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Innovation of Computing-Aware Routing in Intelligent IP Network

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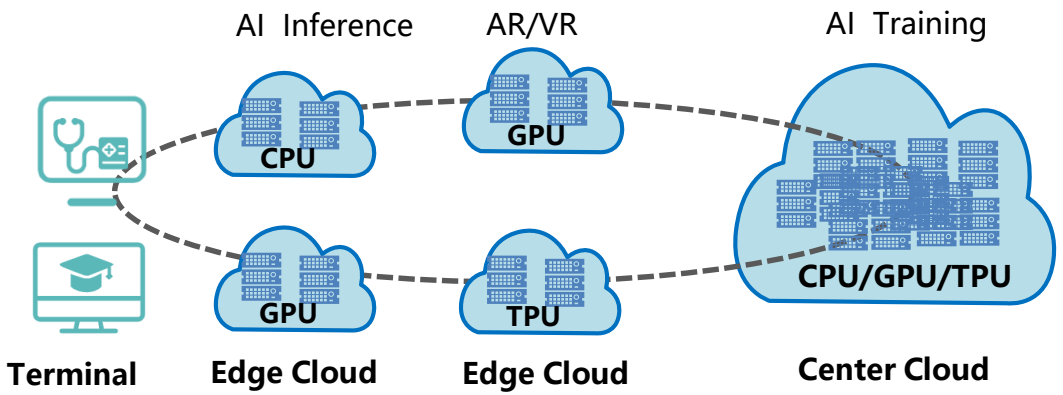
Agenda

- Trend of computing and network
- Challenge and solution of computing and network integration
- Architecture and procedure of computing-aware routing
- Trial of computing-aware routing in Chinese telecom operators
- Use cases and standard progress of computing-aware routing

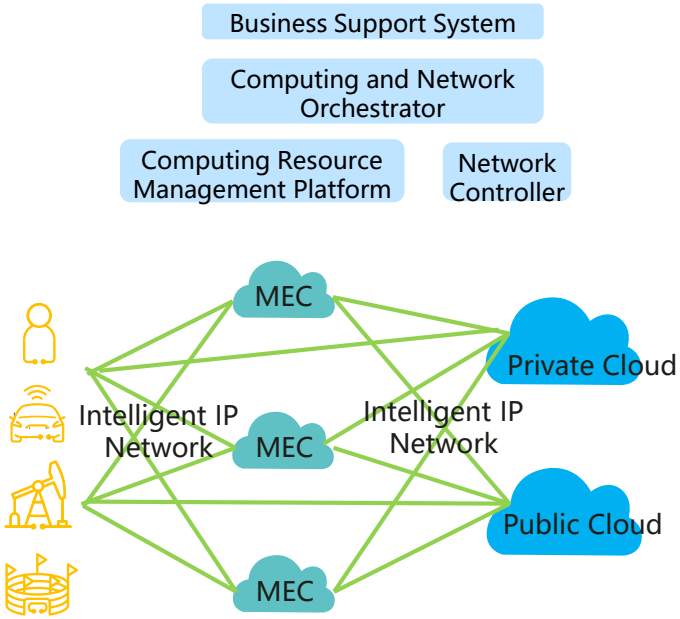
Trend of Computing and Network

Ubiquitous and Heterogeneous Computing Resources



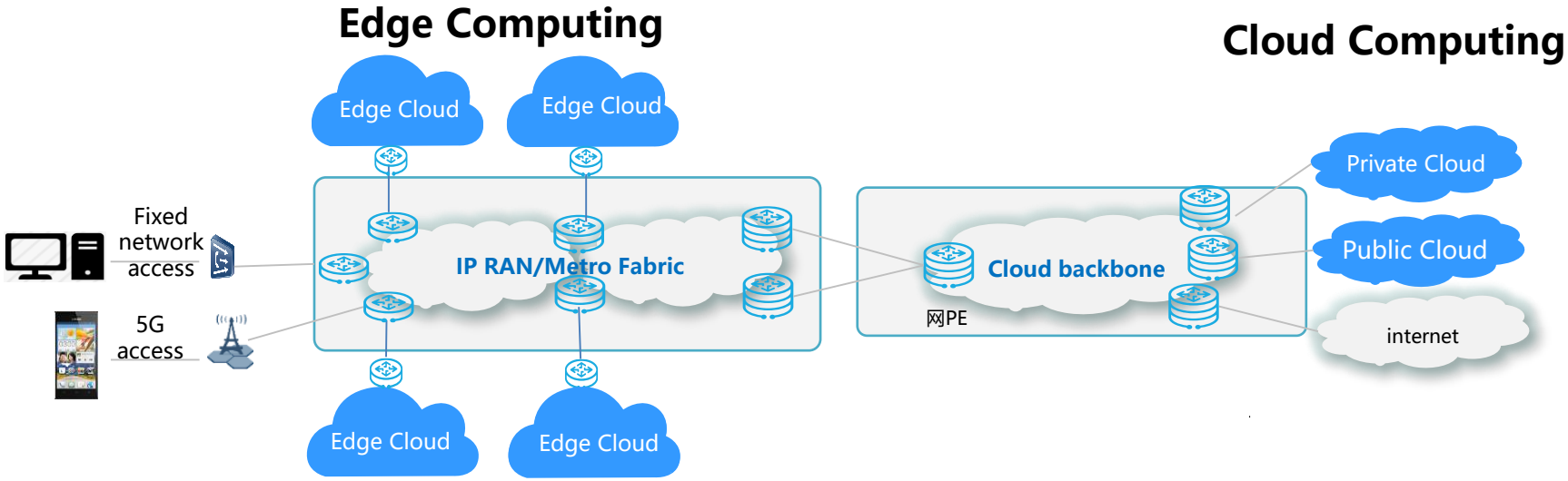
- **Diversified service demands**
  - Low latency, high bandwidth and super computing power
- **Various types of computing resources**
  - CPU、GPU、TPU、DPU、FPGA、ASIC
- **Ubiquitous computing resources**
  - Cluster Computing Center（HPC、AI、Big Data）、Center Cloud、**Edge Cloud**、Network Device、Terminal

Service and Intelligent IP Network from Decoupling to Integration



- **Network & Application Integration**
- **Cloud & Network Integration**
- **Computing & Network Integration**

Challenge of Computing & Network Integration



Cloud-Edge Synergy

- **Application decomposed into multiple micro-services**:
  - computation intensive service such as AI training suitable for the central cloud
  - latency intensive service such as AI inference suitable for the edge cloud
- **Application composed of micro-service:** deployed near (edge cloud) or far (central cloud)
  - considering cost: network cost (near-low, far-high) + computing cost (near-high and far-low)
  - considering latency or computation intensive: near - low latency, far – high computation

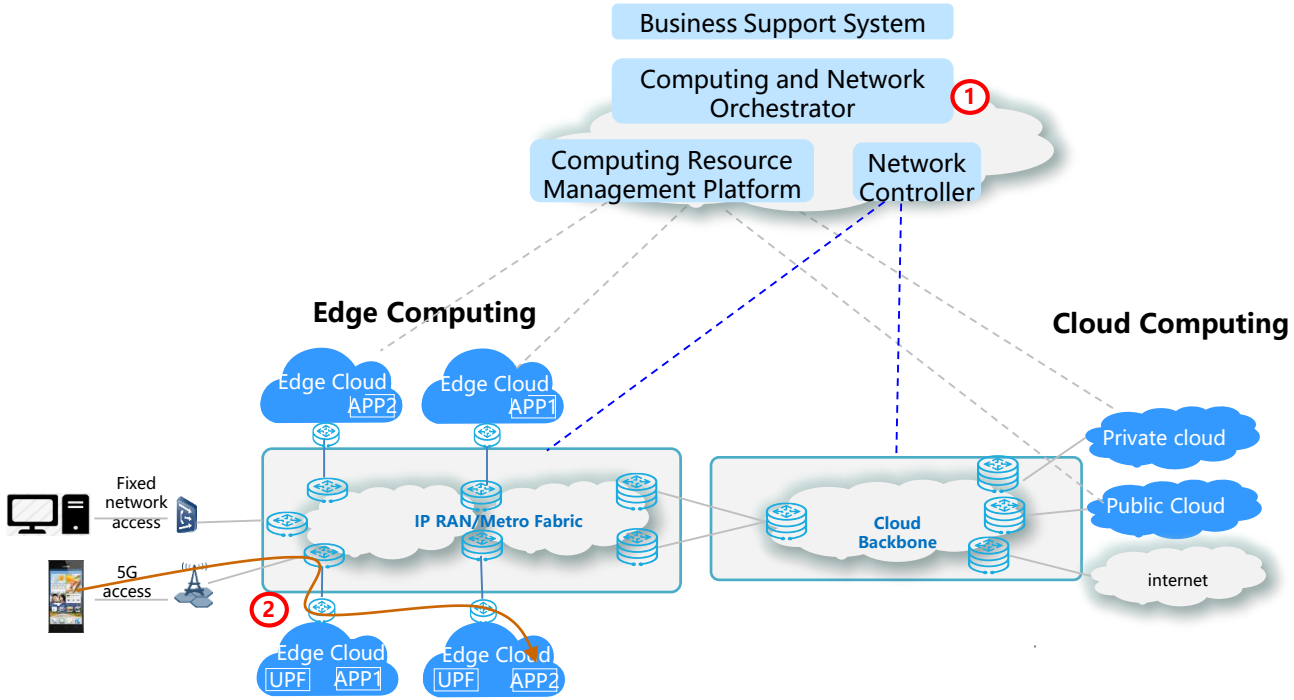
Service deployment selects the clouds considering the **combination of cost, computing resource, SLA, user access point** etc.

Edge-Edge Synergy

- The resources of edge clouds are limited.
- The failure rate of edge clouds is higher than DC.
- The reliability of edge clouds is lower than DC
- The low latency service is deployed in the edge clouds

A service is deployed at **multiple edge sites** with multiple instances. **Service traffic scheduling** need selects the appropriate edge site for user service demand to **improve the edge site resource utilization and provide edge-edge synergy**.

Service Deployment and Scheduling in Computing & Network Integration



① Service Deployment

- The user **requests specific service** with the computing resources, storage, network SLA, cost demands etc.
- The Orchestrator **selects computing resource pools** for service deployment request based on the result of **combination optimization** algorithm **to meet the multi-dimensional requirements** such as computing, storage, network SLA and cost.
- Deploys the service to the selected single or multiple resource pools

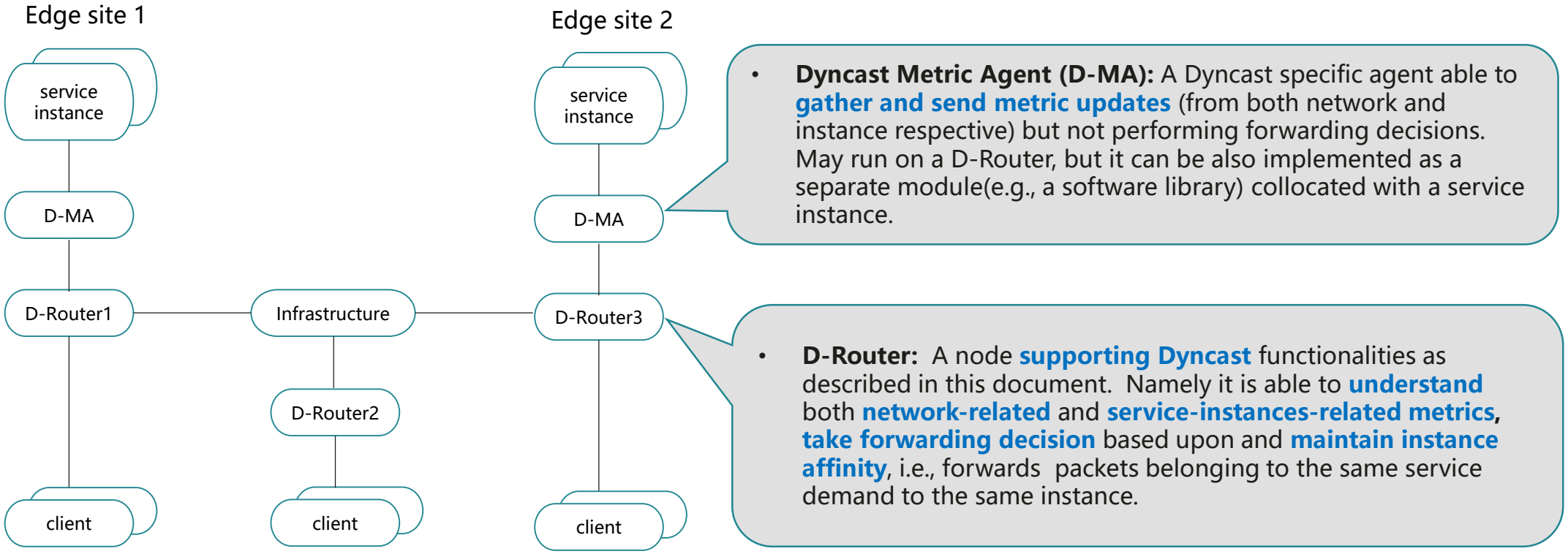
② Service Scheduling:

- After the service is deployed the user terminal **requests to access the service**
- Service Scheduling is to select one service instance based on the result of **combination optimization** algorithm **using computing and network metric**
- **Computing-Aware Routing** is a method of service scheduling

Architecture of Computing-Aware Routing

Dyncast (Dynamic Anycast) is used for computing-aware routing

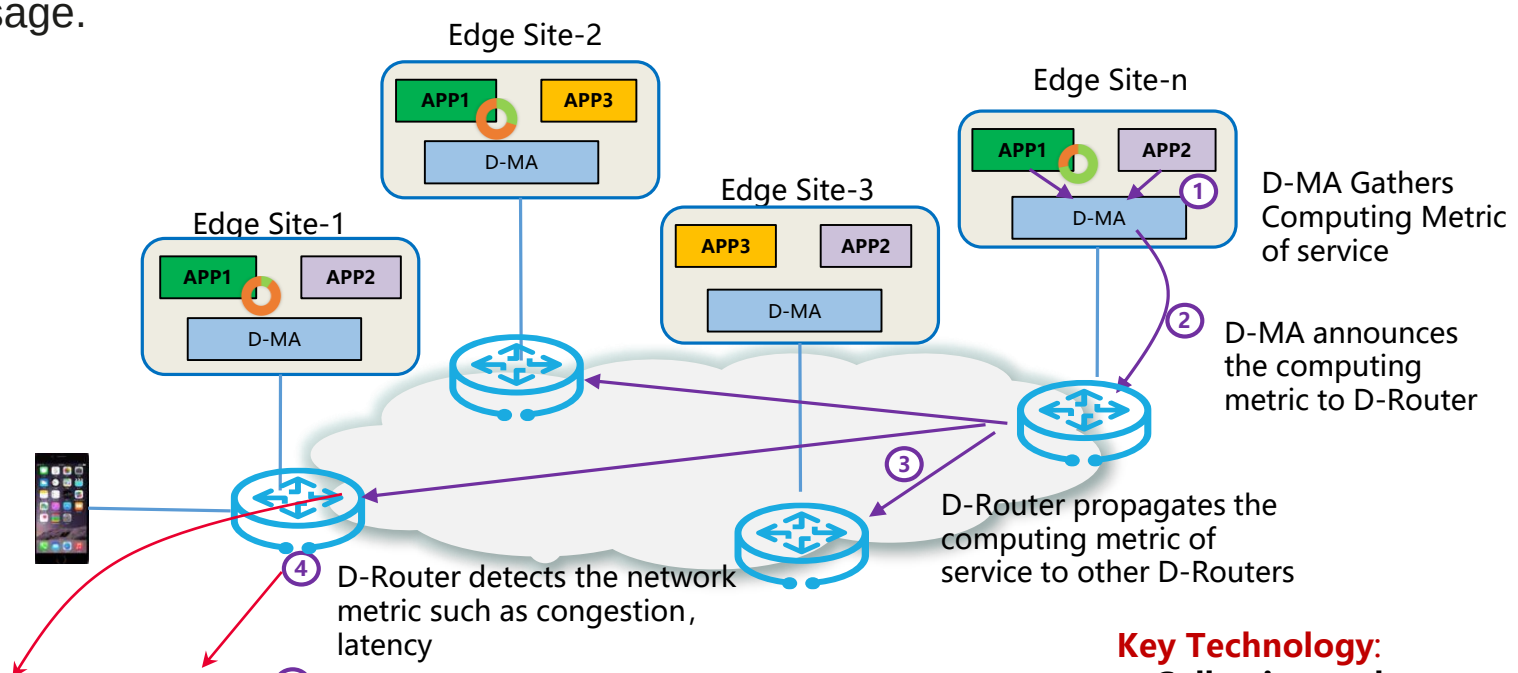
- Inherits the advantages of **Anycast**, which is fast, reliable, and anti-DDOS.
- Anycast routing for one flow to one edge site is based on **dynamic** computing load and network state of service
- **Flow/Instance Affinity** keeps the flow/instance to selected edge site
- Achieve **optimal user experience, computing resource utilization, and network efficiency**



draft-li-dyncast-architecture
Dynamic-Anycast Architecture

Procedure of Computing-Aware Routing – Control Plane

Control Plane: **Announce and propagate** the computing metric of service through **network protocols**, such as BGP, IGP. **New attribute of computing metric** is defined and carried in routing message.



IP Prefix	Nexthop	Computing Metric	Network Metric
APP1 Anycast IP	Edge-1	60	10
	Edge-2	20	8
	Edge-n	10	12

Key Technology:

- **Collection and measurement of site-level computing metric**
- **Method of route update frequency with metric change: BGP MRAI, site-level metric, threshold etc**
- **distributed or centralized mechanism**

Procedure of Computing-Aware Routing – Data Plane

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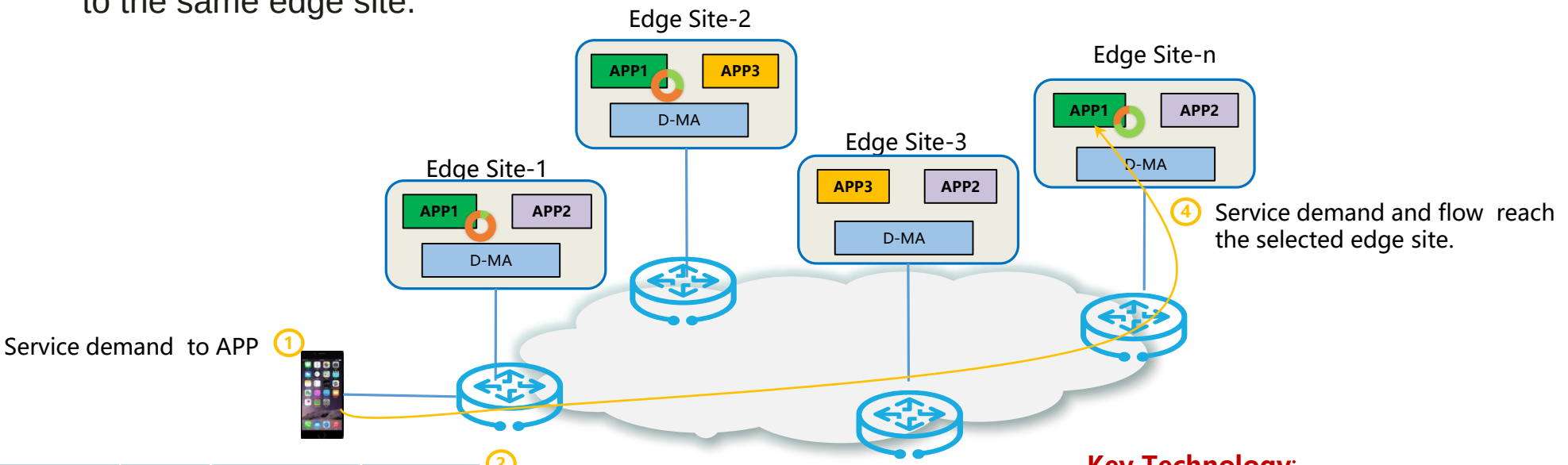
Data Plane: **Take forwarding decision** based upon service identification, computing and network metric. **Maintain flow/instance affinity**, i.e., forward packets belonging to the same service demand to the same edge site.



IP Prefix	Nexthop	Computing Metric	Network Metric
APP1 Anycast IP	Edge-1	60	10
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2 D-Router selects the edge site for the service demand based upon computing and network metric

3 D-Router maintains flow / instance affinity

Key Technology:

- **Scheduling algorithm** considering **combination of computing metric and network SLA**
- **Flow/instance affinity or session persistence** for user mobility

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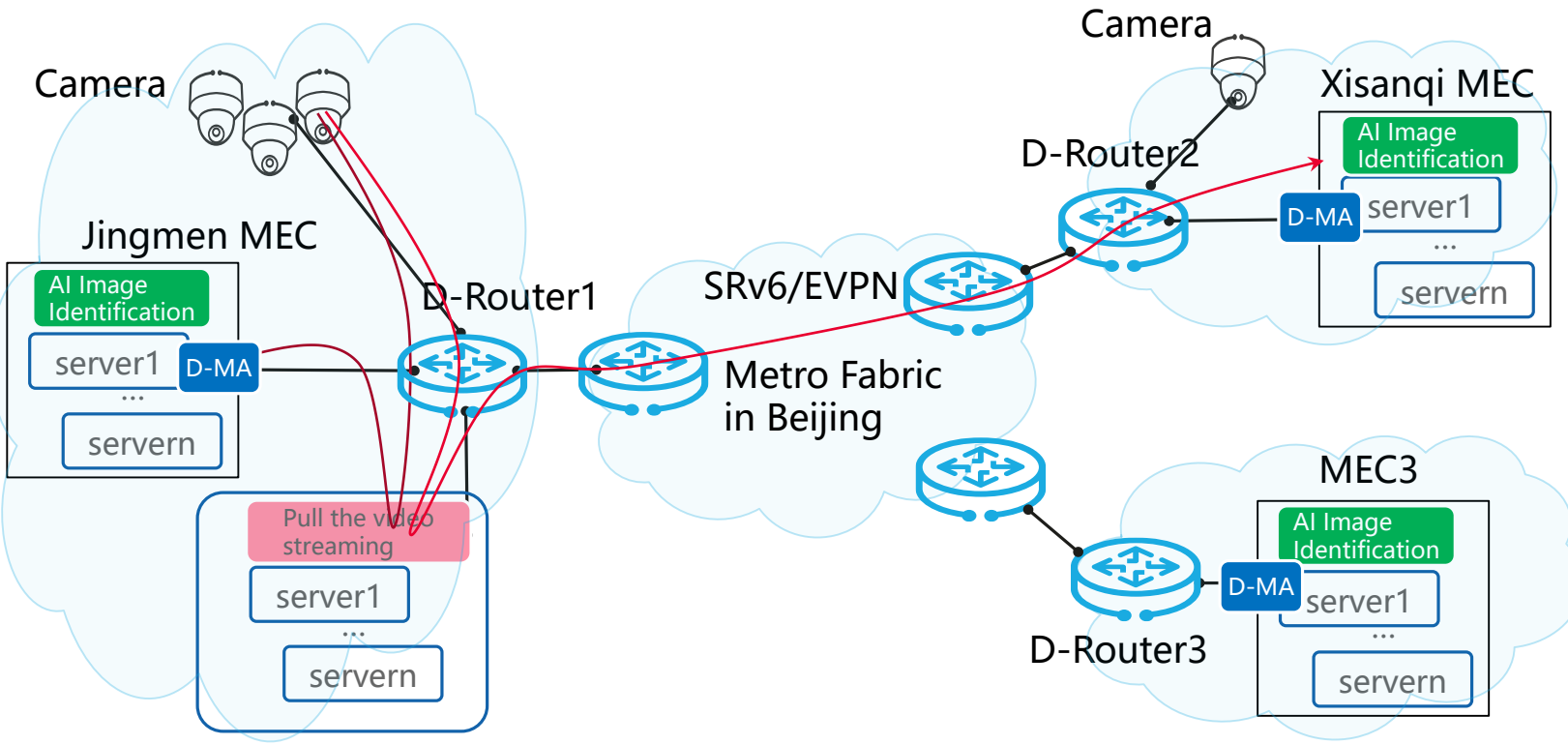
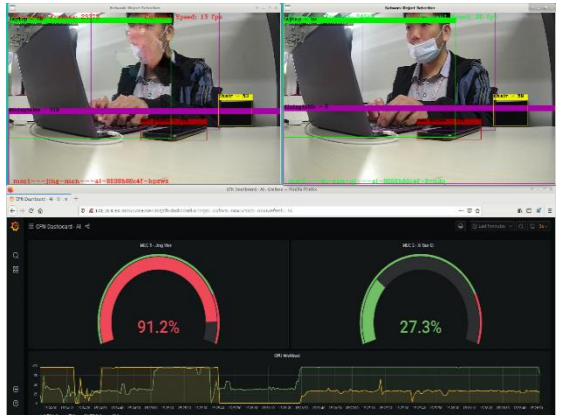
Trial of Computing-Aware Routing in China Unicom

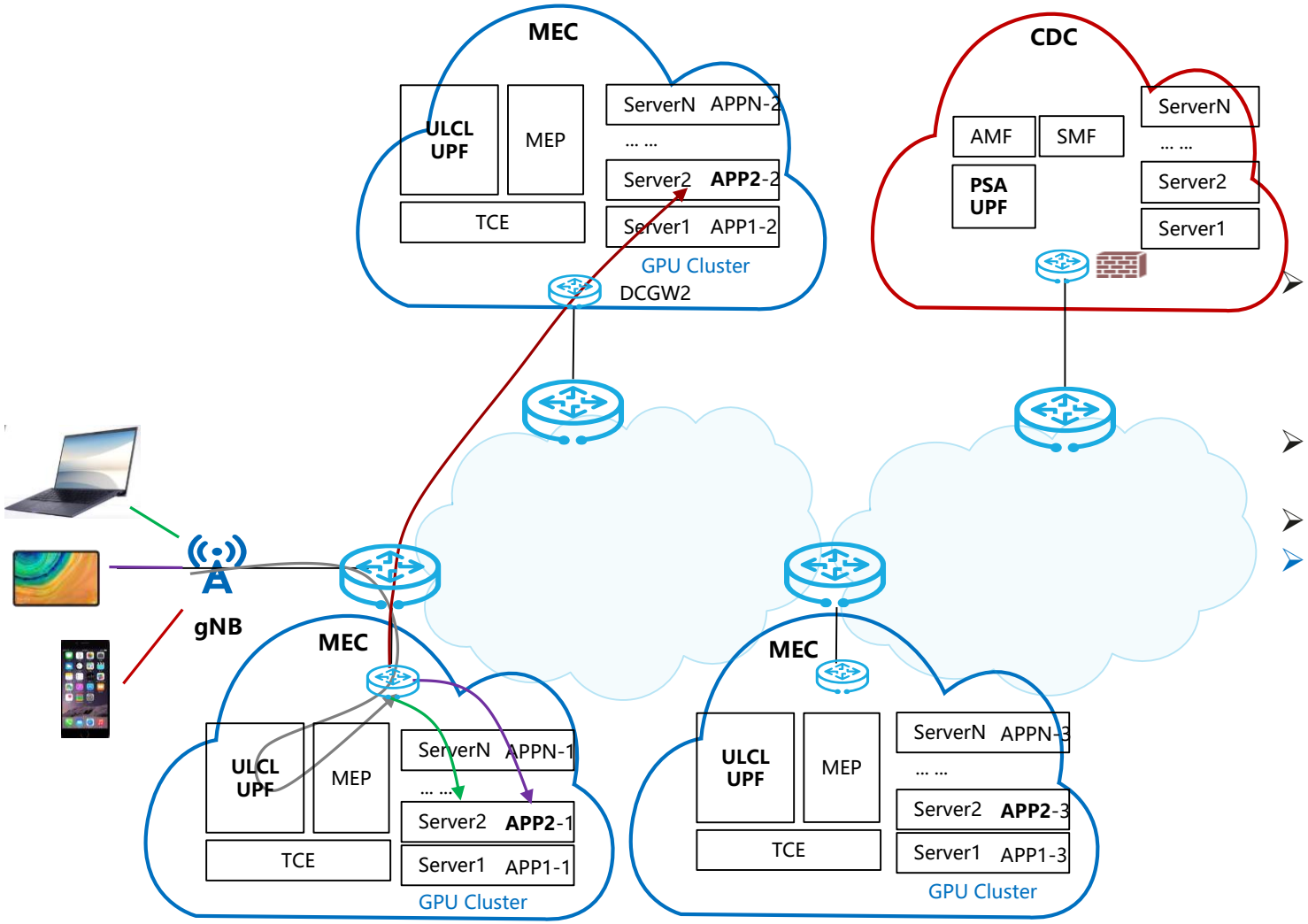




Trial of Smart Security Use Case in Beijing Area of China Unicom

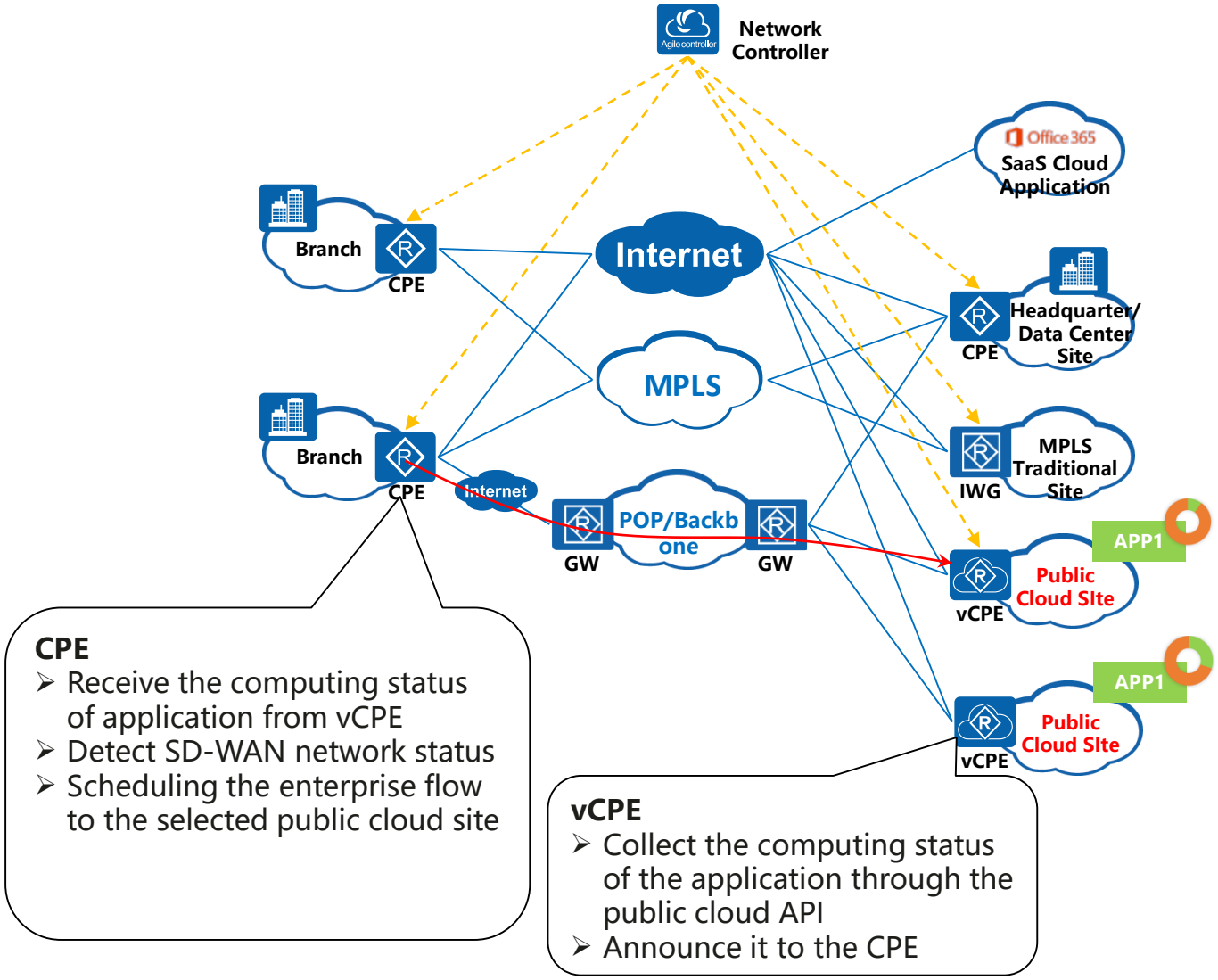
- AI Image applications using GPU deployed in multiple MECs analyze the video stream captured by the camera. One MEC is in Jingmen, One is in Xisanqi.
- The Routers as MEC gateways have **Computing-Aware Routing** function.
- Firstly the video flow of camera is scheduled to Jingmen MEC. When it has high load the video flow is scheduled and steered to the Xisanqi MEC with low load.

Use Case of Computing-Aware Routing in 5G MEC scenario



- Applications such as AR/VR、Cloud Game、V2X deployed in 5G MEC sites to **satisfy the low latency requirement**
- 5G MEC sites close to gNBs with **limited computing resources**
- 5G MEC sites **interconnected**
- **MEC GW with computing-aware routing function can improve the resource utilization rate** of MEC sites and **user experience**.

Use Case of Computing-Aware Routing in SD-WAN

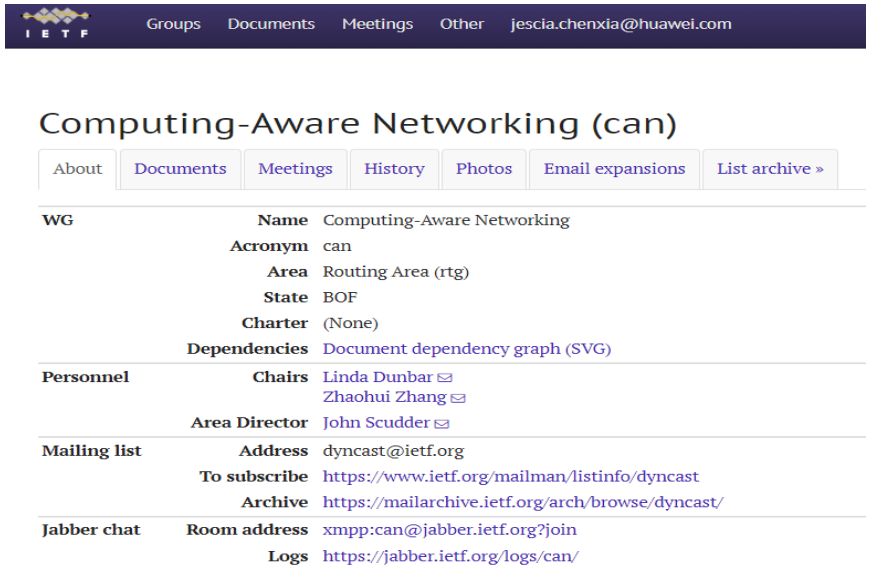


- **Enterprise applications can be migrated to the cloud and deployed at multiple sites.** Redundant backup or load sharing can be performed. By selecting clouds from multiple cloud service providers, it can also avoid service provider lock-in.
- **CPE and vCPE with computing-aware routing function**
- **Improve the resource utilization rate** of the public cloud, and **reduce the cost of renting** the resources of the enterprise public cloud.

Standard Progress in IETF

Meeting

- **Dyncast Side Meeting @IETF109 & @IETF110**
  - https://github.com/dyncast/ietf109
  - https://github.com/dyncast/ietf110
- **CAN BOF @IETF113**
  - https://datatracker.ietf.org/group/can/about/



Draft

Draft topic	Draft name
Dynamic-Anycast (Dyncast) Use Cases & Problem Statement	draft-liu-dyncast-ps-usecases
Dynamic-Anycast (Dyncast) Requirements	draft-liu-dyncast-reqs
Dynamic-Anycast Architecture	draft-li-dyncast-architecture
Providing Instance Affinity in Dyncast	draft-bormann-dyncast-affinity
LISP Support for Dynamic Anycast Routing	draft-kjsun-lisp-dyncast
BGP NLRI App Meta Data for 5G Edge Computing Service	draft-dunbar-idr-5g-edge-compute-app-meta-data
Computing-aware Networking Use case of ALTO	draft-liu-alto-can-usecase
Use Cases for Computing-aware Software-Defined Wide Area Network(SD-WAN)	draft-zhang-dyncast-computing-aware-sdwan-usecase

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Thank you