# Paper review of Mobile Edge Computing

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UCDAVIS

**Group Meeting, October 28, 2016**

# Contents

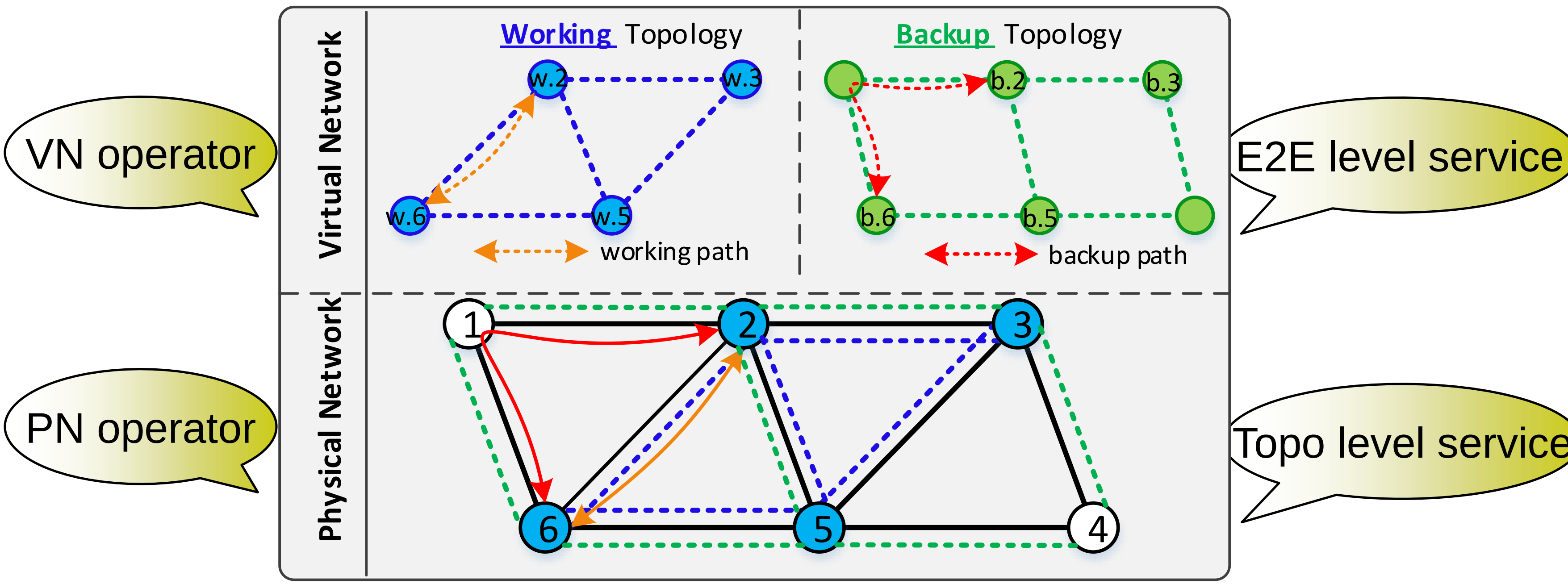
- Introduction of my previous works
- Introduction of Mobile Edge Computing(MEC)
- Traffic patterns of MEC based services
- Congestion problems at Mobile Edge
- Existing works for MEC congestion

# Introduction about myself

- Wei Wang (王伟)
- Beijing University of Posts and Telecommunications(BUPT)
- Email: weiw@bupt.edu.cn, waywang@ucdavis.edu
- Phone: 530-761-6018
- 3rd year Ph.d candidate in Communications Engineering at BUPT
- Research interests: Survivability in virtualized networks, Scheduling of network applications, SDN based control of Transport Networks
- Future interests: IT and network resource optimization for Mobile Edge Computing (maybe)

# Previous works (1)

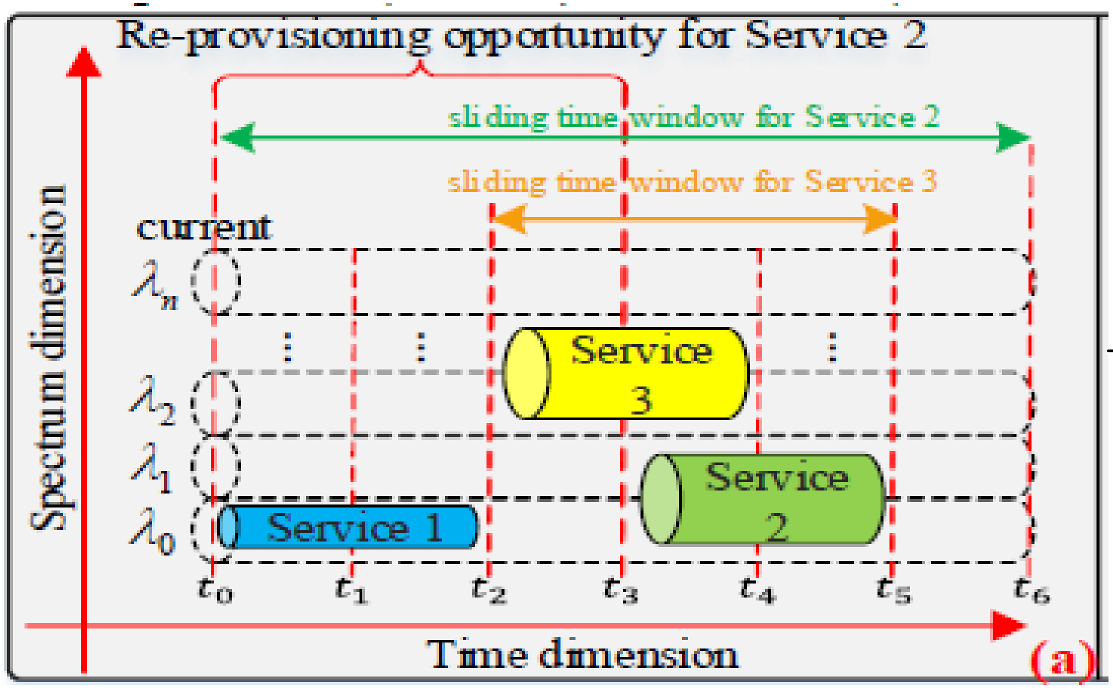
- Multi-layer protection for virtual transport network services (VON)
- Which operator provide resource to protect which kind of service?




Wei, Wang, et al. "First demonstration of virtual transport network services with multi-layer protection schemes over flexi-grid optical networks." *IEEE Communications Letters* 20.2 (2016): 260-263.

# Previous works (2)

- Re-provisioning of Advanced Reservation (AR) requests
- AR requests are scheduled to start after certain initial-delay, so we can re-provision them during the initial-delay for optimization.



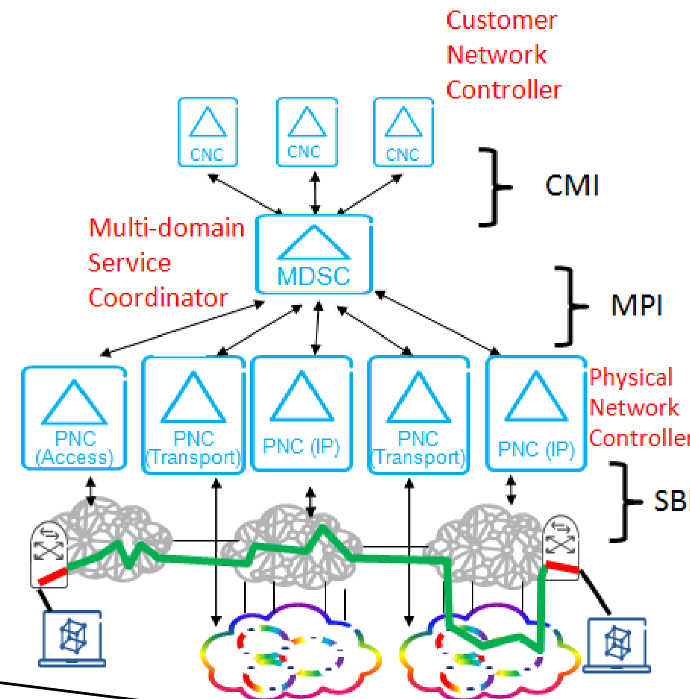

Rescheduling

Re-wavelength assignment

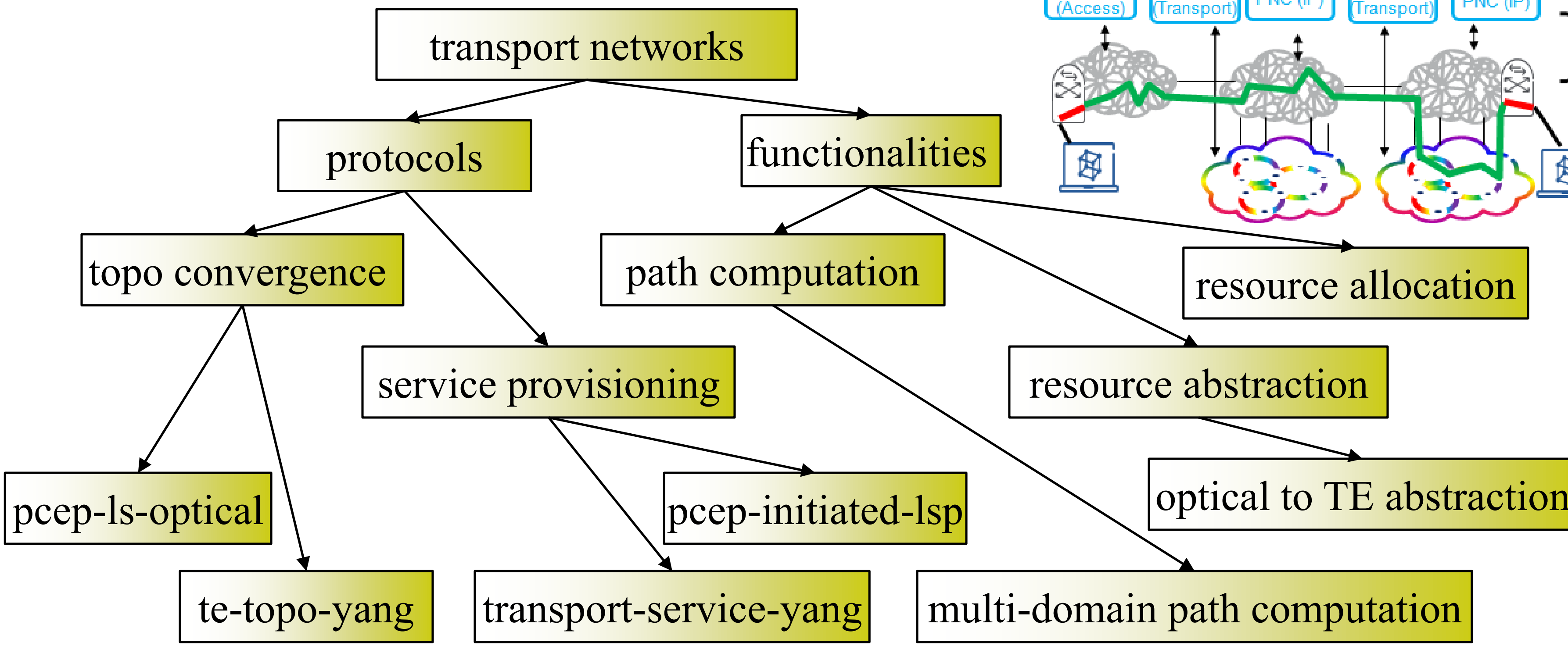
Re-routing

Wei, Wang, et al. "Demonstration of Parallel Service Re-Provisioning over Advanced Reservation enabled Software Defined Optical Transport Networks." OFC, 2016.

# Previous works (3)




- Abstract and Control of TE Networks




https://tools.ietf.org/html/draft-lee-pce-pcep-ls-optical-00
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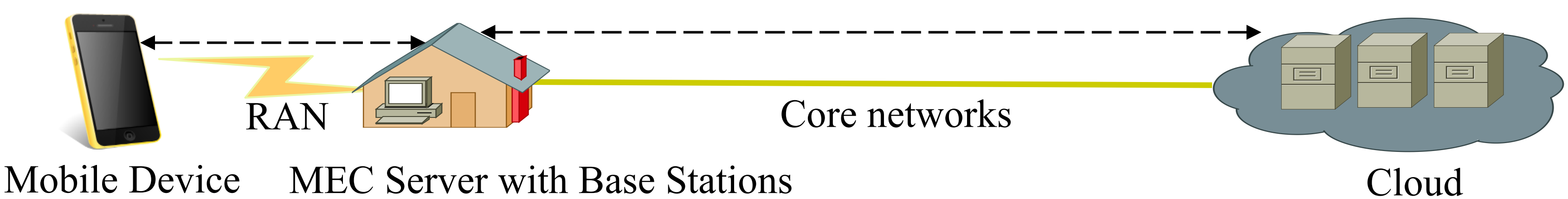
https://tools.ietf.org/html/draft-zhang-teas-transport-service-model-00

# Concept of Mobile Edge Computing

- Mobile Edge Computing (MEC) provides IT and cloud-computing capabilities (MEC server) within the Radio Access Network (RAN) in close proximity to mobile subscribers. The aim is to reduce latency, ensure highly efficient network operation and service delivery, and offer an improved user experience. [1]
- With MEC, mobile device can offload computing tasks to MEC servers AND fetch contents from MEC servers via RAN instead of doing such jobs to/from cloud servers via RAN and Core networks. In such scenario, MEC server may need to synchronize applications and contents with other servers on demand.

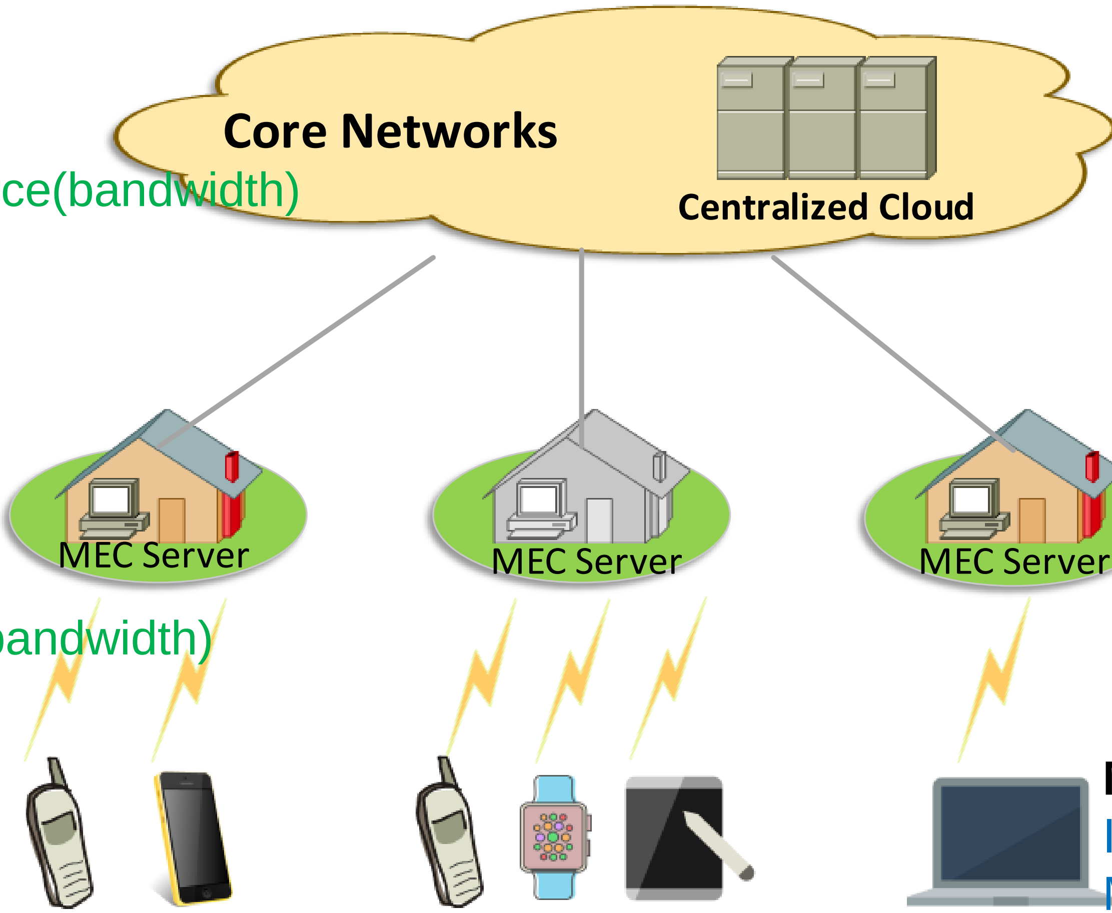



[1] ETSI, Mobile-Edge Computing – Introductory Technical White Paper

# Architecture of MEC and Cloud[2]

**Cloud:**
IT resources (CPU, Mem, Storage)
Service resources (apps, contents)

**Core network:**
Network resource(bandwidth)



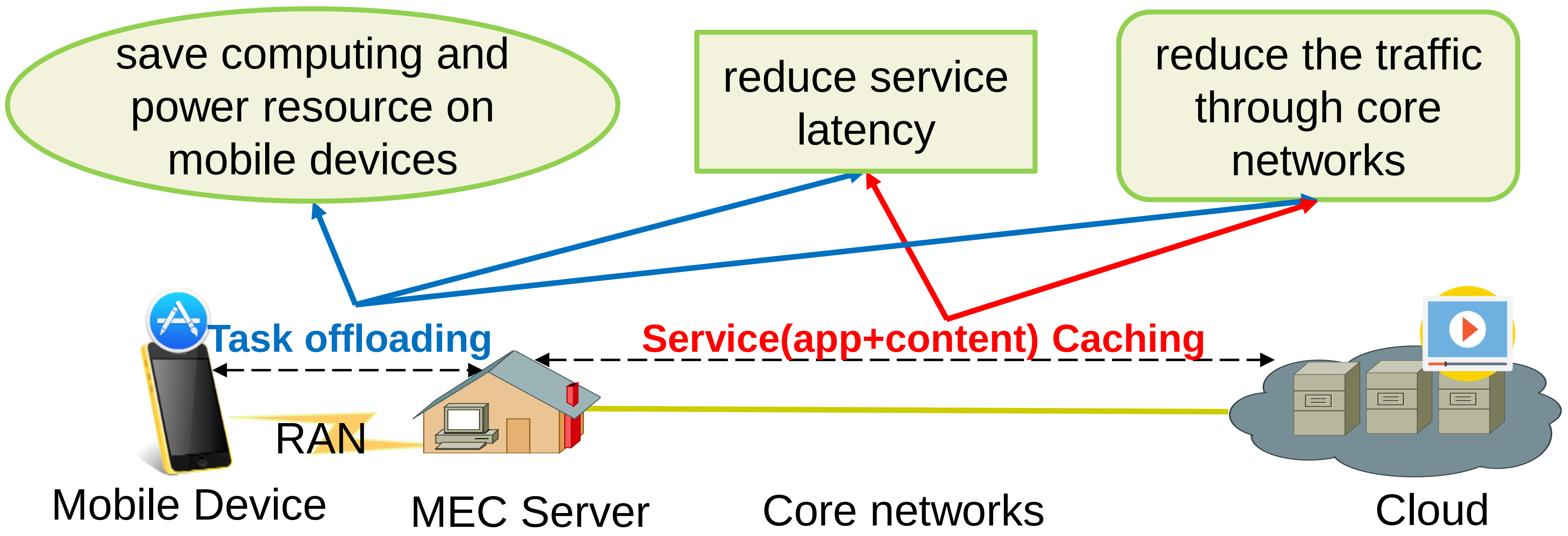

**MEC Server:**
IT resources (CPU, Mem, Storage)
Service resource (apps, contents)

**RAN:**
Access ability(bandwidth)

**Mobile Device:**
IT resources (CPU, Mem, Storage, Power
User applications

[2] Ahmed, Arif, and Ejaz Ahmed. "A survey on mobile edge computing." ISCO 2016, Coimbatore, India.

# Benefits and Objectives of MEC



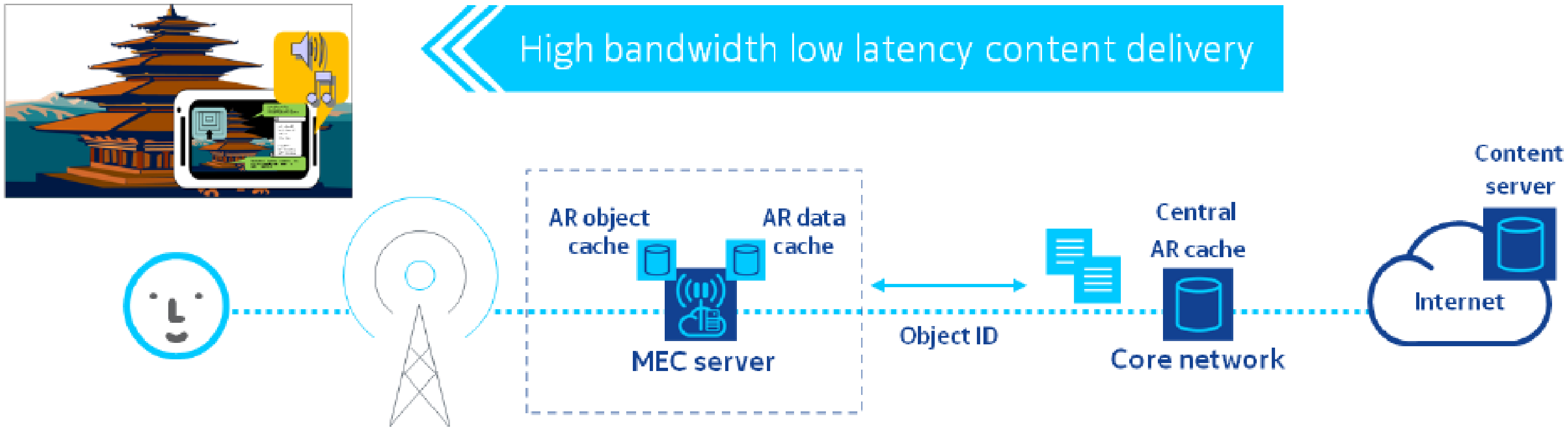

Latency

Energy Consumption

Bandwidth Utilization

# Service example for MEC (1)

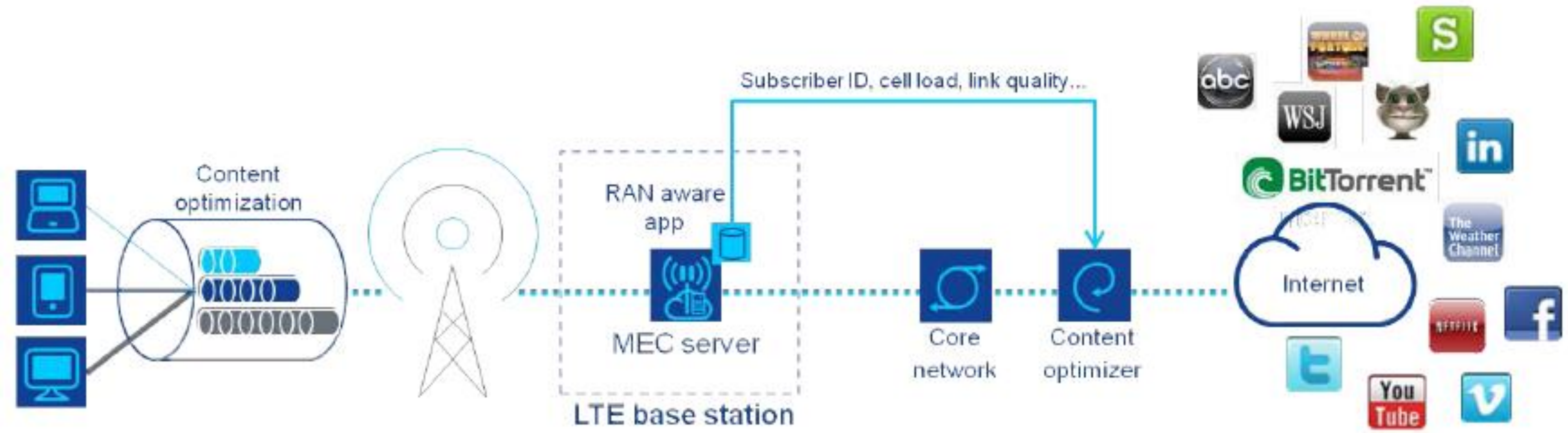
- Augmented Reality (AR) [1] services require an application to analyze the output from a device's camera and/or a precise location in order to supplement users' experience by providing additional information to the user about what they are currently experiencing.
- Hosting the AR service applications and contents at MEC server can reduce service latency.




[1] ETSI, Mobile-Edge Computing – Introductory Technical White Paper

# Service example for MEC (2)

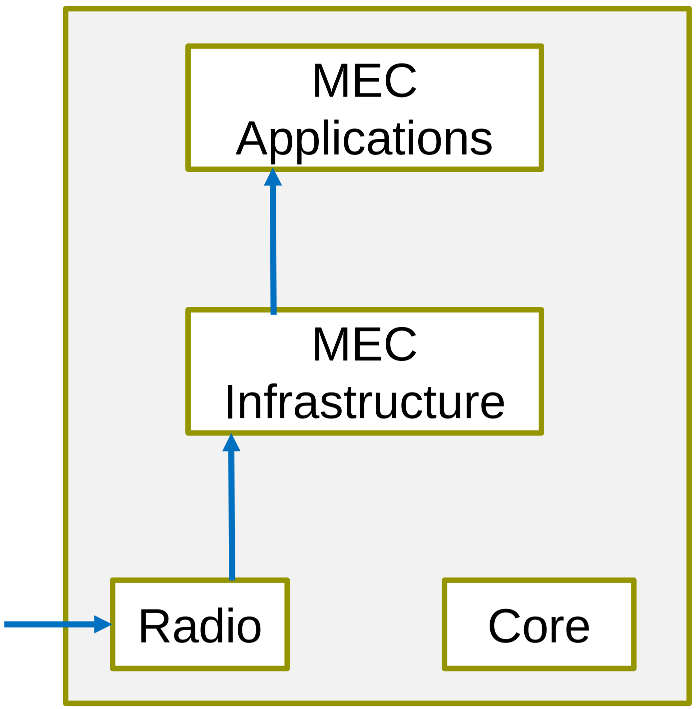
- RAN-aware Content Optimization [1]: MEC server can provide accurate cell and subscriber radio interface information (cell load, link quality) to the content optimizer, enabling dynamic content optimization.
- Other similar services, location-aware, user context-aware, network state-aware.



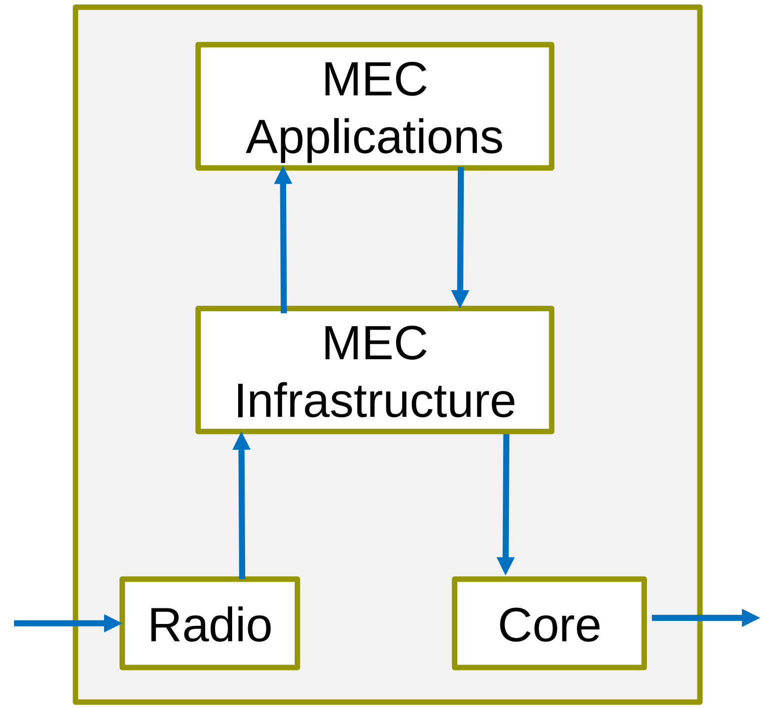

[1] ETSI, Mobile-Edge Computing – Introductory Technical White Paper

# Traffic patterns of MEC service (1)

- User’ traffic patterns under MEC—Terminating/Passthrough [3]




e.g., Augmented Reality, face recognition

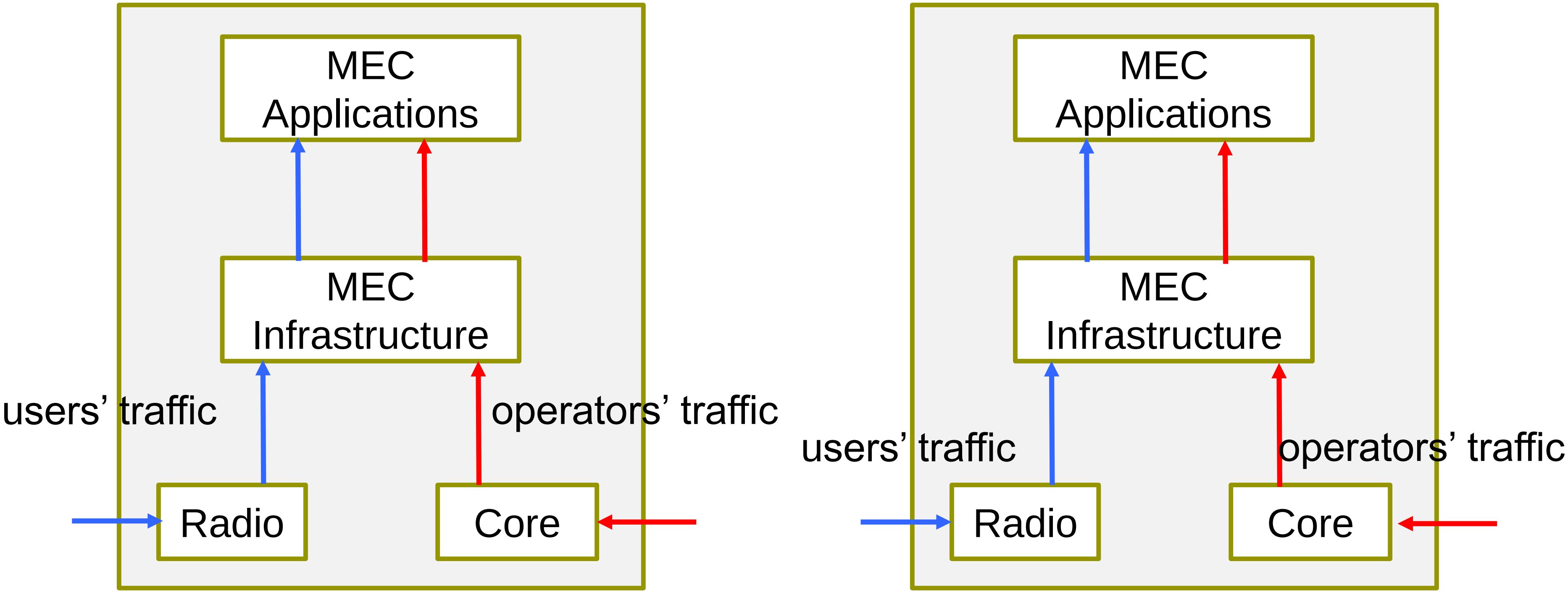



e.g., transcoding of multi-media traffic

[3] Intel and Nokia Siemens Networks, “Increasing mobile operators value proposition with edge computing.”

# Traffic patterns of MEC service (2)

- Operators traffic patterns under MEC---service (apps+contents) pre-placement [4] or dynamic service provisioning [5].





[4] Wang, Shiqiang, Murtaza Zafer, and Kin K. Leung. "Online Placement of Multi-Component Applications in Edge Computing Environments." arXiv preprint arXiv:1605.08023 (2016).
[5] Machen, A., Wang, S., Leung, K. K., Ko, B. J., & Salonidis, T. Poster: Migrating Running Applications Across Mobile Edge Clouds.

# Traffic patterns of MEC service

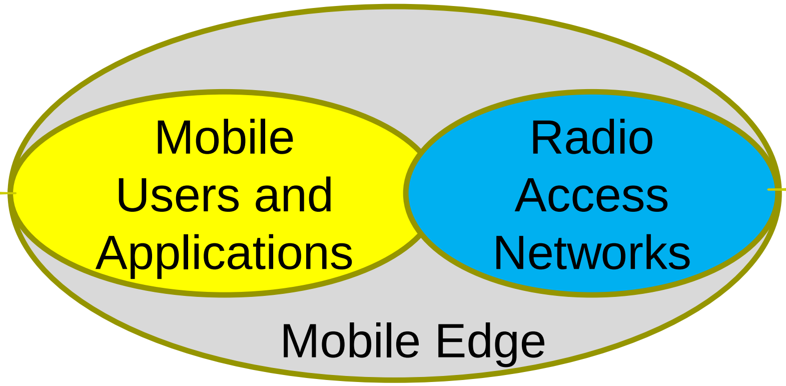
- Some parameters that may influence the traffic in MEC networks

User location

User mobility

Applications info, like app type, the request info, etc.

User privacy info




Subscriber locations and numbers

Physical coverage location

Network info, e.g., current and expected cell congestion, radio condition

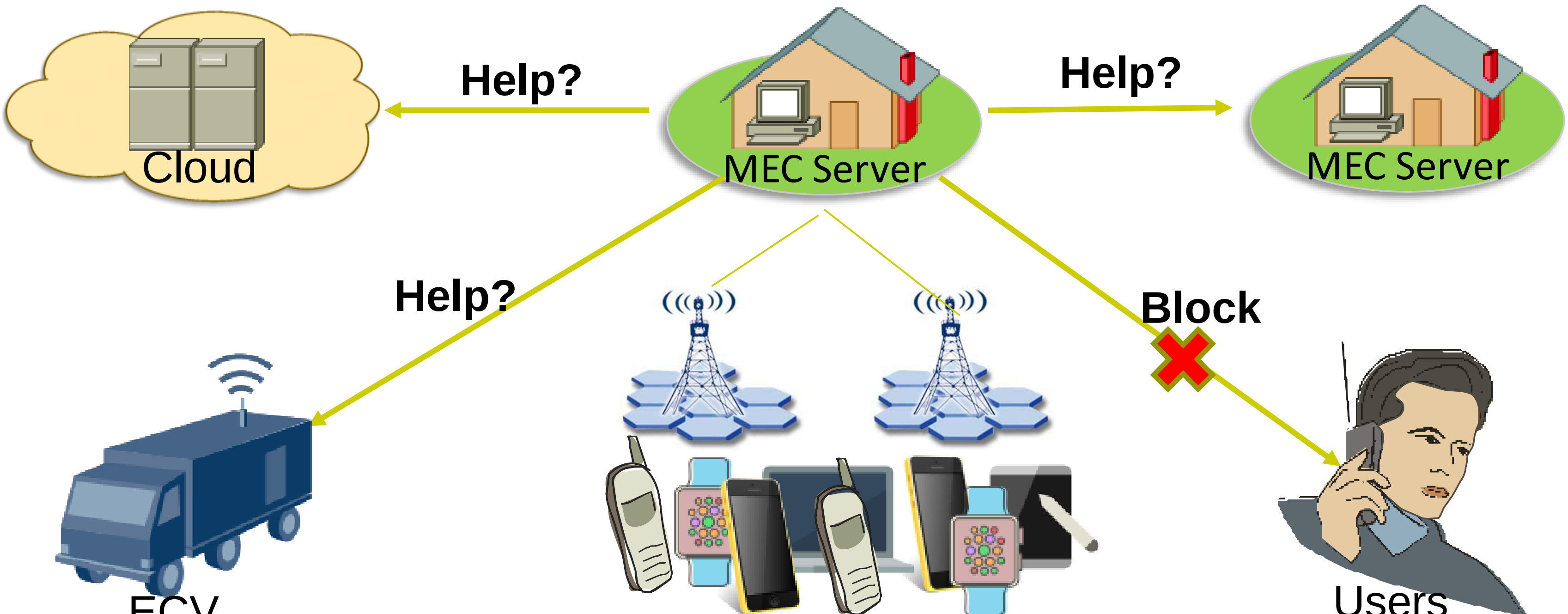
Location aware

User context aware

Network state aware

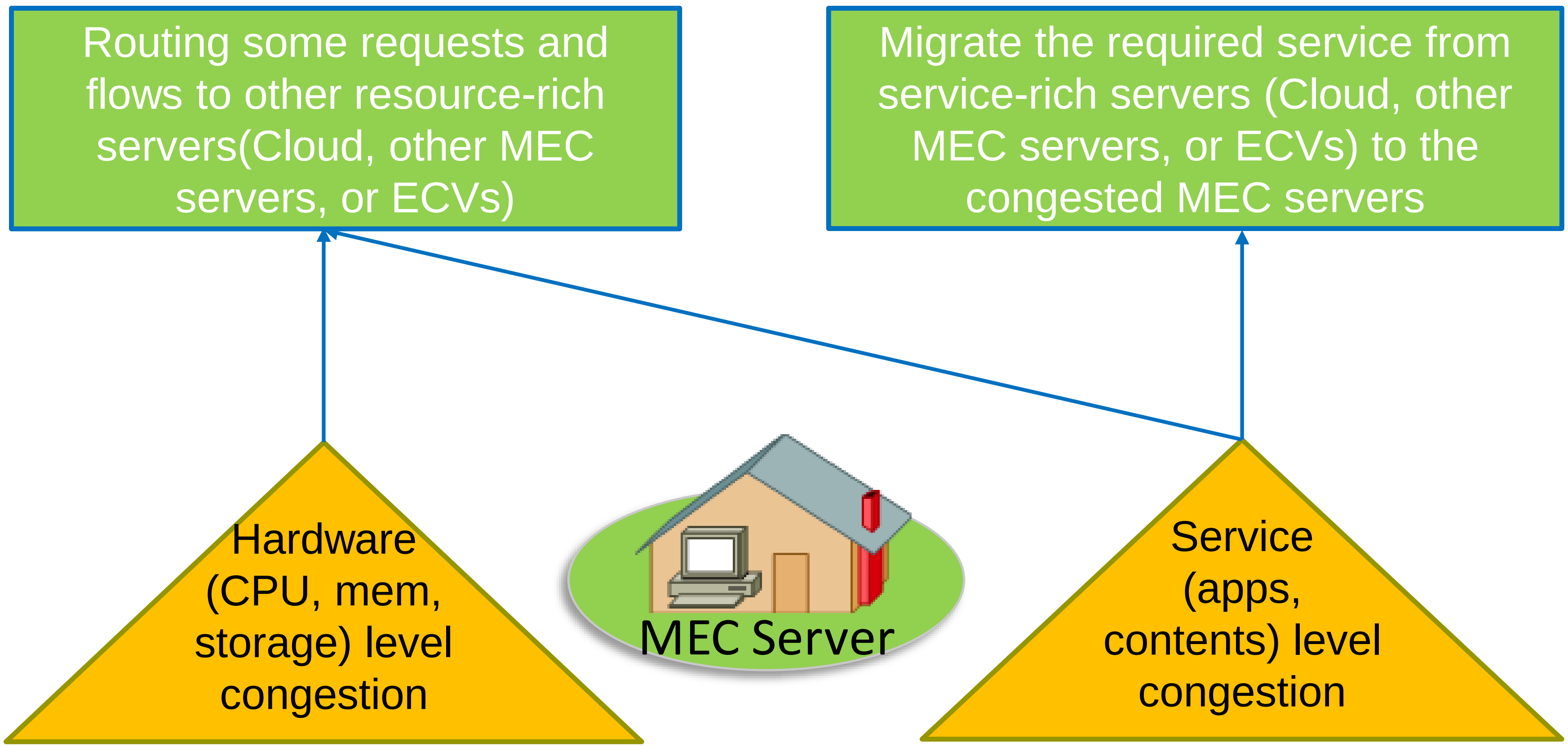
# Congestion of MEC resource

- Due to the mobility of Mobile users, some social events may attract large amount of mobile users to one area, and thus cause the congestion of mobile edge resource, including the access ability of RAN and the computing ability of MEC server.
- How to deal with the congestion of edge computing ability?



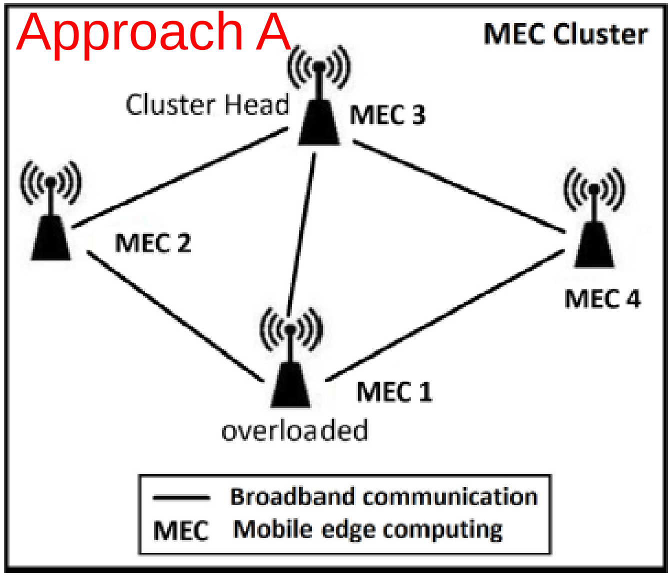
# Multi-Level MEC Congestions

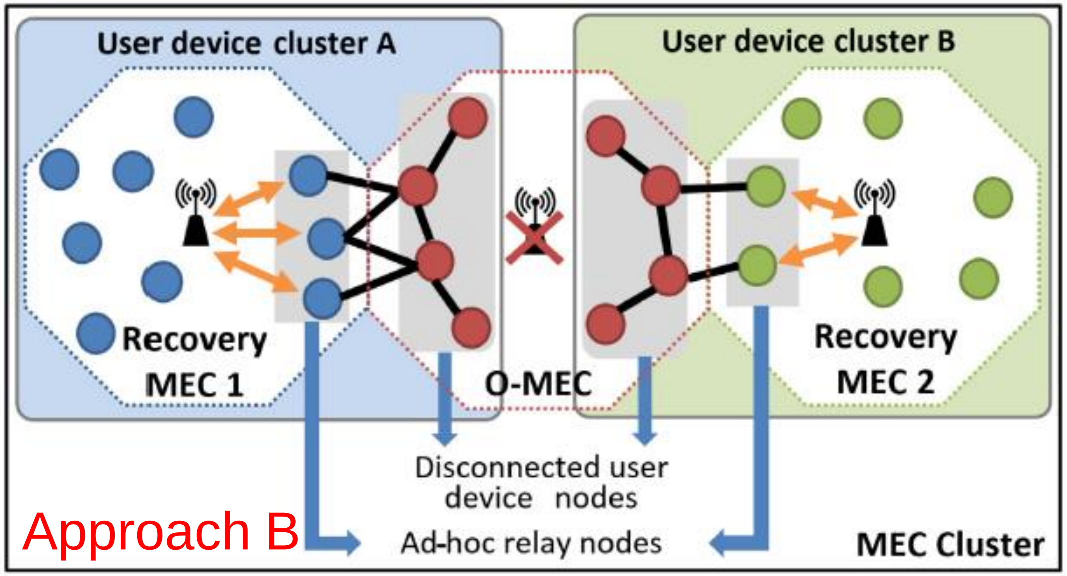
- Hardware level and service level congestion on MEC servers



# Existing work on MEC congestion

- Recovery for overloaded Mobile Edge Computing. [6]
- Approach A, offload tasks to neighbor MEC servers within radio transfer range via overloaded MEC server.
- Approach B, offload tasks to neighbor MEC servers via Ad-hoc relay nodes.




[6] Satria, Dimas, Daihee Park, and Minho Jo. "Recovery for overloaded mobile edge computing." *Future Generation Computer Systems* (2016).

# Solution for service level congestion

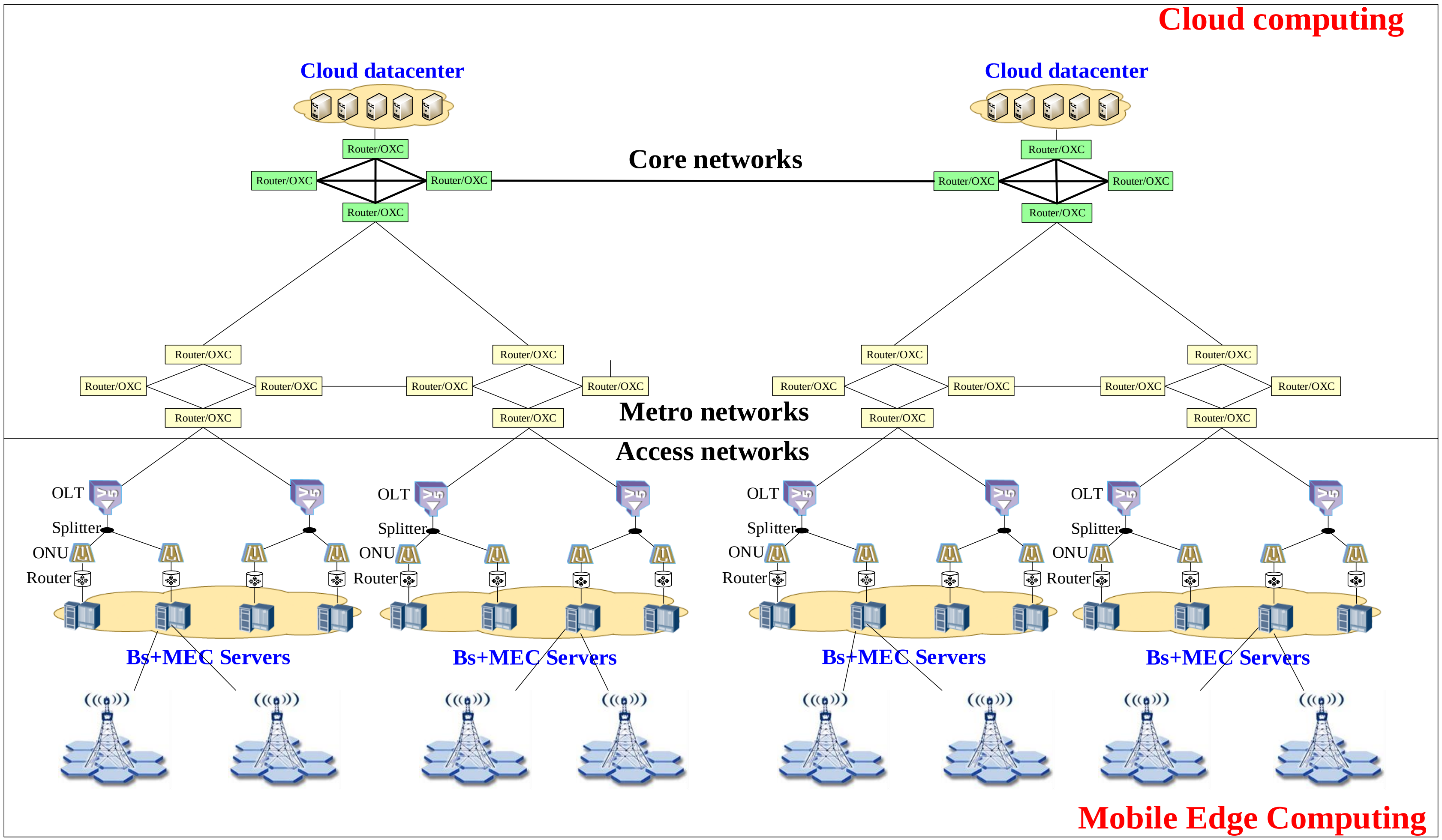
- Latency Aware Routing for Mobile Edge Computing Applications?
- (1)One MEC server serve more and more requests may result in longer processing time, (2)routing some requests to other distant servers will introduce longer transmission time. So, to closest MEC? to other MEC? to Cloud Servers? Minimize total/average latency.

- Dynamic Application Routing and Service Migration?
- (1)Routing some applications to other servers will introduce longer transmission time and extra traffic. While migrate service to closest MEC server need deployment time and introduce extra traffic in core networks. So, route requests to other servers or migrate the required service to closest MEC or other MECs? Minimize latency? energy? traffic?

# Future works

- Clarify the network architecture between MEC server and public cloud and the corresponding resource model
- Clarify the resource model of IT infrastructures in Cloud datacenter and MEC server.
- Clarify the consumption relationship between MEC service and IT&network resources.
- Find out the candidate solutions to deal with MEC server failure or congestion.

# Network architecture for MEC

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Comments on this topic?

# Thank you!

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