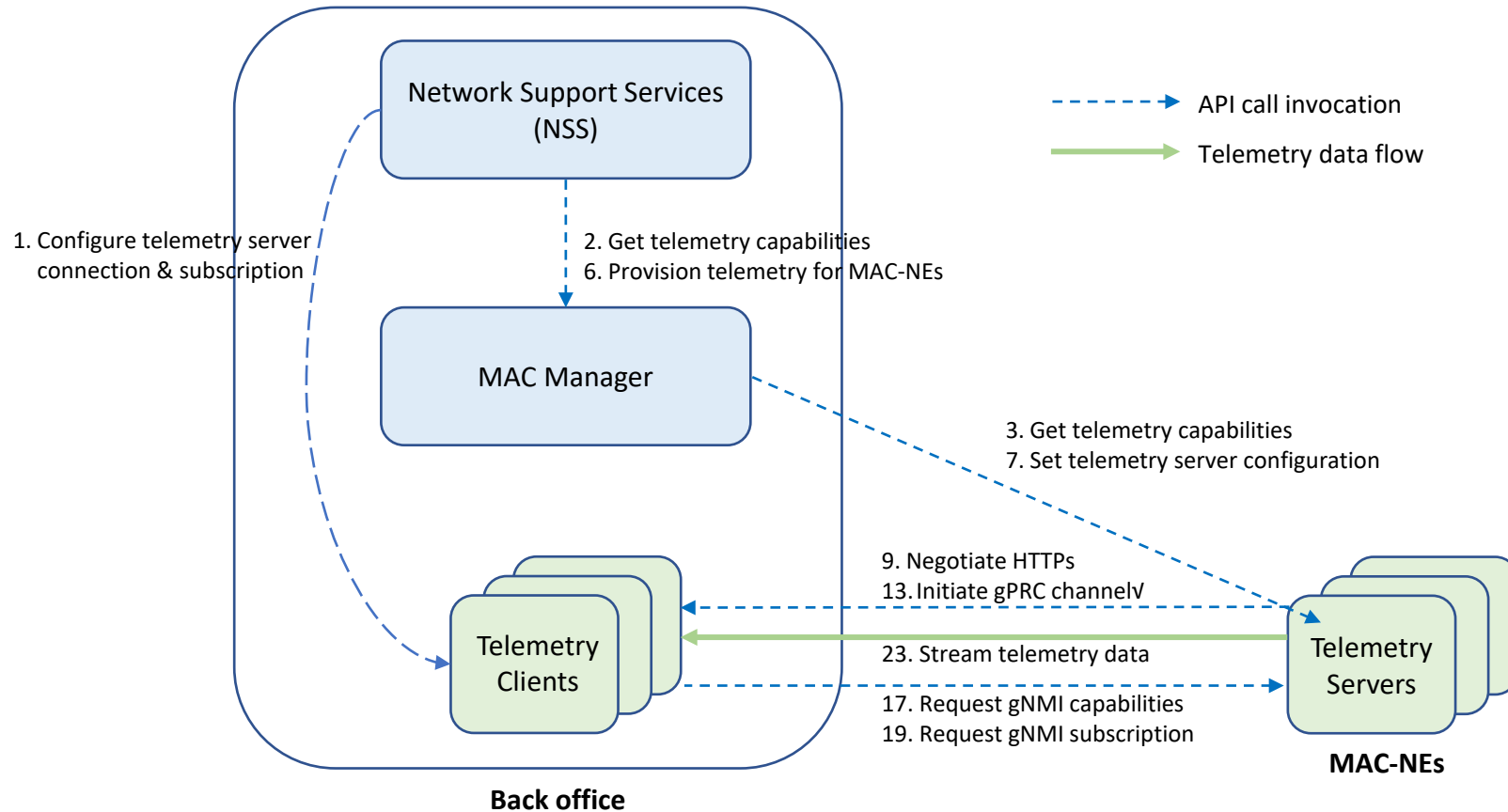
Streaming Telemetry: cloudification exercise

Conclusions

- FMA cloudification is the next undertaking by CSPs and MSOs to further modernize the Distributed Access Architecture.

- FMA can be cloudified along the cloud continuum across the cloud region, edge, and far edge with FMA systems and functions allocated based on their timing characteristics and operation locality.

- The private edge cloud is more suitable for cable operator's latency-sensitive FMA functions.

- Cloud supports HA and OSS with various cloud-native services.

- It is time to implement FMA in the cloud by applying the FMA cloudification approach and leveraging the cloud infrastructure and services.

Creating Infinite Possibilities.

Thank You!

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