Paper Review

Mobile Edge Computing Empowered Fiber-Wireless Access Networks in the 5G Era

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UCDAVIS

Motivation

- Reduce congestion on backhaul
- Support diverse traffic: human-to-human (H2H) traffic (e.g., voice, data, and video) and emerging types of traffic (e.g., machine-centric communications)
- Network integration (wired and wireless)

Mobile Edge Computing

- Transform base stations into intelligent service hubs
- Provides backhaul with real-time information about radio access network (RAN) and traffic requirements
- MEC offers low latency and throughput providing a pathway for 5G

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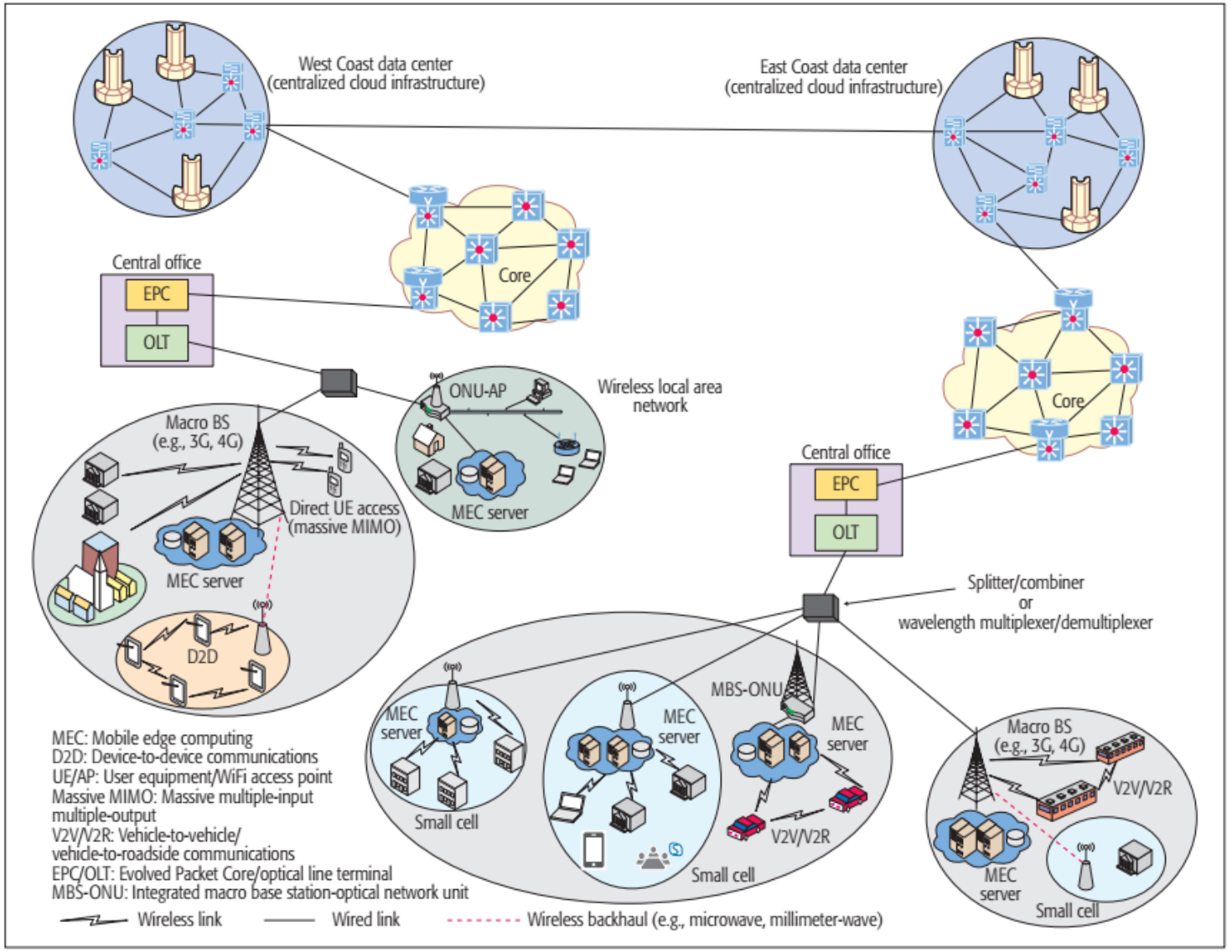

Figure 1. Illustration of mobile edge computing and cloudification of 5G networks.

Ethernet-based FiWi access networks

- Ethernet to be used to transport Common Public Radio Interface (CPRI) frames (C-RAN)
- Ethernet-based FiWi provide a solution for broadband access, mobile backhaul (e.g., IEEE 802.3ah EPONs) and Ethernet-based front-end (e.g., IEEE 802.11 WLANs)
- MEC servers are integrated at edge of FiWi networks.

MEC: Service Scenarios and Challenges

- Edge Video Orchestration and Distributed Caching
- Backhaul Optimization
- Vehicle-to-Vehicle/Roadside (V2V/V2R) Communications
- Internet of Things Services

Design Challenges

- Network Integration and Coordination
- Distributed Resource Management
- Coexistence of H2H and MEC traffic
- Cloud and Cloudlet Coexistence
- Reliability and Mobility

MEC over FiWi Network Architecture

	Conventional D-RAN	Cloud-RAN	Emerging cloudlet enhanced D-RAN
Base stations	Standard complexity and high cost	Lower complexity, conceivably cheaper	Lower complexity and cheaper
Diversity gains	Per-BS diversity gains	Multiplexing and computational (multi-user) diversity gains	Both multiplexing and computational diversity gains at the network edge
Hardware resources	Dedicated digital signal processors (DSPs) or application-specific integrated circuit implementations	High-volume commodity hardware (e.g., general-purpose processors)	High-end rack servers, cloudlets, Nokia Siemens Networks' radio applications cloud server
Backhauling	Backhaul links of up to several tens of kilometers, leading to high latencies in the range of several tens of milliseconds	1) Backhaul links with critically higher throughput required and latency on the order of a few milliseconds; 2) CPRI is widely used for fronthaul interface	1) Significantly lower round-trip latency and real-time information offered within RAN; 2) Ethernet-based (e.g., IEEE 1904.3) and virtual networking techniques in the fronthaul in support of variable bit rates
Flexibility	Hardware driven	Software driven	1) Driven by both hardware and software (e.g., Nokia Liquid Application, RACS, OpenStack++); 2) multipoint-to-multipoint communication
Programmability	Based on DSP	Based on general-purpose processor	Supports both DSP and general-purpose processor

Table 1. Comparison of conventional D-RAN, C-RAN, and emerging cloudlet enhanced D-RAN.

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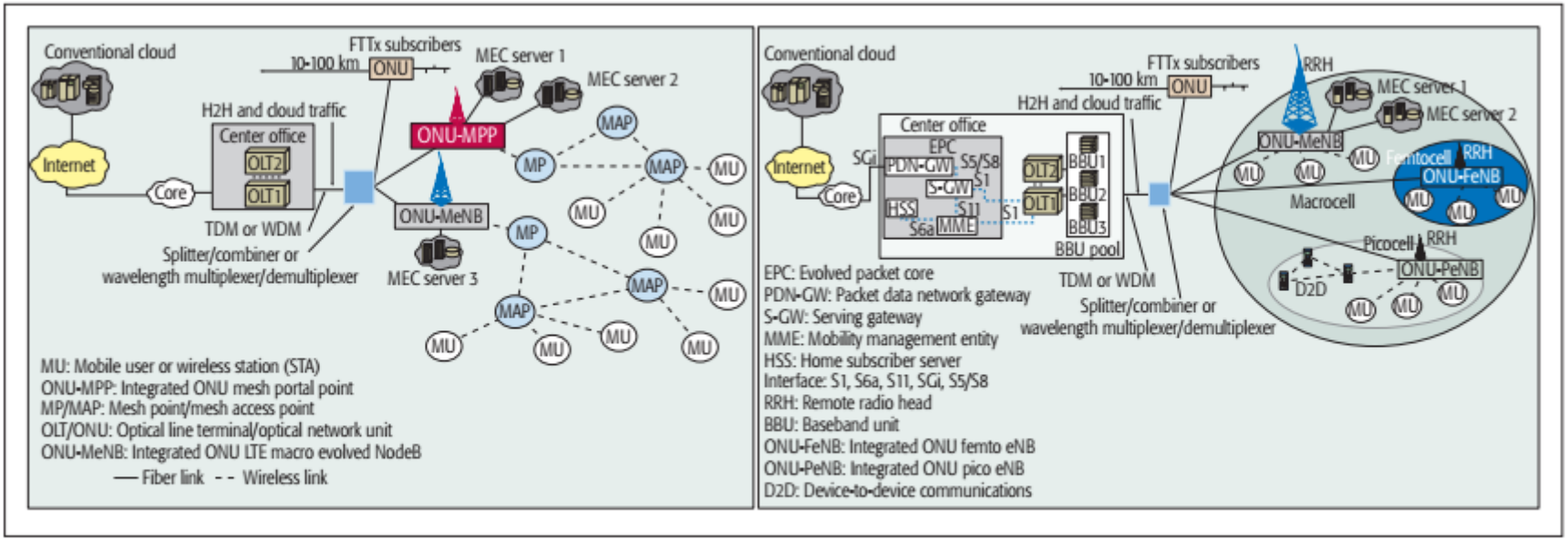

Figure 3. MEC over FiWi network architectures: a) MEC over Ethernet-based FiWi networks and MEC over 4G LTE-based FiWi networks; b) coexistence of MEC and C-RAN over FiWi enhanced 4G LTE HetNets.

TDMA for resource managment

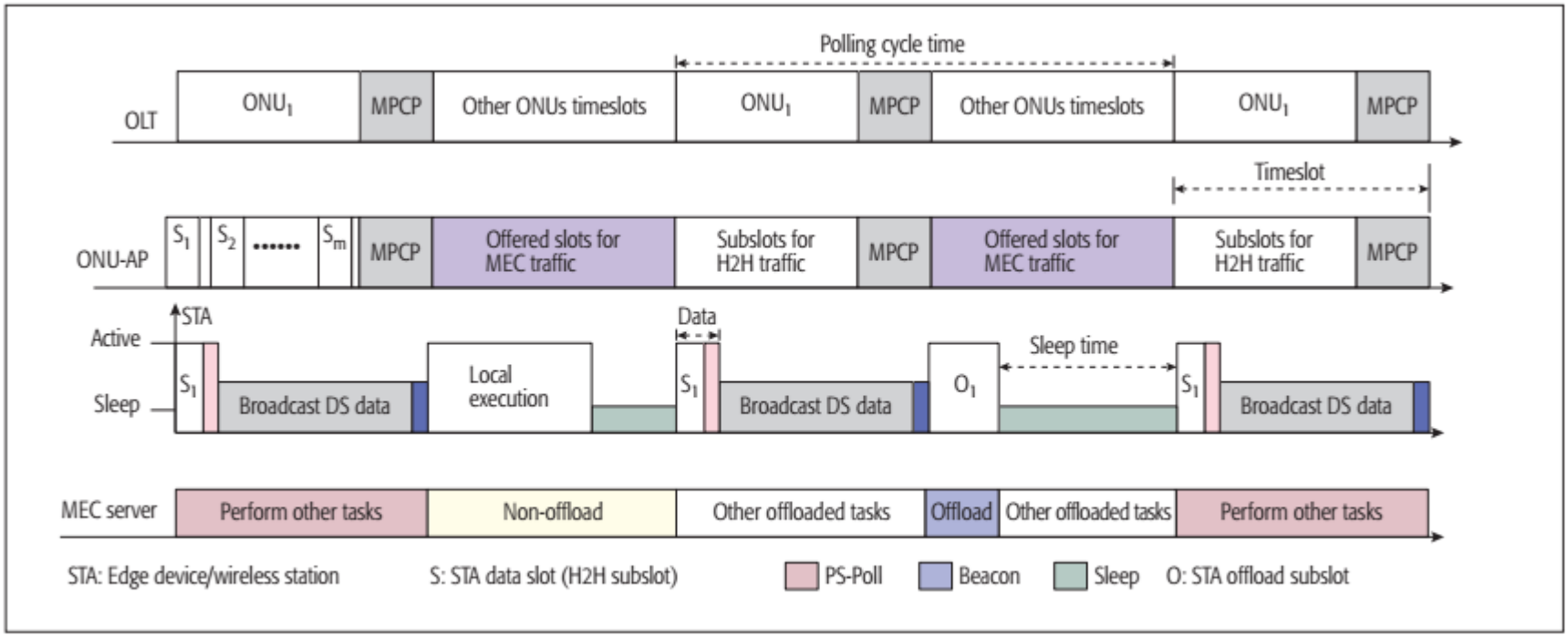

Figure 4. Illustration of TDMA-based unified resource management scheme and sleep mode for MEC over WLAN-based FiWi networks.

Performance Evaluation

- Computation offloading: offloading compute-intensive tasks to an MEC server
- Offloading should be performed if the time to execute a task locally (on edge device) is more than response time of offloading that task onto an MEC server. This difference is called *offload gain*.
- *Response time efficiency*: ratio of the offload gain and response time of a task that is locally executed on edge devices.

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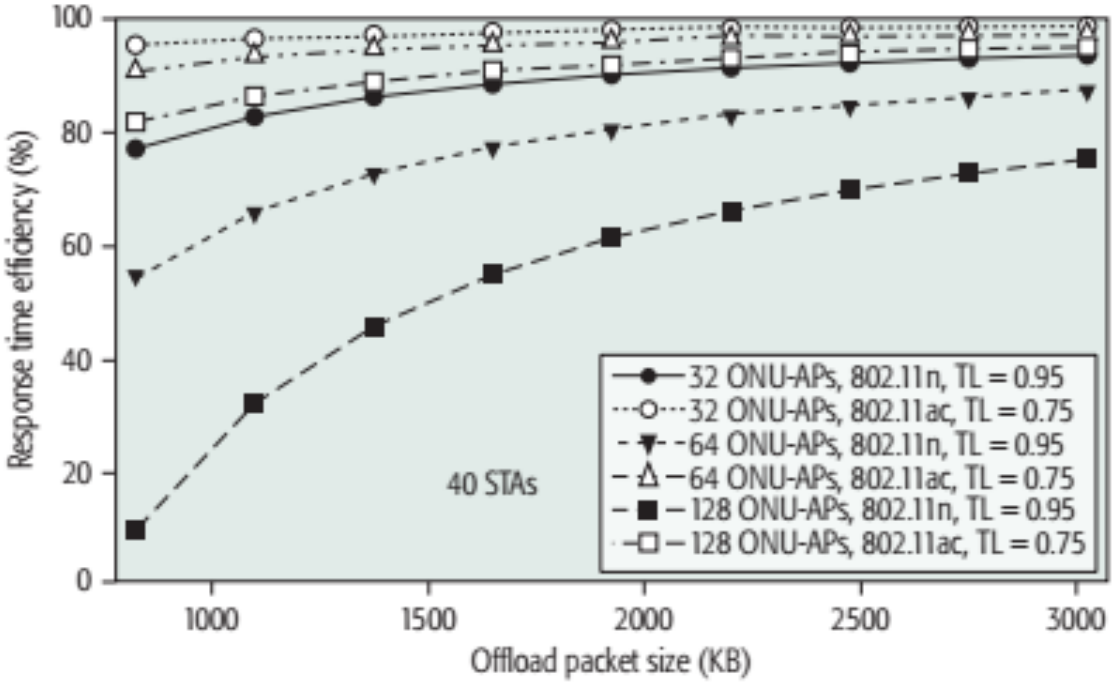
Response time efficiency (%)
100
80
60
40
20
0
1000
1500
2000
2500
3000
Offload packet size (KB)
40 STAs
32 ONU-APs, 802.11n, TL = 0.95
32 ONU-APs, 802.11ac, TL = 0.75
64 ONU-APs, 802.11n, TL = 0.95
64 ONU-APs, 802.11ac, TL = 0.75
128 ONU-APs, 802.11n, TL = 0.95
128 ONU-APs, 802.11ac, TL = 0.75

Overview

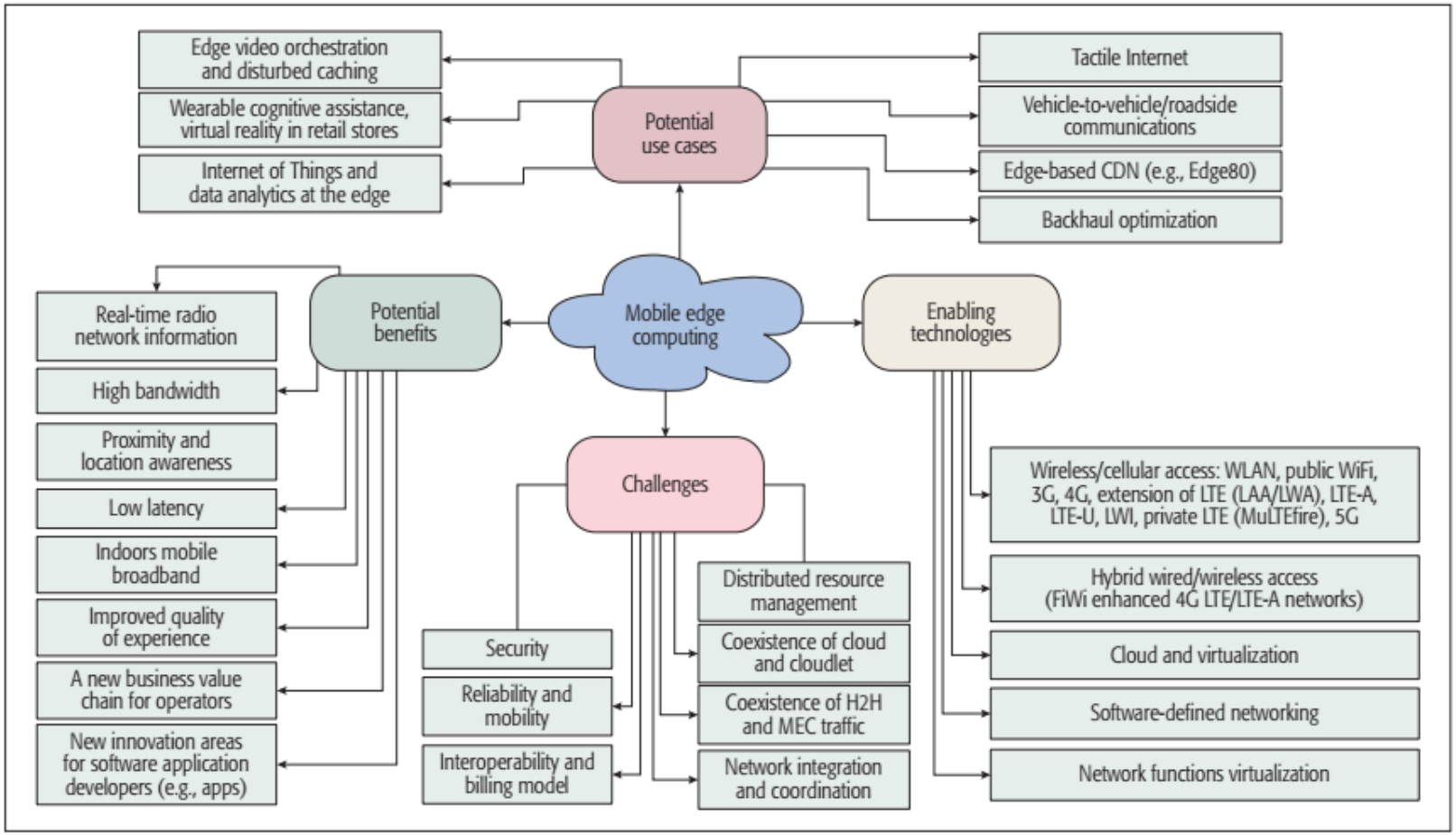

Figure 2. Overview of mobile edge computing: benefits, potential use cases, enabling technologies, and challenges (LWA: LTE and WiFi aggregation, LAA: licensed assisted access, LTE-U: LTE Unlicensed, LWI: LTE/WiFi interworking, CDN: content delivery network).

Contributions

- Empower integrated fiber-wireless (FiWi) access networks to offer MEC capabilities
  - Different RAN technologies like WLAN, 4G LTE, LTE-A HetNets
  - Accounting for both network architecture and resource management