Agenda

- Virtualized CMTS Overview

- CMTS Cloudification Objectives and Options

- Cloud Service Platform Characteristics

- CMTS workload placement

- CMTS-as-a-Service

- Conclusions

Acknowledgment: John Chapman, CTO Broadband Technologies Cisco Fellow

Cisco Systems Inc

Virtualized CMTS (vCMTS) Overview

Internet

Core Network

CCAP Core

CIN

RPD

CM CM CM

On-Prem vCMTS

Management Plane (MP)

CCAP Manager	RPD Manager	Subscriber Manager	CICD
Configurator	Telemetry Collector	System Optimization	Deployer

Non-Real Time (NRTC)

Profile Management	Load Balancing	Packet Cable / PCMM	PNM
MAC Domain	CM Registration	RPHY GCP	DTP

Near-Real Time Control (nRTC)

CM Ranging	DSX	DCC	DBC	OPT	OUDP

Real Time Control (RTC) | **User Plane Function (UPF)**

US Scheduler	UCD	DOCSIS MAC	Routing/ Forwarding	DHCP Relay Agent

Server Platform

Cloud Native Infra: K8s, Docker, etc

Host OS

Server HW / FW (Bare metal or VM)

vCMTS Architecture Today

- On-premises, dedicated physical servers

- Cloud-native software platform

- Multiple service domains w/ distinctive timing requirements

MP = Management Plane (> 1 sec)

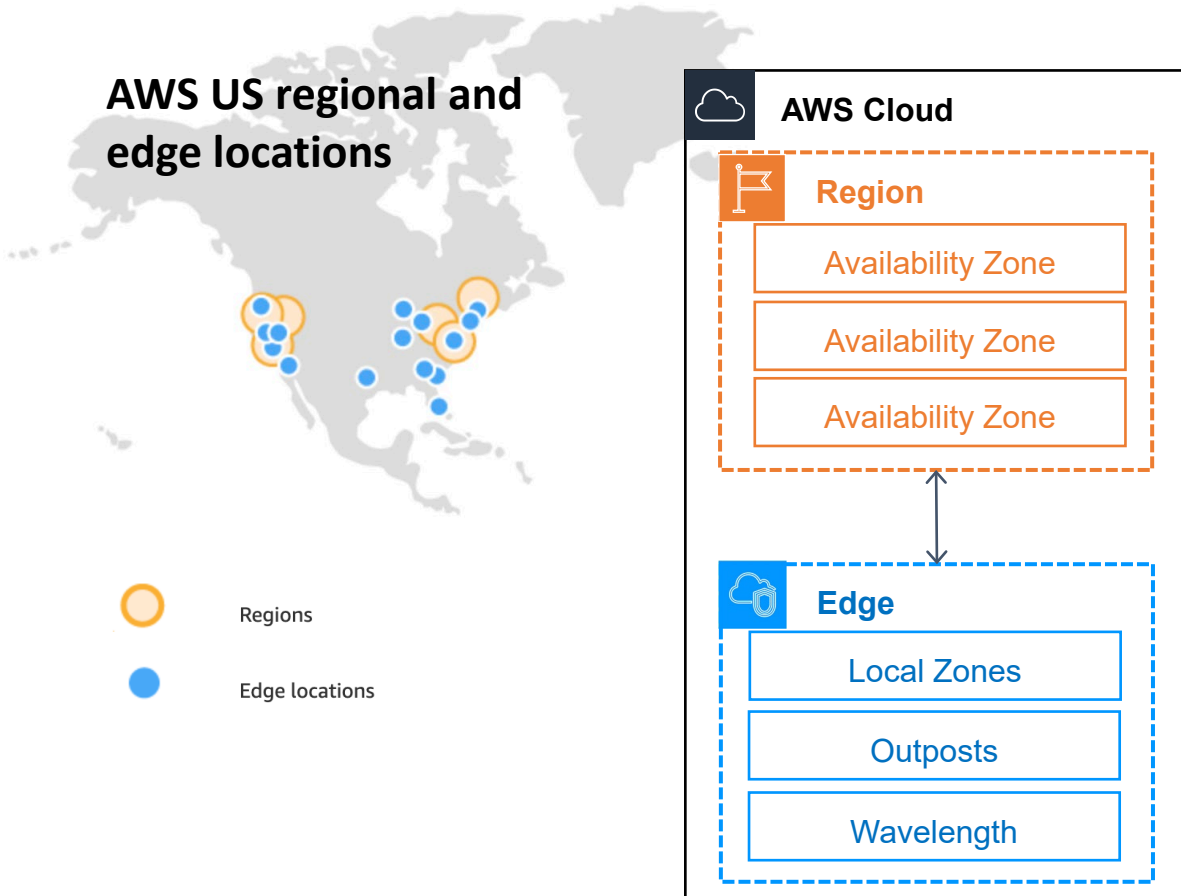NRTC = Non-Real Time (>1 sec) controller & applications

nRTC = Near-Real Time (10msec –1 sec) controller & applications

RTC = Real time (< 10ms) control services

UPF = User plane function (<10ms), also known as the data plane (name comes from mobile)

Public Cloud Infrastructure

Example – AWS Global Infrastructure

AWS US regional and edge locations

Regions

Edge locations

AWS Cloud

Region

Availability Zone

Availability Zone

Availability Zone

Edge
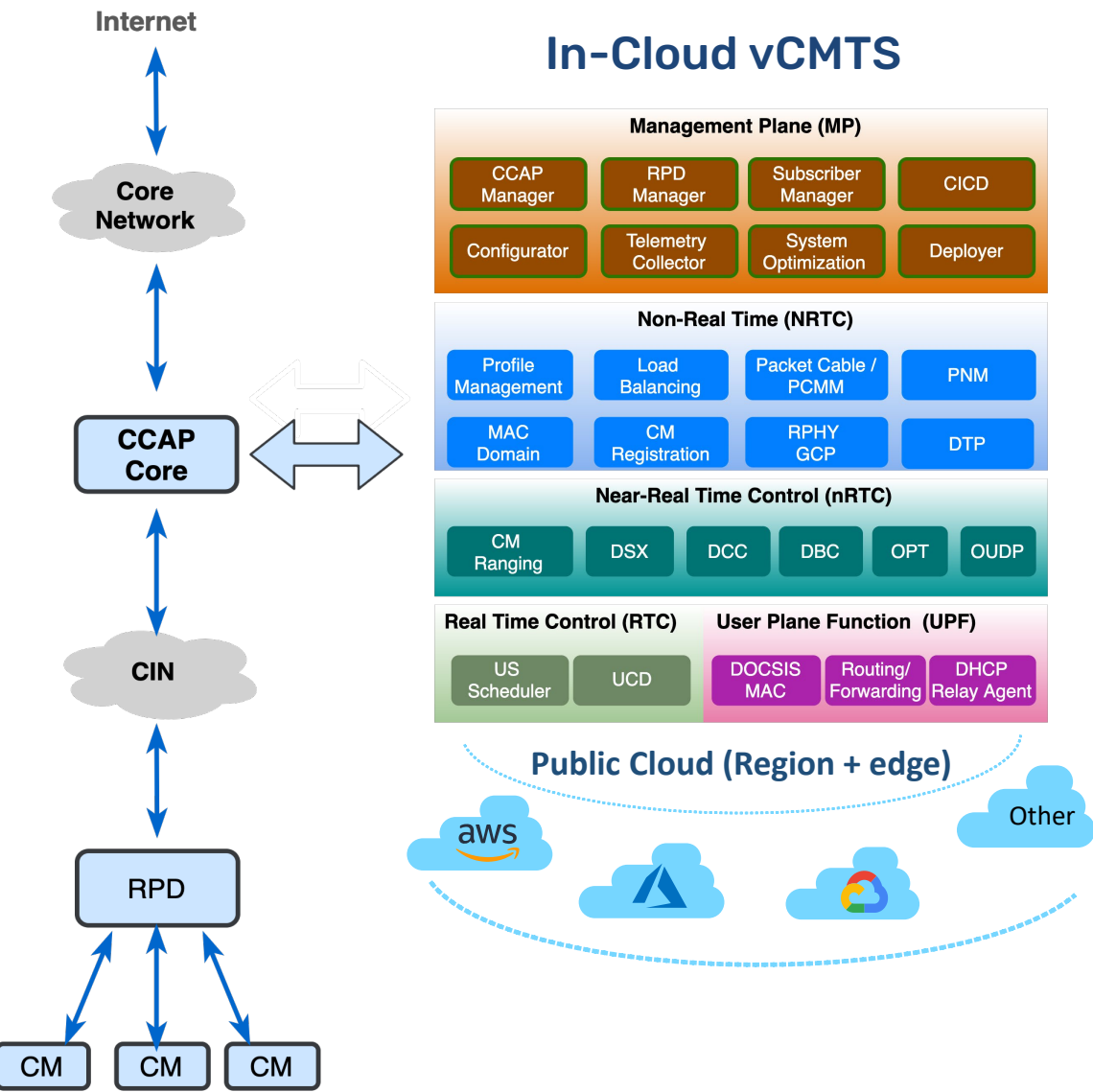
Local Zones

Outposts

Wavelength

Global coverage with easy access options

AWS Global Infrastructure

- 25 geographic Regions

- 81 Availability Zones

Multiple Edge Infrastructure Solutions

- On-premises solution (AWS Outposts)

- Metro area solution (AWS Local Zones)

- 5G Edge solution (AWS Wavelength)

Moving vCMTS to Cloud

Internet

Core Network

CCAP Core

CIN

RPD

CM **CM** **CM**

In-Cloud vCMTS

Management Plane (MP)
| CCAP Manager | RPD Manager | Subscriber Manager | CICD |
| Configurator | Telemetry Collector | System Optimization | Deployer |

Non-Real Time (NRTC)
| Profile Management | Load Balancing | Packet Cable / PCMM | PNM |
| MAC Domain | CM Registration | RPHY GCP | DTP |

Near-Real Time Control (nRTC)
| CM Ranging | DSX | DCC | DBC | OPT | OUDP |

Real Time Control (RTC)
| US Scheduler | UCD |

User Plane Function (UPF)
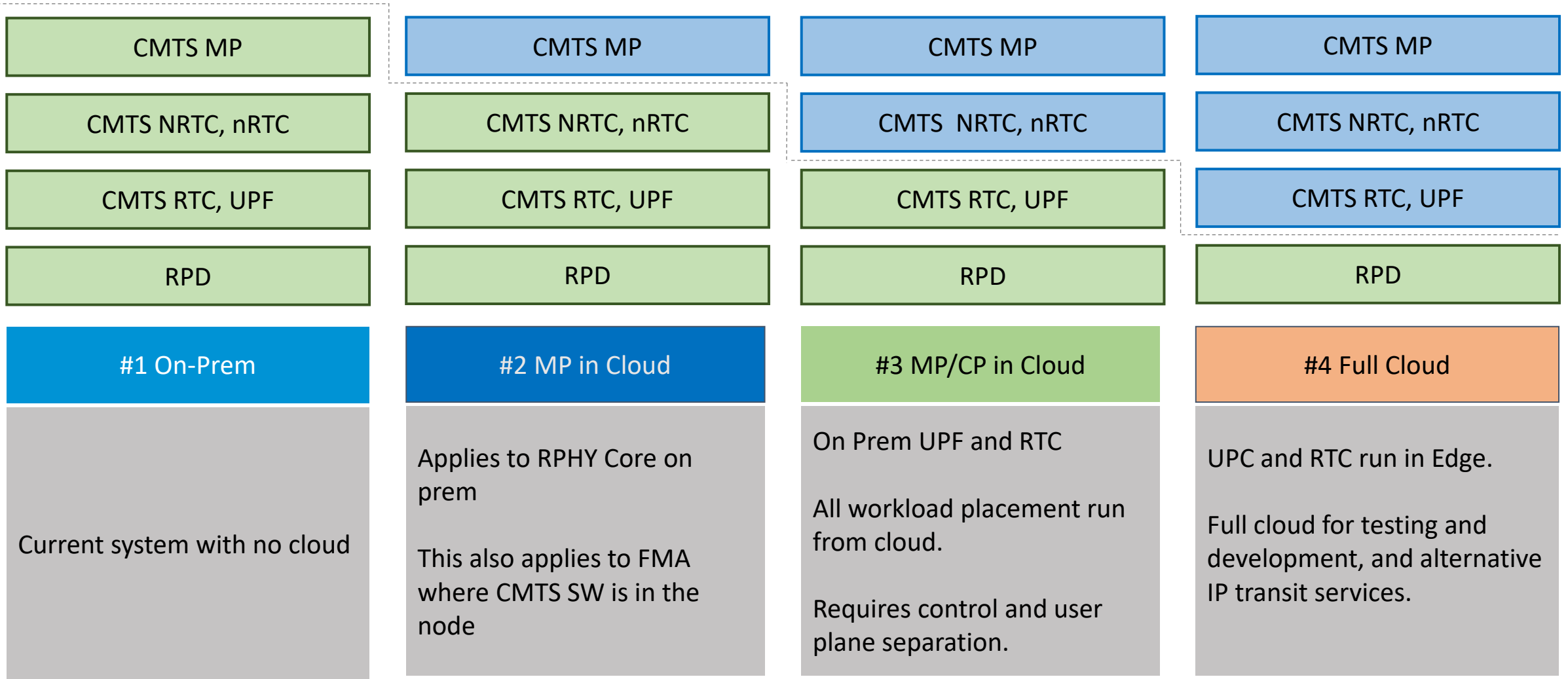| DOCSIS MAC | Routing/ Forwarding | DHCP Relay Agent |

Public Cloud (Region + edge)
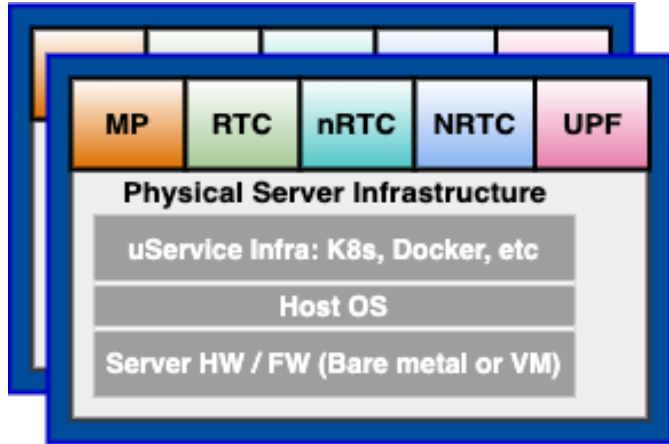
aws   Other

Drivers for hosting vCMTS in cloud

- Unlimited capacity w/o upfront capex
- Consumption based cost model
- Flexibility and agility
- Built-in resiliency and security
- Managed infrastructure/platform
- Global coverage

Select the cloud platforms to best suite the business needs

- Region proximity, edge availability
- Reliability and performance
- Tooling compatibilities
- Cost

vCMTS Cloudification Architecture Choices

CMTS MP	CMTS MP	CMTS MP	CMTS MP
CMTS NRTC, nRTC	CMTS NRTC, nRTC	CMTS NRTC, nRTC	CMTS NRTC, nRTC
CMTS RTC, UPF	CMTS RTC, UPF	CMTS RTC, UPF	CMTS RTC, UPF
RPD	RPD	RPD	RPD
#1 On-Prem	**#2 MP in Cloud**	**#3 MP/CP in Cloud**	**#4 Full Cloud**
Current system with no cloud	Applies to RPHY Core on prem This also applies to FMA where CMTS SW is in the node	On Prem UPF and RTC All workload placement run from cloud. Requires control and user plane separation.	UPC and RTC run in Edge. Full cloud for testing and development, and alternative IP transit services.

vCMTS Host Platform Comparison

Dedicated Physical Servers

User managed servers

Servers are owned by users

Fixed capacity once installed

Over or under provision risk
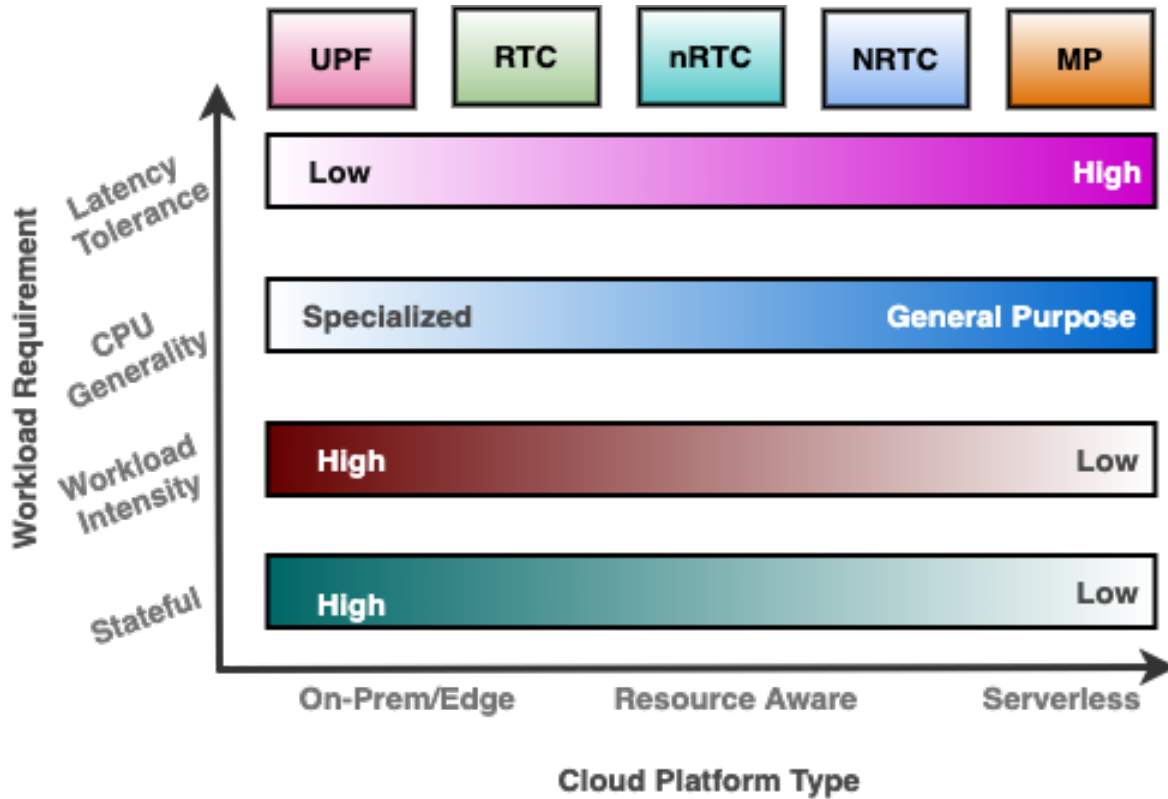
On-site redundancy for HA

Resource Aware
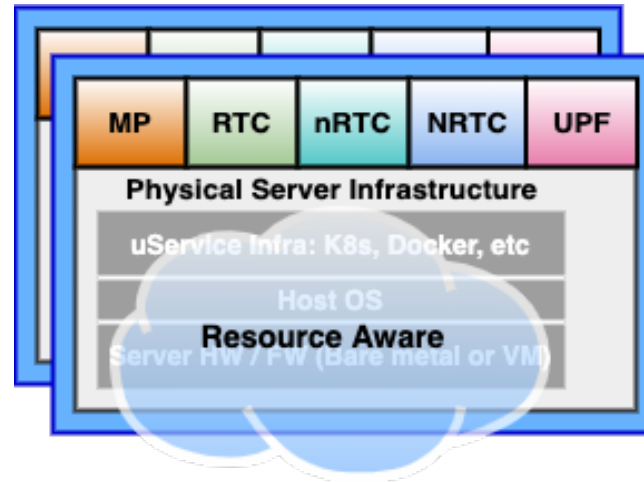
User configured CPU, memory and storage

Pay by instances

Provisioned scaling, coarse-grained

Support geo-redundancy

Serverless
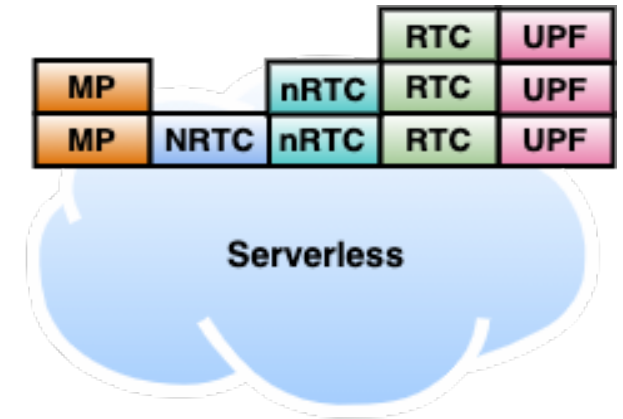
Cloud configured CPU, memory and storage

Pay by transaction

Elastic scaling, fine-grained

Support geo-redundancy

CMTS Workload Placement Considerations

Matching Platform w/ Workload

UPF & RTC:

- On-prem/Edge
- In-box resource sharing

nRTC:

- Edge or In-Region
- Resource Aware

NRTC & MP:

- In-Region
- Serverless

Full Cloud CMTS Deployment Model

## Example – Full Cloud CMTS on AWS
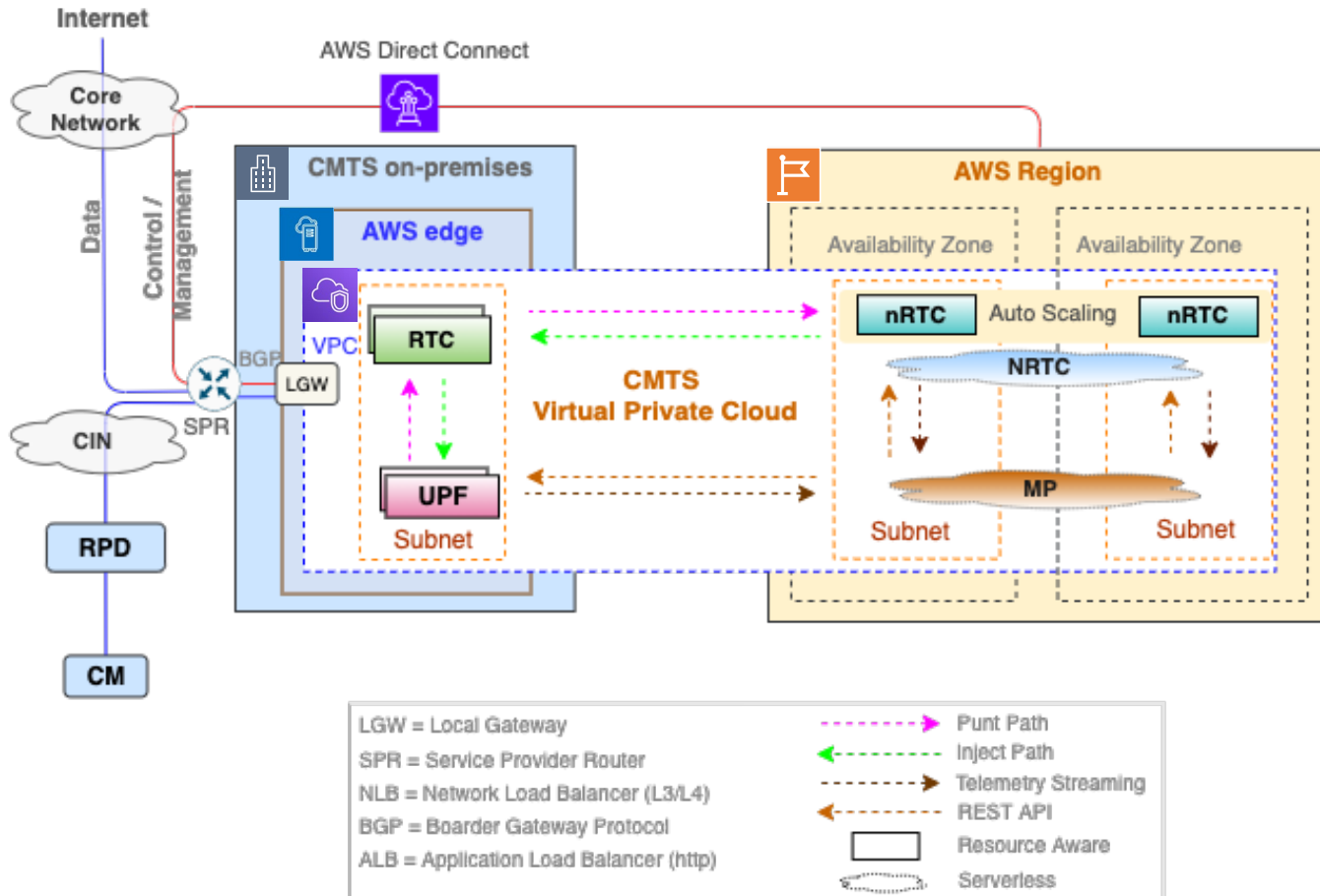
Full Cloud across Edge and Region

- CCAP Core fully operates in Cloud (Edge + Region)

- Edge connects to Region via cloud direct connect service / SP core network

- BGP distributes routes for the distributed CMTS service endpoints.

- DOCSIS punt/injection interfaces separate UPF and CP.

- REST API and telemetry streaming interfaces used for MP

CMTS State Handling on the Serverless Platform

- CMTS needs to maintain states for the cable network elements, including service groups (SGs), cable modems (CMs), and service flows (SFs).

- Serverless compute is stateless, as the compute resource may only last for one invocation.

- Two ways to handle states on a serverless platform:
  - Use serverless data store outside the microservices/functions
 - Use workflow to orchestrate stateless tasks

Manage States with Serverless Datastore

NRTC on AWS Serverless Platform
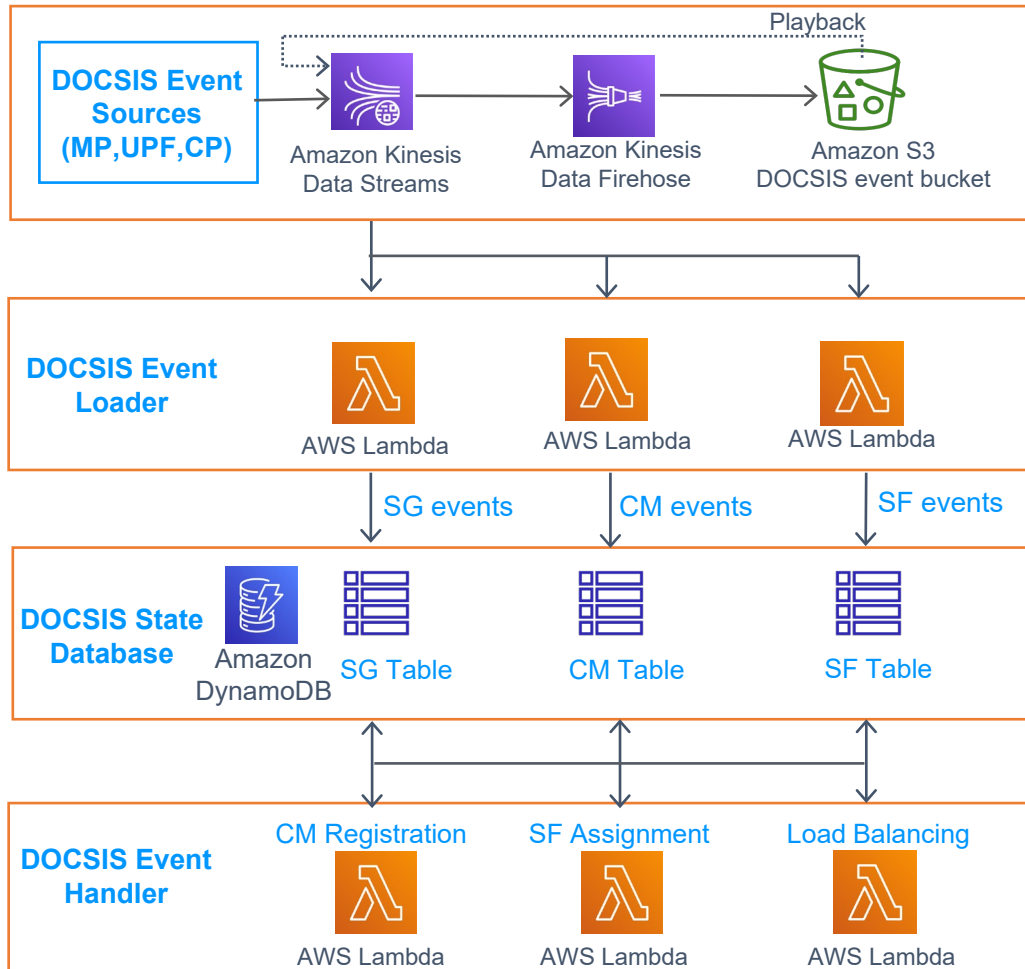
**Manage States as Events**

- Externalize states as events

- Decouple a stateful logic into stateless event handlers

- Preserve event sources
  - Stream events to propagate states
  - Log events for AI/ML analytics,
  - Replay events for debugging/fault recovery

- Route events to functions
  - Sort events to database tables
  - Trigger the handlers watching the table
  - Persist the state change across triggers

Manage State with Serverless Worflows

Serverless Profile Management on AWS
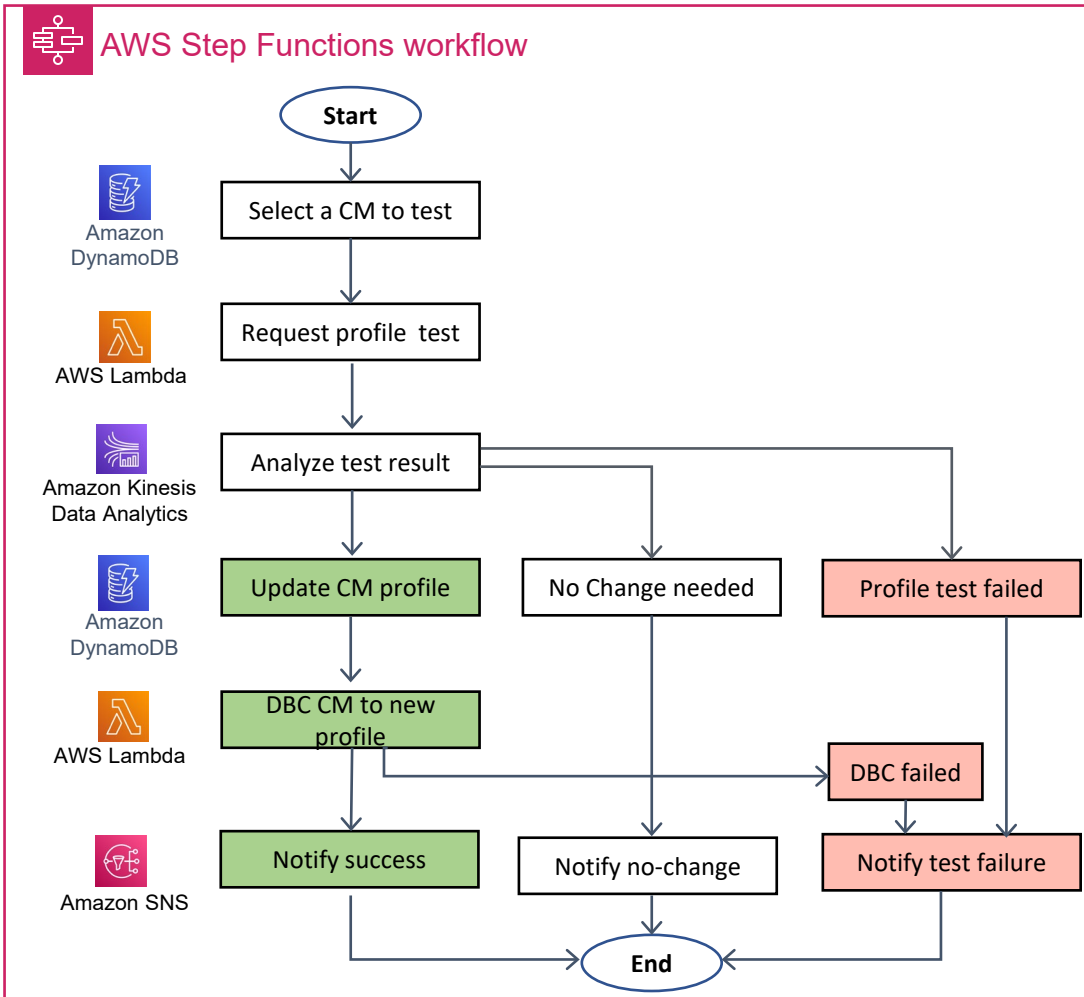
Hold States in Workflows

- A workflow holds application states and actions to transition from one state to another.

- Each action is a stateless event handler, unaware of its location in the execution sequence.

- Knowledge of the execution order helps prepare the resource needed by the event handlers

- The workflow itself is a serverless cloud service with built-in elasticity and resiliency.
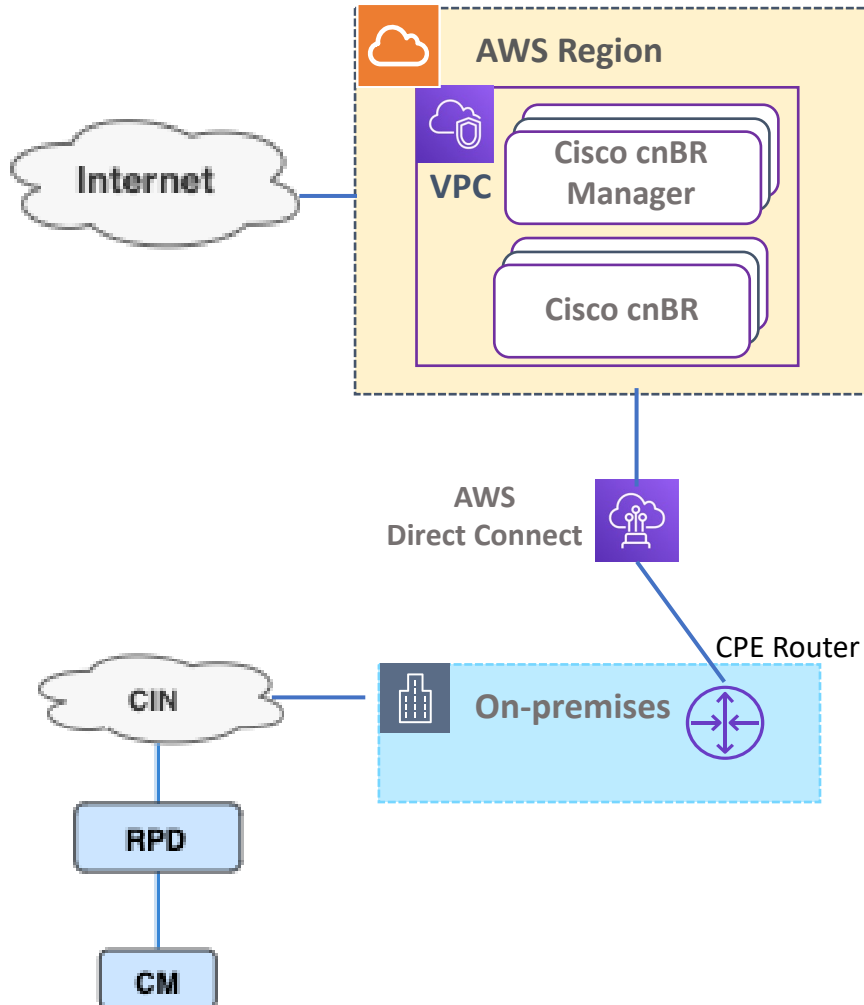
Cloudification Proof of Concept

Objective:

- Experiment all CMTS workload in Cloud
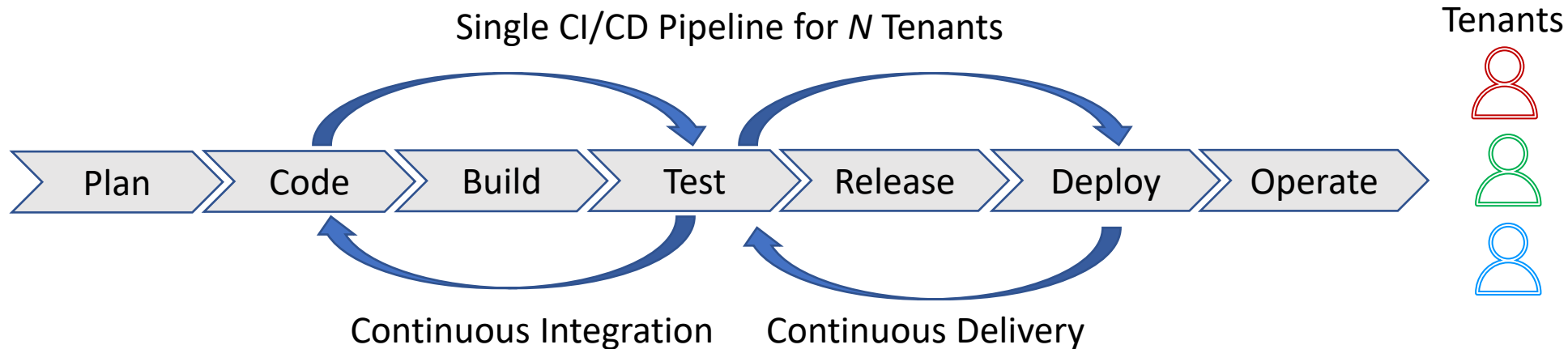- Study impact on service placement

Strategy:

- Jump start with lift-and-shift
- Test driven development, targeted optimizations
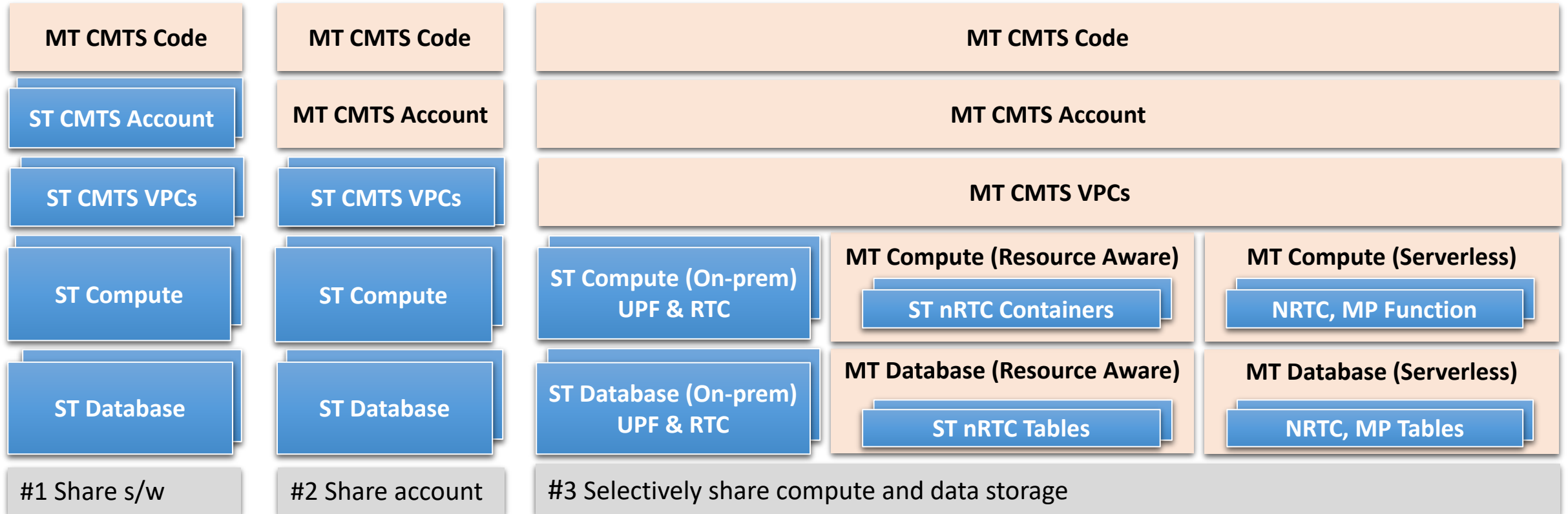
PoC Setup:

- Cisco vCMTS runs on Amazon EC2 instances in the AWS Region
- AWS Region connects to CIN at Cisco lab via AWS Direct Connect

CMTS-as-a-Service

- CMTS is hosted by cloud and delivered to users over the internet/direct connections.

- CMTS-as-a-Service requires multi-tenancy to be successful and sustainable
  - Share common CI/CD pipeline to speedup development/upgrade, save time/cost
  - Share compute and storage resource cost and maintenance overhead

Single CI/CD Pipeline for N Tenants

Tenants

| Plan | Code | Build | Test | Release | Deploy | Operate |

Continuous Integration   Continuous Delivery

CMTS Multi-tenancy Options

Multi-Tenant CMTS Resource Sharing & Isolation

MT = Multi-Tenant
ST = Single Tenant

MT CMTS Code	MT CMTS Code	MT CMTS Code		
ST CMTS Account	MT CMTS Account	MT CMTS Account		
ST CMTS VPCs	ST CMTS VPCs	MT CMTS VPCs		
ST Compute	ST Compute	ST Compute (On-prem) UPF & RTC	**MT Compute (Resource Aware)** — ST nRTC Containers	**MT Compute (Serverless)** — NRTC, MP Function
ST Database	ST Database	ST Database (On-prem) UPF & RTC	**MT Database (Resource Aware)** — ST nRTC Tables	**MT Database (Serverless)** — NRTC, MP Tables
#1 Share s/w	#2 Share account	#3 Selectively share compute and data storage		

Cloudification unleashes the power of cloud computing for CMTS

- Cloudification allows the CMTS to take advantage of the highly scalable Cloud infrastructure/platform

- In cloud, you pay for what you use, spend less time managing the infrastructure, more time innovating CMTS

- Two types of cloud resources to consider for placing CMTS services today:
  - Resource-aware, in Region and Edge, offers similar development and operation environment as the server based vCMTS today.
  - Serverless, in Region only, offers built-in auto scaling and hides all underlying resource provisioning complexities.

- Cloudification can start out with a test-driven development approach to iteratively optimize CMTS operation in cloud.

- Ultimately offering CMTS-as-a-Service with multi-tenancy + cleaner CI/CD model.

Thank You!

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