What can MEC do and what its infrastructures need?

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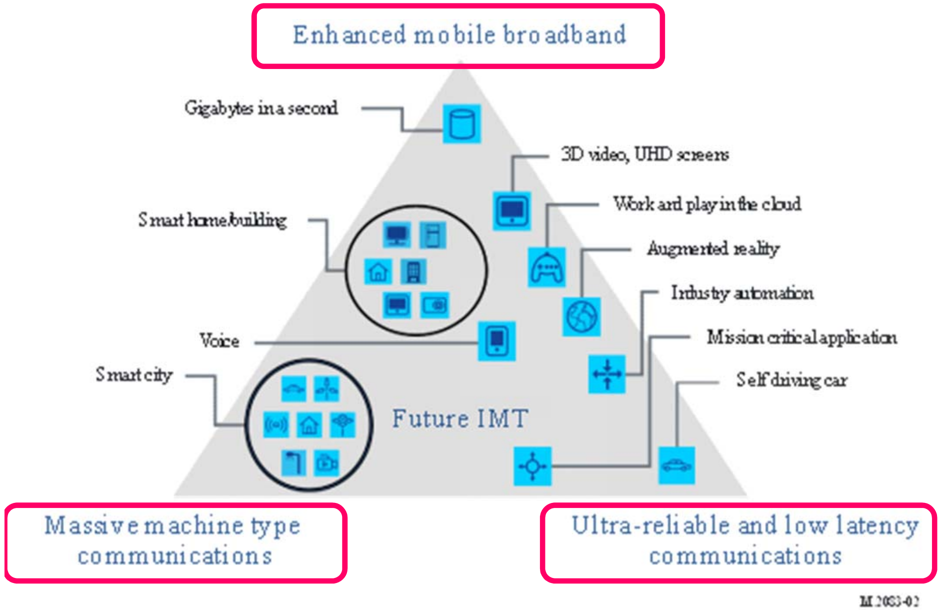
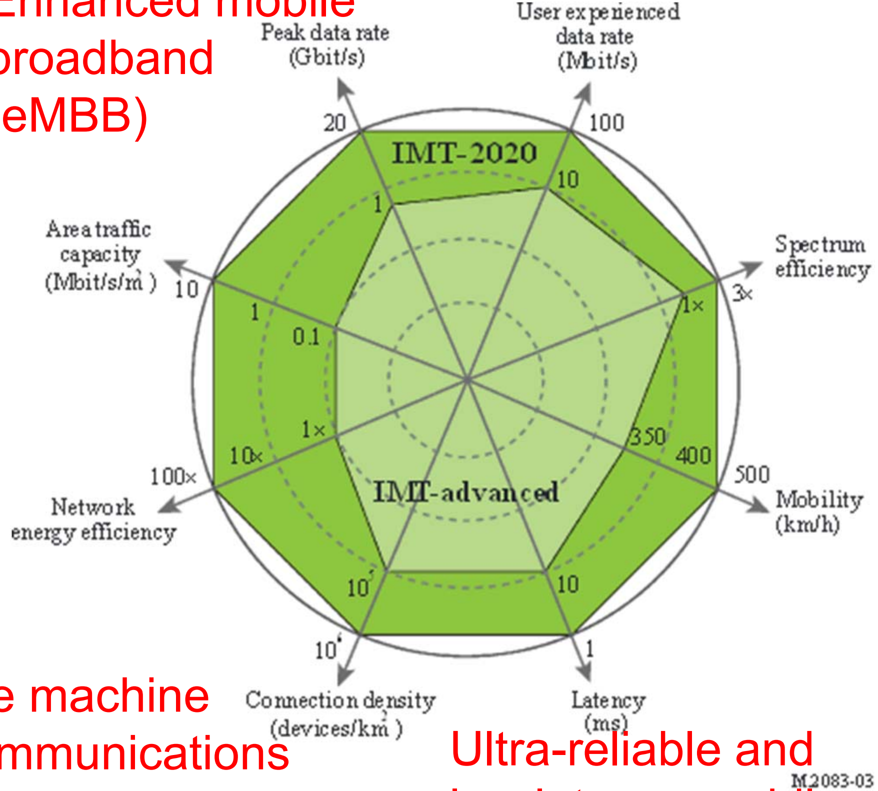
5G capabilities



Enhanced mobile broadband (eMBB)



Massive machine type communications (mMTC)

Ultra-reliable and low latency mobile communications (URLCC)

Rec. ITU-R M.2083-0

Three key capabilities of 5G

eMBB
(enhanced Mobile BroadBand)

URLLC
(Ultra Reliable Low Latency Communication)

mMTC
(massive Machine Type Communication)

Not all of these features are required for all applications

5G and virtualization

- In 5G systems, the infrastructure is virtualized
  - Multiple slices are provisioned to support various applications
  - Network Softwarization

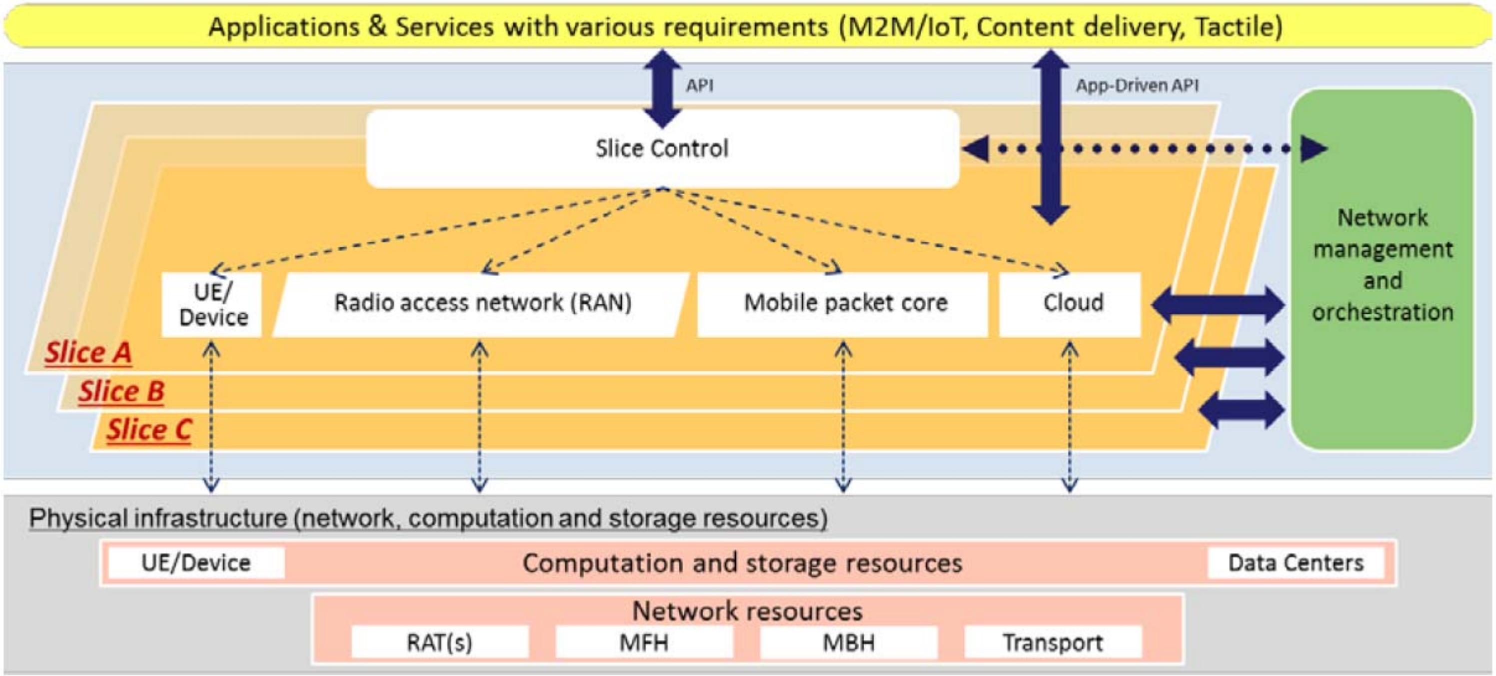


Fig. 12.2-1 Network softwarization view of 5G systems

5GMF White Paper "5G Mobile Communications Systems for 2020 and beyond"

5G Slices

- Depending on the application, requirements for a slice (bandwidth, latency, #of devices) are different

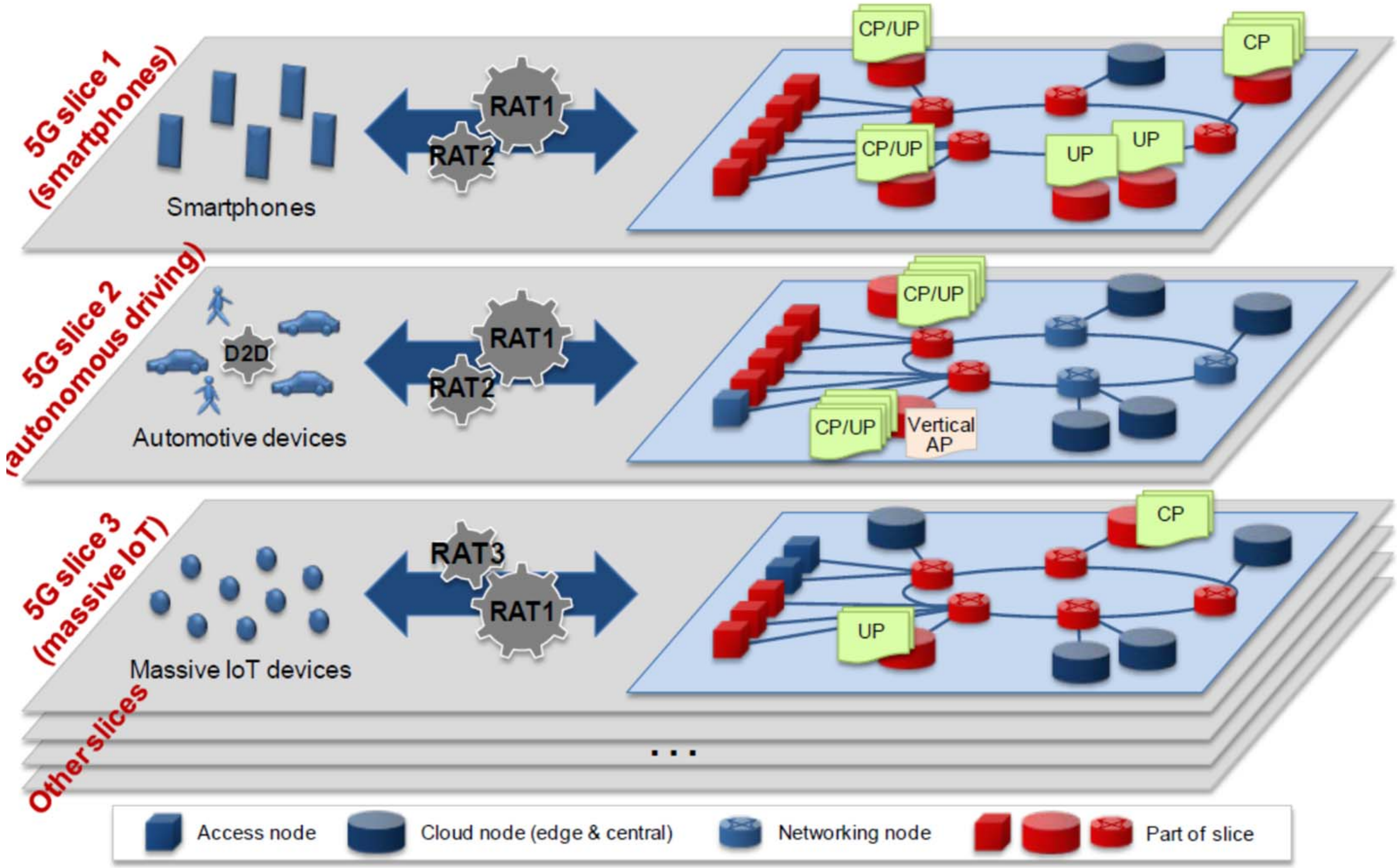


Figure 9: 5G network slices implemented on the same infrastructure

Enhanced mobile broadband (eMBB)

Ultra-reliable and low latency mobile communications (URLCC)

Massive machine type communications (mMTC)

NGMN 5G White Paper

Advantages of virtualization includes:

- Increase resource usage efficiency
  - Physical resource can be shared by multiple virtual infrastructures
  - Greener, lower cost
- Increase portability of processing
  - Provisioning and migration of processing environment becomes easy
  - The same template can be used anywhere

What is “MEC”

- Multi-access Edge Computing
  - Edge computing (standard) of 5G mobile network. Standardized at ETSI (European Telecommunications Standards Institute).
  - Multi-access Edge Computing: system which provides an IT service environment and cloud-computing capabilities at the edge of an access network which contains one or more type of access technology, and in close proximity to its users
    - Includes wired, WiFi, LPWA etc.
- Called “Mobile Edge Computing” until 2018
  - Definitions are slightly different
    - mobile edge system: special kind of MEC system that is a collection of mobile edge hosts and mobile edge management necessary to run mobile edge applications within an operator network or a subset of an operator network

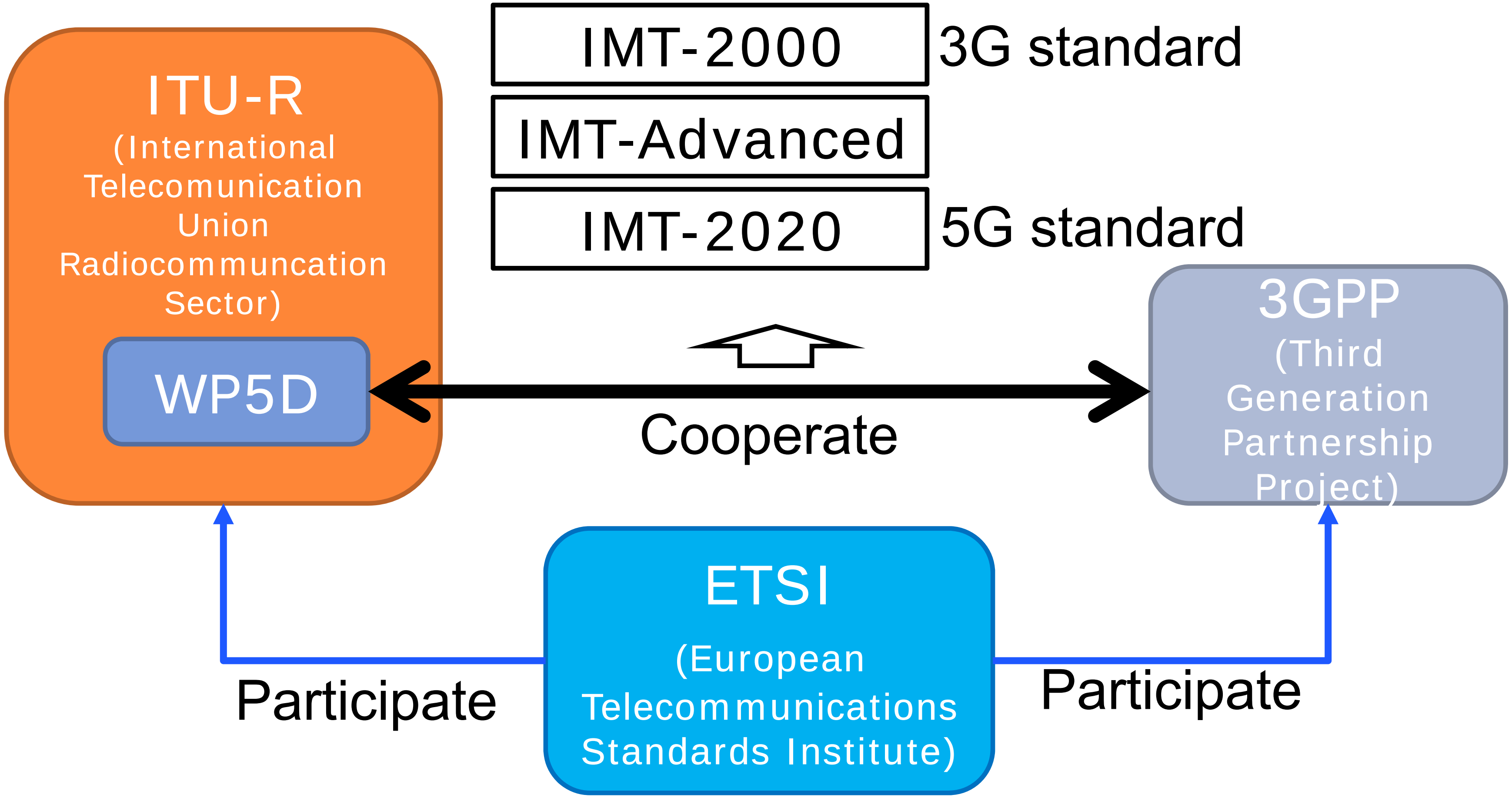
ETSI GS MEC 001 V1.1.1 (2016-03) Mobile Edge Computing (MEC); Terminology

ETSI White Paper No. 11 Mobile Edge Computing A key technology towards 5G

What is “Edge”

- No clear definition
  - Device edge：At devices such as mobile device and IoT censors which are at the “ultimate edge” of the network.
  - Network edge（Telco Edge)： Network connection point where device edges are connected.
- The “edge” of MEC is the network edge

5G standard and MEC



NFV (Network Function Virtualization)

<u>MEC (Multi-access Edge Computing)</u>

MEC market

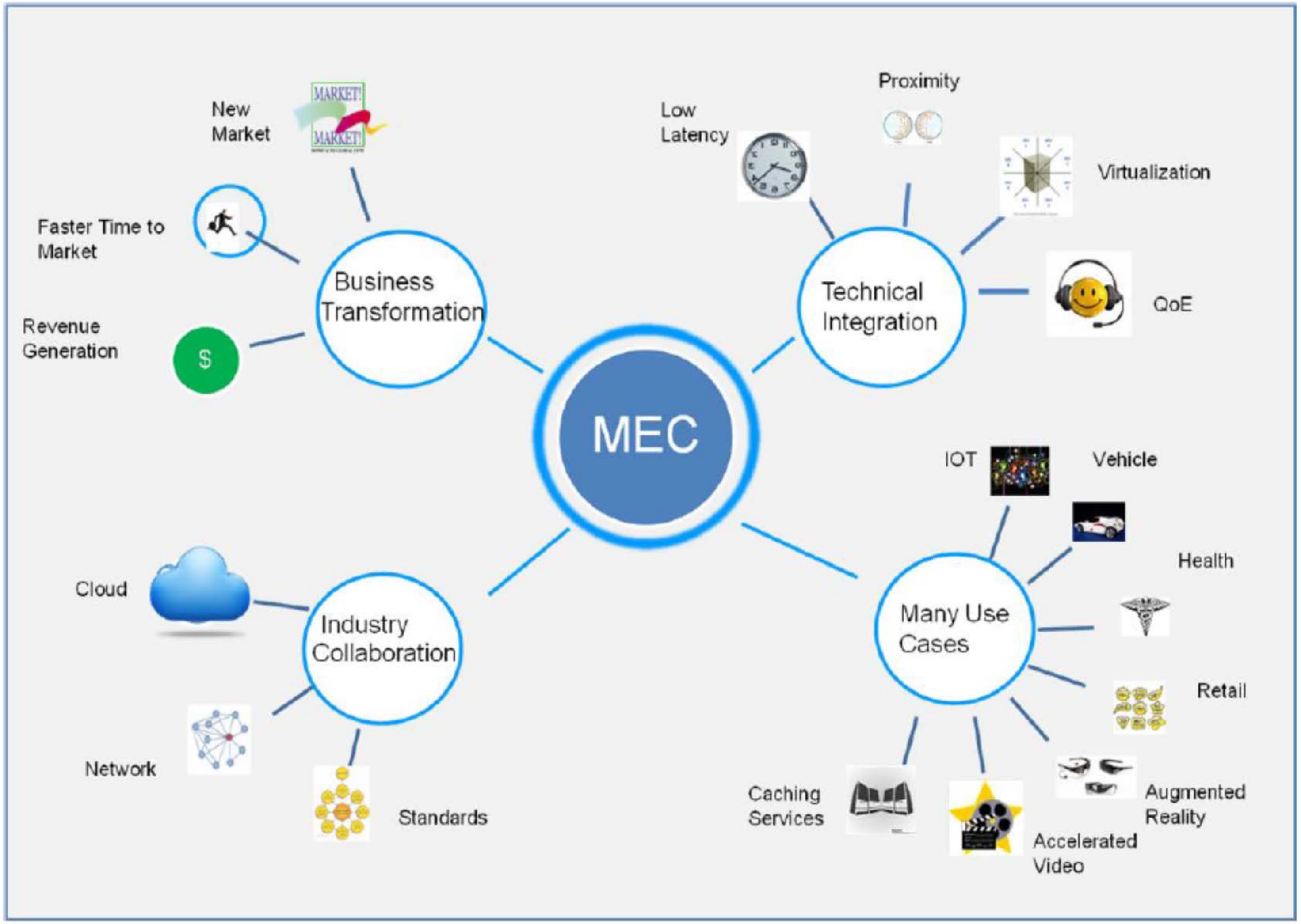


Figure 1: MEC market drivers

https://www.etsi.org/images/files/ETSIWhitePapers/etsi_wp11_mec_a_key_technology_towards_5g.pdf

Advantages of MEC

- Task offload
  - Edge devices can offload tasks to proximal MEC, lowering performance and power requirements
- Low latency
  - Enables applications to run in local environment and improves performance and user experience, leveraged by the ultra low-latency feature of 5G
  - Real-time processing
- Conserves uplink network bandwidth and reduces network congestion
  - Provides reliable services to edge device users

Use Cases of MEC

- Mobile video delivery optimization using throughput guidance for TCP
- Local content caching at the mobile edge
- Security, safety, data analytics
- Augmented reality, assisted reality, virtual reality, cognitive assistance
- Gaming and low latency cloud applications
- Active devise location tracking
- Application portability
- SLA management
- MEC edge video orchestration
- Mobile backhaul optimization
- Direct interaction with MEC application
- Traffic deduplication
- Vehicle-to-infrastructure communication
- Location-based service recommendation
- Bandwidth allocation manager for applications
- Video caching, compression and analytics service chaining
- Radio access bearer monitoring
- Radio network information generation in aggregation point
- Unified enterprise communications
- Application computation off-loading
- Optimizing QoE and resource utilization in multi-access network
- Camera as a service
- Video production and delivery in a stadium environment
- Media Delivery Optimizations at the Edge
- Factories of the Future
- Flexible development with Containers
- Multi user, multi network applications
- Indoor Precise Positioning and Content Pushing
- Multi-RAT application computation offloading
- IPTV over WTTx

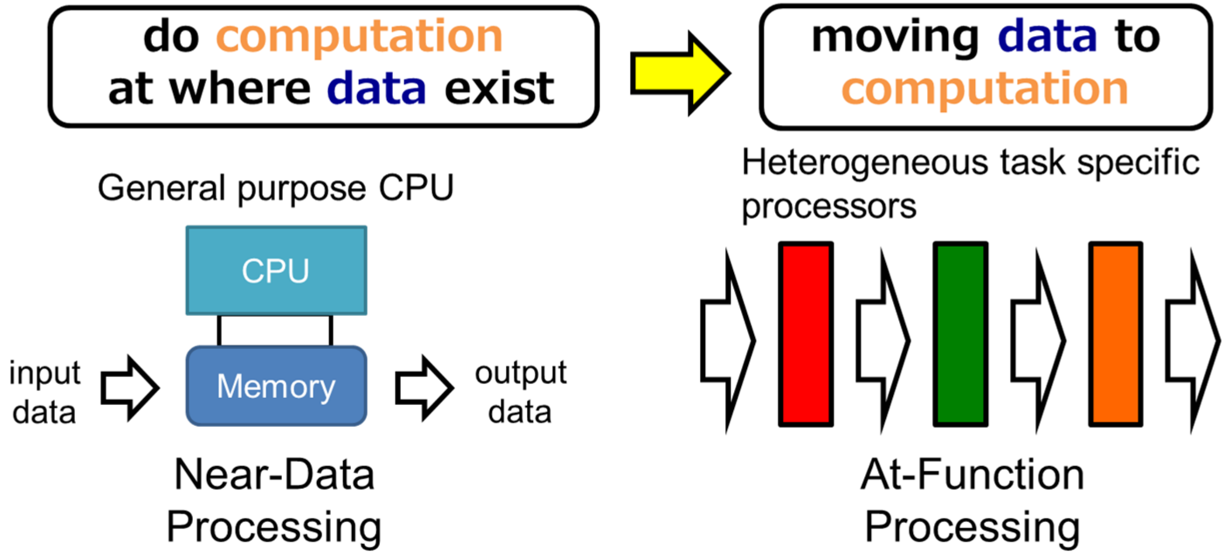
ETSI GS MEC 002 V2.1.1 (2018-10) Multi-access Edge Computing (MEC); Phase 2: Use Cases and Requirements

Requirements for MEC infrastructure

- Performance
  - Need to support various different application requirements
    - Some applications require guaranteed latency/throughput
      - Such as real-time machine control
      - Leveraging eMBB and URLLC features of 5G
- Virtualization
  - Applications (tasks) cannot be determined in advance. Need to support number of applications simultaneously
  - Separation between slices is required for security
  - 5G infrastructure itself is virtualized

Solutions: Performance

- Hybrid computing infrastructure including FPGA and DSA to realize guaranteed performance
  - FPGA and DSA are energy efficient for some applications
- Peer-to-peer flexible communication between engines (FPGA, DSA etc.) to support various applications with different requirements



Solutions: Virtualization

- Virtualization of FPGA and DSA is still a challenge
- Since FPGA and DSA are used mainly for performance, fine grain virtualization is not required
  - First step will be “bare-metal” type virtualization, in which FPGAs and DSAs are assigned to slices in the unit of a chip
- Portability of processing (i.e. configuration migration) is important but also a challenge

Conclusion

- MEC is one of the key technology in the 5G network. But technology and standard to support MEC is still under discussion.
- Hybrid computing infrastructure including FPGA and DSA can be a part of the solution to realize MEC
- Since the virtualization of infrastructure is essential, how to virtualize FPGA and DSA will be a challenge. We may need to start from a realistic approach.