MEC IN ACTION: AN OVERVIEW OF EDGE COMPUTING ACTIVITIES

Part 1

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Presentation at the

W3C®

Web & Networks IG

https://www.w3.org/wiki/Networks

Agenda

- Intro on edge computing
- ETSI MEC standard
  - MEC V2X API and Predictive QoS
- Use cases of interest
- 5GAA
  - Predictive QoS
  - MEC demo
- Conclusions

Part 1

Abstract

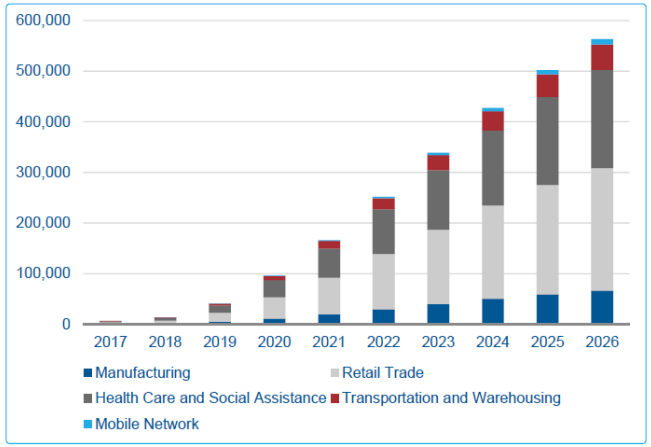
The talk will be focused on Intel activities on edge computing, ranging from standardization (e.g. ETSI MEC), industry groups (e.g. 5GAA – 5G Automotive Association) and mentioning also some PoCs and experimental activities.

Particular focus will be given to MEC use cases of potential interest for W3C (e.g. application offloading), and on Intel engagement in the automotive domain (mentioning a recent 5GAA Demo on MEC and predictive QoS).

Intro on Edge Computing

Edge - Market Forecasts

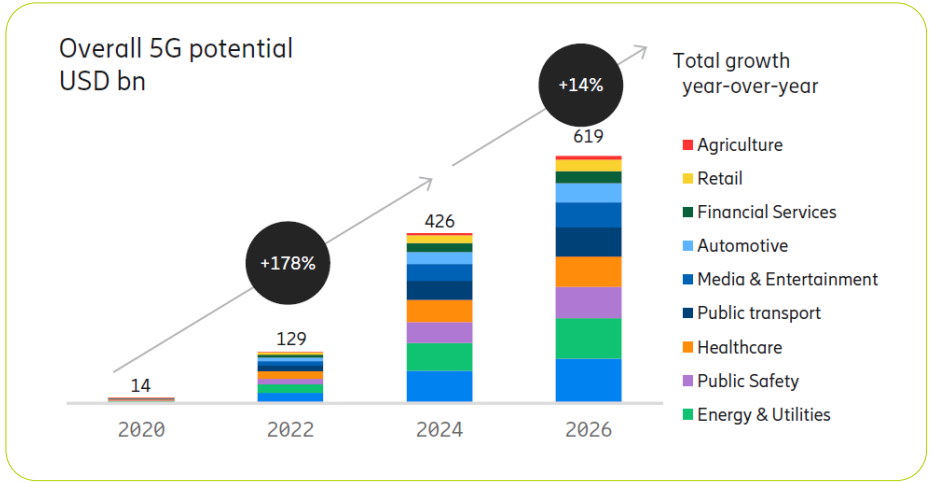
Figure 5: U.S. MEC Installations



Source: iGR, 2017

- MEC incorporates the benefits of virtualization and cloud-computing in order to place high-powered computing capabilities as close as possible to subscribers.
- *The largest number of installations, according to iGR (2017), will be for retail and health care and social assistance. And this forecast was still not considering other emerging verticals (e.g. VR/AR, automotive, industrial automation, …)*

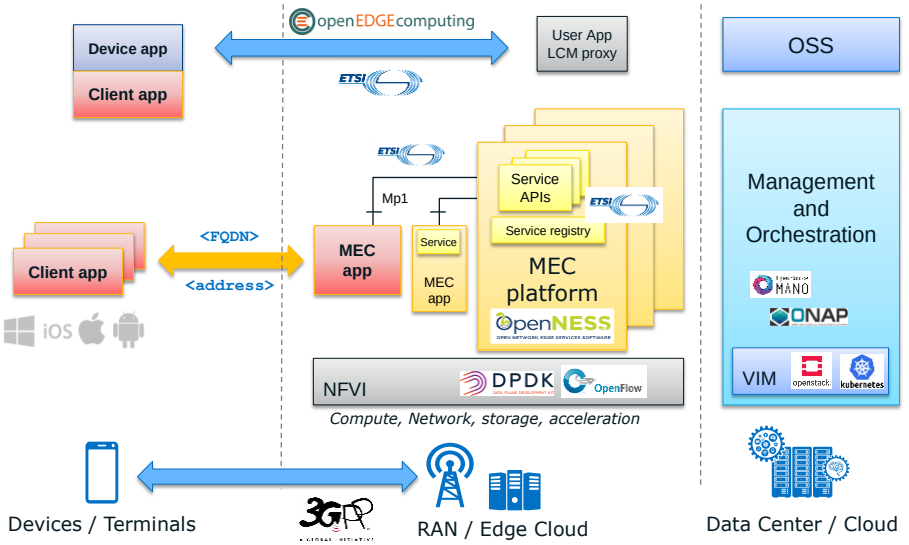
Distributed Cloud unlocks 25% of the 5G operator revenue potential (*)



(*) Source: Ericsson study on 5G business potential

Overview on Edge Computing activities

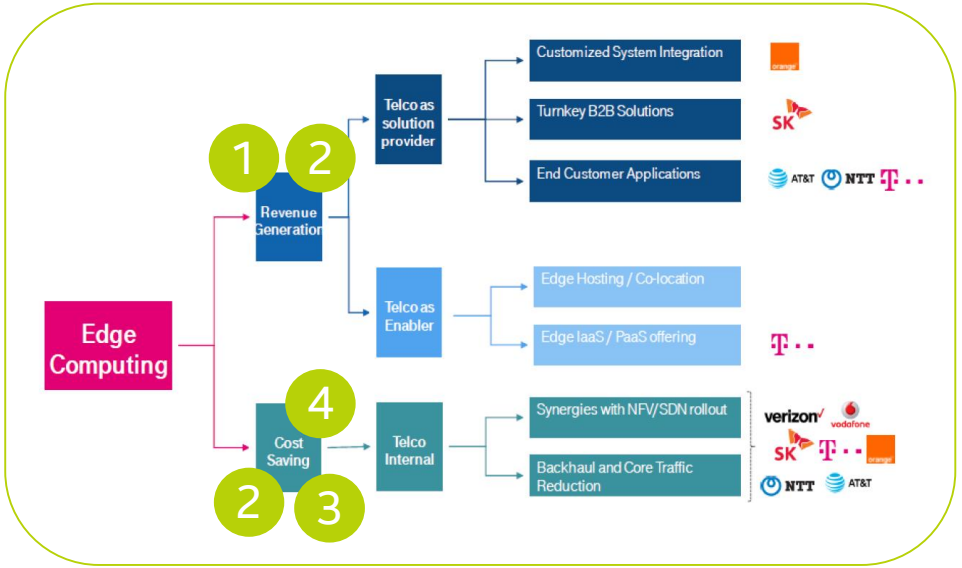
- Many SDOs (ETSI, 3GPP, ..) and industry groups covering different aspects of edge computing.
- Figure shows the different functional entities in the MEC architecture, and their respective SDO/project where they are specified.
  - The MEC platform is a key component in the MEC system that enables applications to discover, advertise and consume MEC services, and provide the virtualization infrastructure with a set of rules for the user traffic forwarding plane
  - **OpenNESS** is an open source reference platform made available by Intel (ref: www.openness.org)
  - 3GPP defines the interfaces needed to implement MEC within the cellular edge and core network



Suggested reading: INTEL White Paper on "Edge Computing: from standard to actual infrastructure deployment and software development"
https://builders.intel.com/docs/networkbuilders/edge-computing-from-standard-to-actual-infrastructure-deployment-and-software-development.pdf

Why MEC ? KPIs and their impact on business

1. Delay improvement
2. Network utilization and cost savings
3. Energy efficiency, TCO analysis
4. Computational and Networking resources



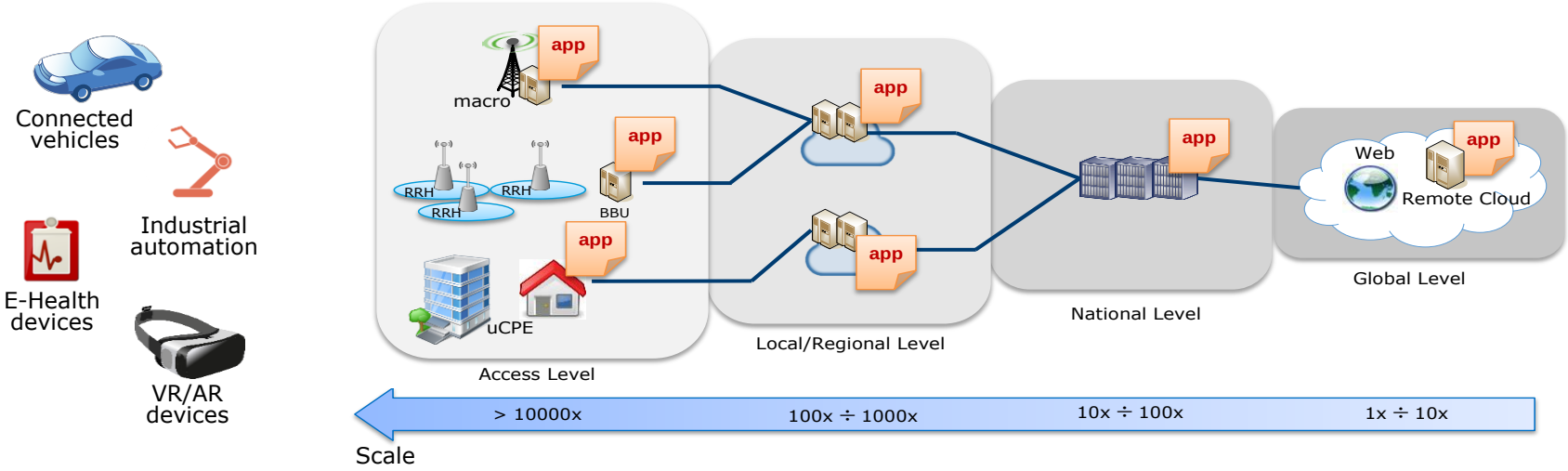
- Motivation for these KPIs comes from e.g. current positioning of operators (*)
- Also importantly, performance metrics are applications-specific as they are tailored to vertical segments (e.g., automotive, industrial automation, VR/ AR etc.).
- Performance assessment of MEC is key.

Suggested reading
An INTEL paper [10] on MEC-enabled delay performances, published for EUCNC 2018 (receiving also a Best Paper Award! ☺)

(*) A. Manzalini (TIM), "Multi-access Edge Computing: Decoupling IaaS-PaaS for enabling new global ecosystems", Berlin 19-20 Sept 2018, Edge Computing Congress, 2018

Where is the *edge*?

- MEC performance should be compared against different deployment options
- MEC gains depends also on the vertical / use case



ETSI MEC

ETSI MEC (Multi-Access Edge Computing)

Pioneering open standards for Edge Computing

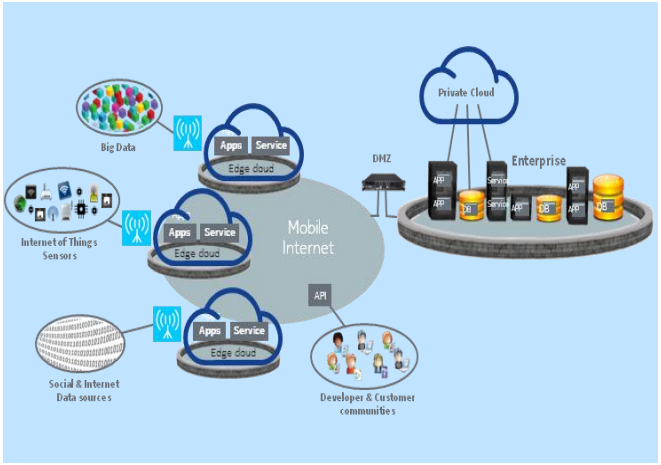
- Since 2014

First and leading international Standard available on this space

INTEL is one of the founding members, and now again part of the MEC leadership, with the position of ETSI MEC vice-chairman and Lead of Industry Groups.

Leadership across Ecosystem

Hewlett Packard Enterprise, NOKIA, intel, VIAVI, vodafone, HUAWEI



Cloud-computing at the network edge.

- Proximity
- Ultra-low latency
- High bandwidth
- Real-time access to access network and context information
- Location awareness

Broad Participation

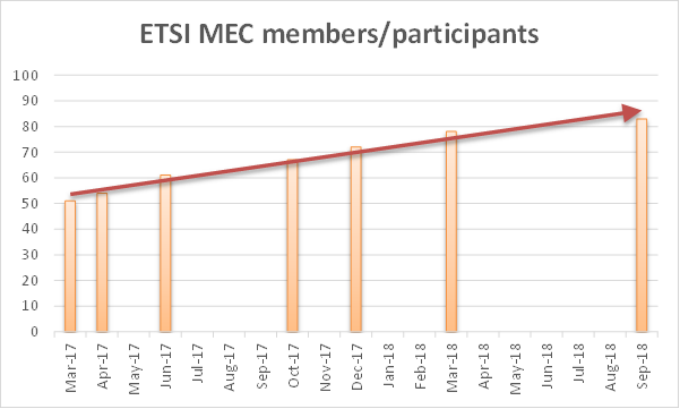
NOKIA, HUAWEI, intel, docomo, VIAVI, ZTE, InterDigital, SONY, AVENIR, ADVA, Saguna, uc3m, virtuosys, Telefónica, AT&T, Accelleran, Türk Telekom, TIM, KEYSIGHT TECHNOLOGIES, IBM, SURREY, orange, CTTC, GSMA, JUNIPER NETWORKS, INTRACOM TELECOM, flex, TNO, COBHAM, NETAS, kpn, NEXTWORKS, Tech Mahindra, ACS, ASTRI, SAMSUNG, affirmed, CPLANE NETWORKS, Akamai

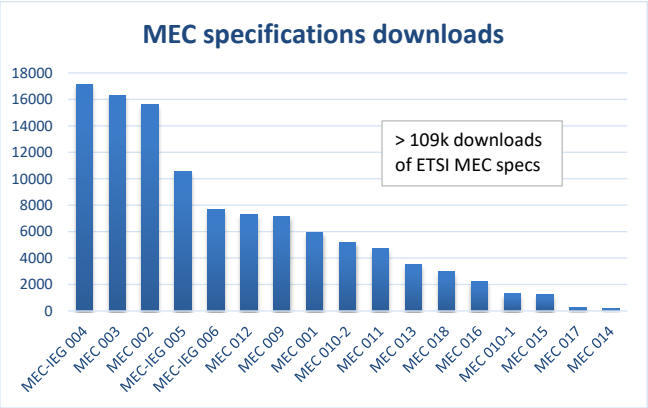
Now counting 98 partners among MEC members and participants

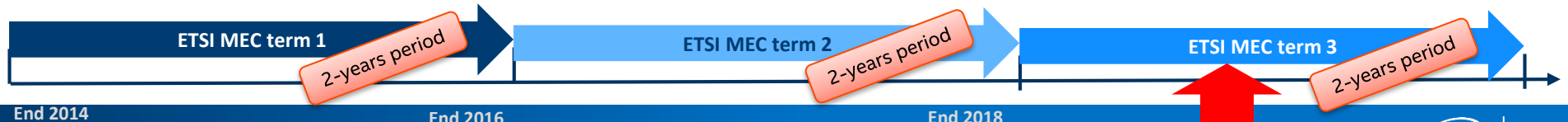
What is “MEC“ ?

Multi-access Edge Computing offers to application developers and content providers cloud-computing capabilities and an IT service environment at the edge of the network.

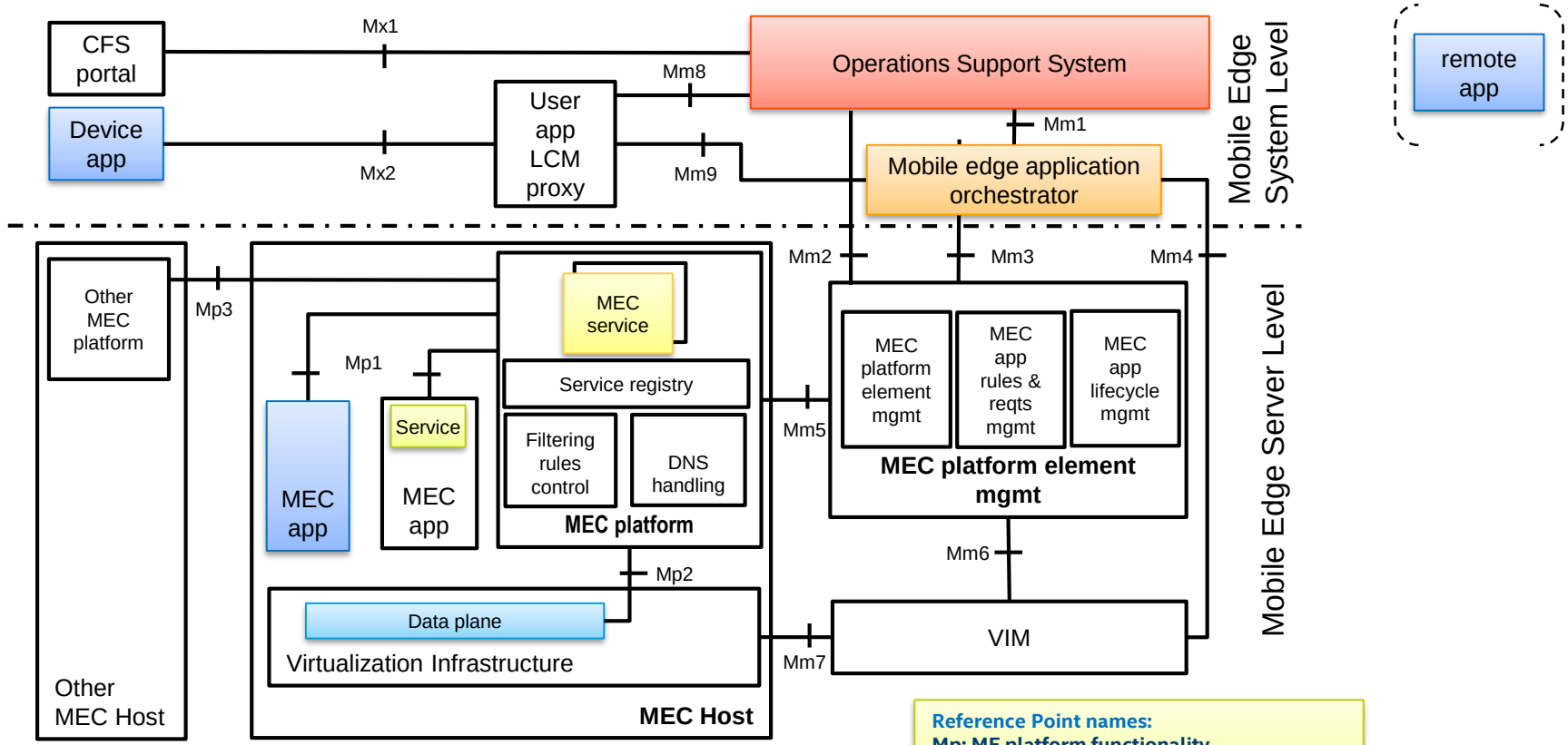
Some statistics:







MEC System Reference Architecture



Reference: ETSI ISG MEC GS MEC-003 "Framework and Reference Architecture"

Reference Point names:
Mp: ME platform functionality
Mm: management
Mx: connections to external entities

MEC Specifications

Divided in 2 categories:

Mobile Edge Service related work

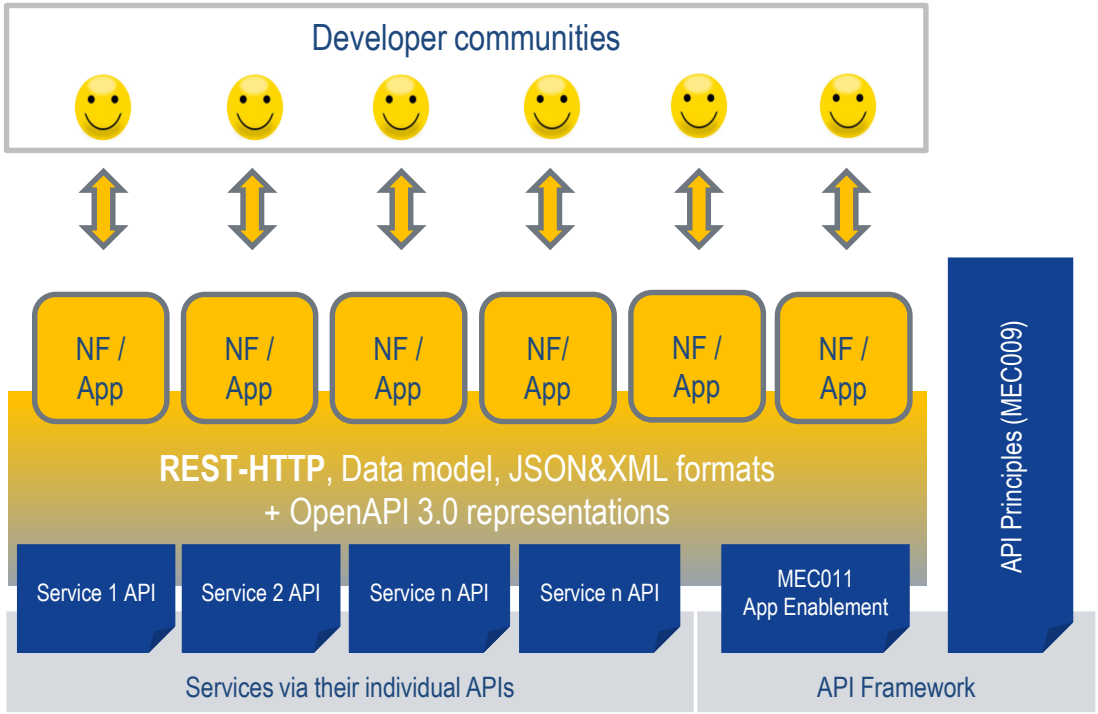
Example:

- **GS MEC 009: General Principles for Mobile Edge Service APIs**
- **GS MEC 012: Radio Network Information API**
- **GS MEC 013: Location API**
- **GS MEC 014: UE Identity API**
- **GS MEC 015: Bandwidth Management API**
- **GS MEC 016: UE Application Interface**

Mobile Edge Platform related work

Example:

- **GS MEC 010-1: System, Host and Platform Management**
- **GS MEC 010-2: Application Lifecycle, Rules and Req. Mgmt**
- **GS MEC 011: Mobile Edge Platform Application Enablement**



OpenAPI description files, MEC-0023

https://www.openapis.org/

Scope: Describing ETSI MEC RESTful APIs using the **OpenAPI** specification.

OpenAPI Specification (aka Swagger Specification)

- Open source framework for defining & creating RESTful APIs
- OpenAPI Specification compliant API description file
  - Inherently includes MEC data structure definitions
  - Machine readable facilitating content validation
  - Allows autocreation of stubs for both service client & server

Motivation with ISG

- Specification accessibility & validation
- Accessibility → Wider adoption: 3rd party developers
- Adoption → Critical review & feedback

Where we are now

- ETSI Repository live: https://forge.etsi.org/
  - Mobile Edge Platform Application Enablement API - GS 011
  - Radio Network Information API - GS 012
  - Location API - GS 013
  - UE Identity API - GS 014
  - Bandwidth Management API - GS 015
  - UE Application Interface API - GS 016
  - Fixed Access Information API - GS 029

Future Plans

- Complete set of APIs available via ETSI Repository
- Currently exploring other approaches towards a more extensive engagement with the developer community.

Ecosystem engagement in MEC

- ## Proof-of-Concepts (PoCs)
  - PoCs are an important tool to demonstrate the viability of MEC, even as an early implementation.
  - List of PoCs: https://mecwiki.etsi.org/index.php?title=Ongoing_PoCs
- ## Hackathons
  - Goals: MEC promotion and SW developers engagement, feedback to the standards, MEC innovation.
  - Hackathon framework published by ETSI as open call for proposers: https://mecwiki.etsi.org/index.php?title=MEC_Hackathon_Framework
  - Many Hackathons organized worldwide since September 2018
- ## MEC Deployment Trials (MDT)
  - From PoC to proof of viability in a Live Network environment.
  - List of new MDT projects recently approved by MEC: https://mecwiki.etsi.org/index.php?title=Ongoing_MDTs

Coming soon:

DROIDCON MEC Hackathon
14-15 April 2020

https://it.droidcon.com/2020/hackathon/

MEC V2X API

MEC V2X API

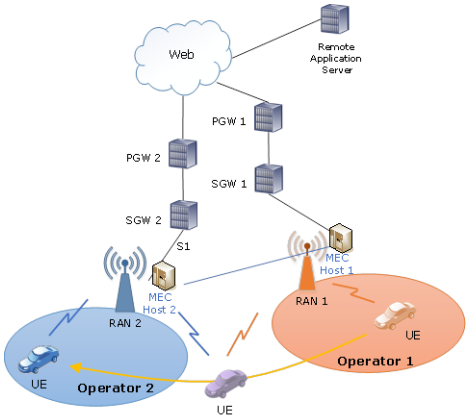
- The MEC standards have been designed to facilitate V2X interoperability in a multi-vendor, multi-network and multi-access environment. The introduction of the VIS API (V2X Information Service API) is aimed at helping the ecosystem adopt MEC for automotive use cases.
- The MEC VIS includes the following functionalities:
  - Gathering of PC5 V2X relevant information from the 3GPP network (e.g. the list of authorized UEs, the relevant information about the authorization based on the UE subscription and the relevant PC5 configuration parameters).
  - Exposure of this information to MEC apps (also potentially belonging to different MEC systems).
  - Enablement of MEC apps to communicate securely with the V2X-related 3GPP core network logical functions (e.g. V2X control function).
  - Enablement of MEC apps in different MEC systems to communicate securely with each other.
  - Possibly gathering and processing information available in other MEC APIs (e.g. RNI API, Location API, WLAN API etc.) in order to predict radio network congestion and provide suitable notifications to the UE.
- From that perspective, the VIS service is relevant to Mp1 and Mp3 reference points of MEC architecture.

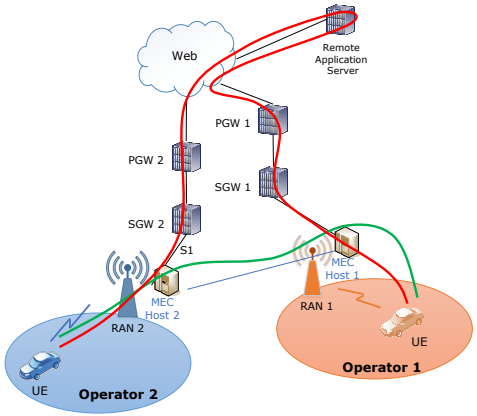
Suggested reading: ETSI MEC V2X API – stable draft
https://docbox.etsi.org/ISG/MEC/Open/mec0030v2010_stable%20draft.pdf

Multi-operator scenarios and V2X services

The left hand side of the figure shows a typical multi-operator scenario, highlighting the case of temporary absence of radio coverage, e.g. in roaming situations.

As showed in the right-hand side of the figure, in a traditional V2X system (without the VIS service) the interconnection between MNOs is terminated at the remote side, with clear disadvantages in terms of high E2E latency; on the other hand, thanks to the exploitation of the VIS service (enabling also a "horizontal communication" between MEC systems), the interconnection between MNOs can be realized with low E2E latency.





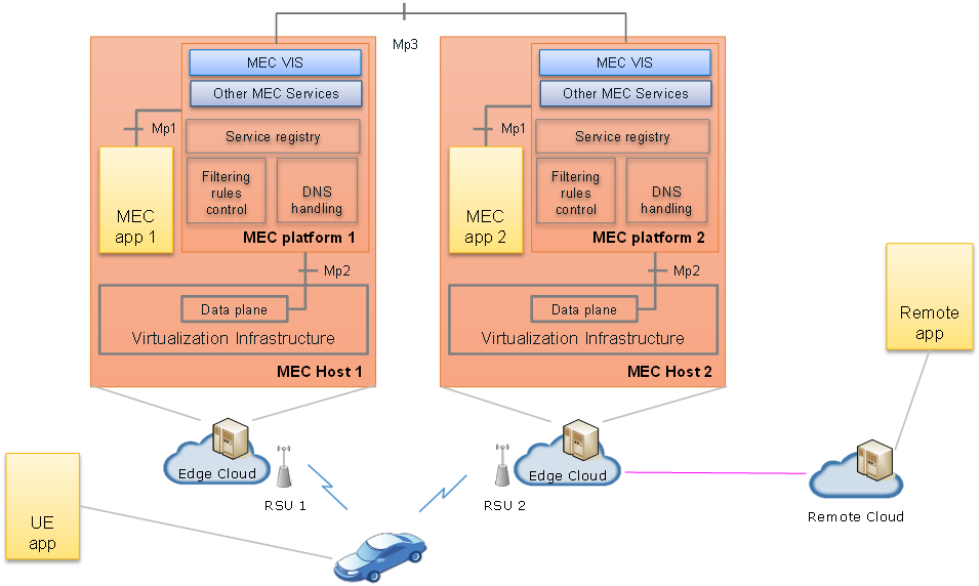
Ref: MEC030 GS stable draft, available at the following link: https://docbox.etsi.org/ISG/MEC/Open/mec0030v2010_stable%20draft.pdf

Example of application instances in a V2X service with VIS API

In the framework of V2X services, a car is hosting a client application, and is connected to a certain MEC host (and a related MEC application).

In presence of multiple MEC hosts, the VIS permits to expose information between MEC applications running on different MEC hosts. In addition, other remote application server instances can be located somewhere else (e.g. private clouds owned by the operator or by the OEM).

The VIS service may be produced by the MEC platform or by the MEC application.



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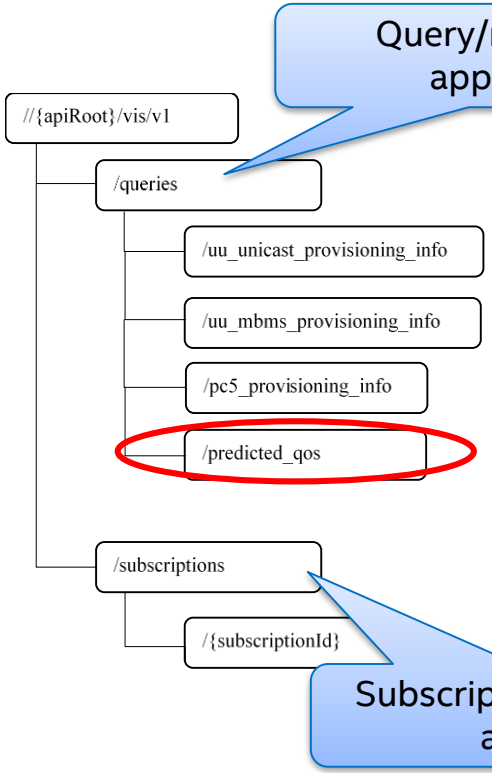
Resource structure of the API



Resource name	Resource URI	HTTP method	Meaning
Uu unicast provisioning information	/queries/uu_unicast_provisioning_info	GET	Retrieve provisioning information required for V2X communication over Uu unicast.
Uu MBMS provisioning information	/queries/uu_mbms_provisioning_info	GET	Retrieve provisioning information required for V2X communication over Uu MBMS.
PC5 provisioning information	/queries/pc5_provisioning_info	GET	Retrieve provisioning information required for V2X communication over PC5.
predicted QoS information	/queries/predicted_qos	GET	Retrieve journey-specific predicted QoS information for a vehicular UE.
all subscriptions for a subscriber	/subscriptions	GET	Retrieve a list of active subscriptions for this subscriber.
		POST	Create a new subscription.
existing subscription	/subscriptions/{subscriptionId}	GET	Retrieve information on current specific subscription.
		PUT	Modify existing subscription by sending a new data structure.
		DELETE	Cancel the existing subscription.
notification callback	Client provided callback reference	POST	Send a notification.

Ref: MEC030 GS stable draft, available at the following link: https://docbox.etsi.org/ISG/MEC/Open/mec0030v2010_stable%20draft.pdf

MEC use cases

(focus on potential interest for the W3C IG)

MEC GS 002: MEC Use cases and requirements

Scope of the deliverable:

This document specifies the requirements (e.g. network integration, application platform services, application portability, security, performance and operations) for MEC with the aim of promoting interoperability and deployments.

Current status

- v1 Published 2016.03 (Phase 1).
- v2 Published 2018.10 (Phase 2).
- Currently a new version of Phase 2 spec is open
  - This work item will record new use cases in an informative annex, specify related new normative technical requirements, and correct errors and omissions in the specification.

Timeline:

- Publication of revision expected 2021Q1.
- https://portal.etsi.org/webapp/workProgram/Report_Schedule.asp?WKI_ID=58905

Use cases from ETSI MEC GS002

Consumer-oriented services. Innovative services that generally benefit directly the end-user, i.e. the user using the device. This can include:

- gaming;
- remote desktop applications;
- augmented and assisted reality;
- cognitive assistance;
- Stadium/retail real time services;
- Application computation offloading; 
- etc.

Use cases from ETSI MEC GS002

Operator and third party services: Services that take advantage of computing and storage facilities close to the edge of the operator's network. These services don't usually benefit the end-user, but can be operated in conjunction with third-party service companies:

- active device location tracking;
- big data;
- video analytics and service chaining;
- connected vehicles;
- security, safety;
- enterprise services;
- etc.

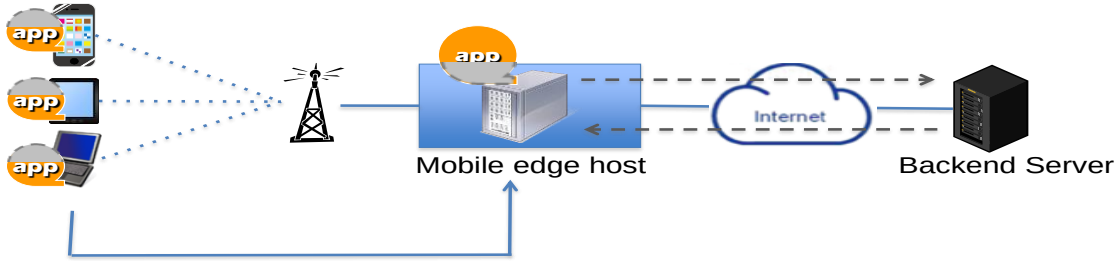
Use cases from ETSI MEC GS002

Network performance and QoE improvements: services generally aimed at improving network performance via application-specific or generic improvements. The user experience is generally improved, but these are not new services provided directly to the end-user:

- content/DNS caching;
- performance optimization;
- video optimization and acceleration;
- etc.

Application Computation Offloading

Application Computation Offloading



- Application computation offloading is one of the use cases enabled by MEC technology [MEC002].
  - The MEC host executes compute-intensive functionalities with higher performance compared to mobile devices, improving user experience. Consumer can use low complexity devices by off-loading compute capacity to the MEC host.
- In particular, the task offloading opportunity depends on the tradeoff between computation (time and energy) for the task execution and energy spent to transmit data (i.e. the input/output of the offloaded task). Then, at the end, the affordability of this offload depends on the specific application considered. Examples:
  - Video processing / AI / ML: characterized by huge data to process, and possibly also by huge data to transfer
  - Antivirus (showcased by EU project TROPIC as example for application offloading): this is instead characterized by smaller amount of data to be transferred. At the end, the task can be conveniently offloaded to a server, with energy benefits for the terminal.

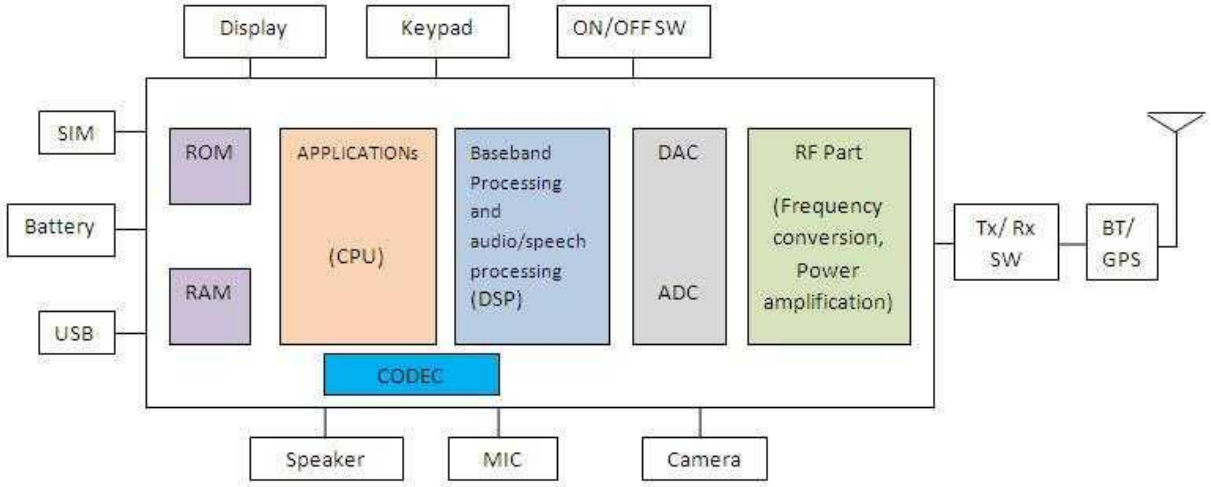
Application computation offloading: motivation

Challenges:

- Increasing challenges on UE energy consumption (radio, app processor, display, etc..)
- Existence of multiple radios in the UE also increases the power consumption.
- In addition, the computational tasks performed by UE are expected to increase

Consequence:

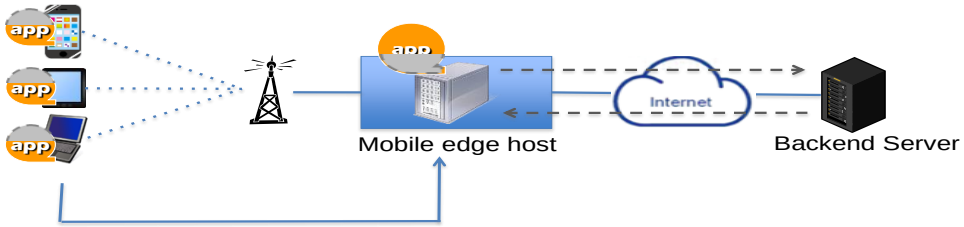
Detrimental impact on energy consumption (given existing UE batteries technologies)



Ref: http://www.rfwireless-world.com/Articles/5G-Cell-Phone-Architecture.html

Possible W3C interest (and synergy with MEC)

- Current solutions on application offloading are proprietary (not standardized).
- There could be a need to trigger this offloading process from the client side, e.g. asking for (edge) cloud resources directly from the terminal (/ browser).
- A possible new Web API definition in W3C could benefit from these cloud resources, e.g. also by exploiting tasks/functionalities and processing capabilities running on a MEC host.
  - In this perspective, the existing MEC specifications can be the best "counterpart" of this potential W3C standardization work. (Further MEC enhancements – although not planned - may potentially include e.g. standardizing some specific server side APIs, and/or enhance the interface between the browser and the MEC system).



Part 2

5GAA

(5G Automotive Association)

Part 2

predictive QoS in 5GAA

Part 2

5GAA

Intel Demo on MEC

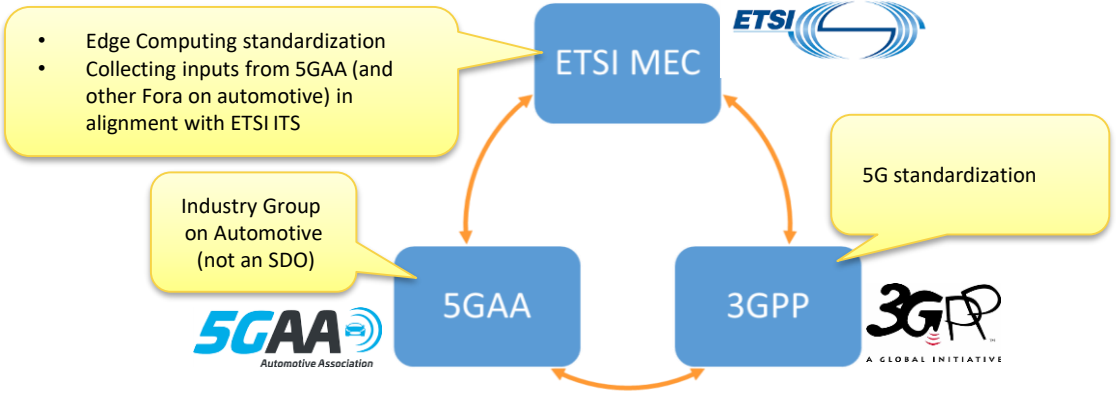
https://5gaa.org/news/5gaa-live-demos-show-c-v2x-as-a-market-reality/

intel
experience what's inside™

Conclusions

Conclusions ☺

- Edge computing is commonly recognized as an important technology for 5G
- ETSI MEC (Multi-access Edge Computing) is leading international standard for Edge Computing (more recently also 3GPP started a work on edge computing for supporting 5G communication networks).
- Edge Computing (/MEC) is access agnostic (applicable to 5G, WiFi, fixed networks, …) and also covering **many verticals** like automotive, as well as other industrial use cases.
  - Example below: synergy between standards and 5GAA (5G Automotive Association)



Examples of **industry groups** relevant for ETSI MEC:

- 5G-ACIA (Alliance for Connected Industries and Automation)
- 5GAA (5G Automotive Association)
- AECC (Automotive Edge Computing Consortium)
- VR-IF (Virtual Reality Industry Forum)
- OFC (Open Fog Consortium)
- SCF (Small Cell Forum)
- GSMA (MEC working group)
- BBF (BroadBand Forum)

INTEL is board member in 5GAA and 5G-ACIA, also in VR-IF and present in many other industry groups

Ref [5]: an Intel-driven 5GAA White Paper on Edge Computing http://5gaa.org/wp-content/uploads/2017/12/5GAA_T-170219-whitepaper-EdgeComputing_5GAA.pdf

Thank you!

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