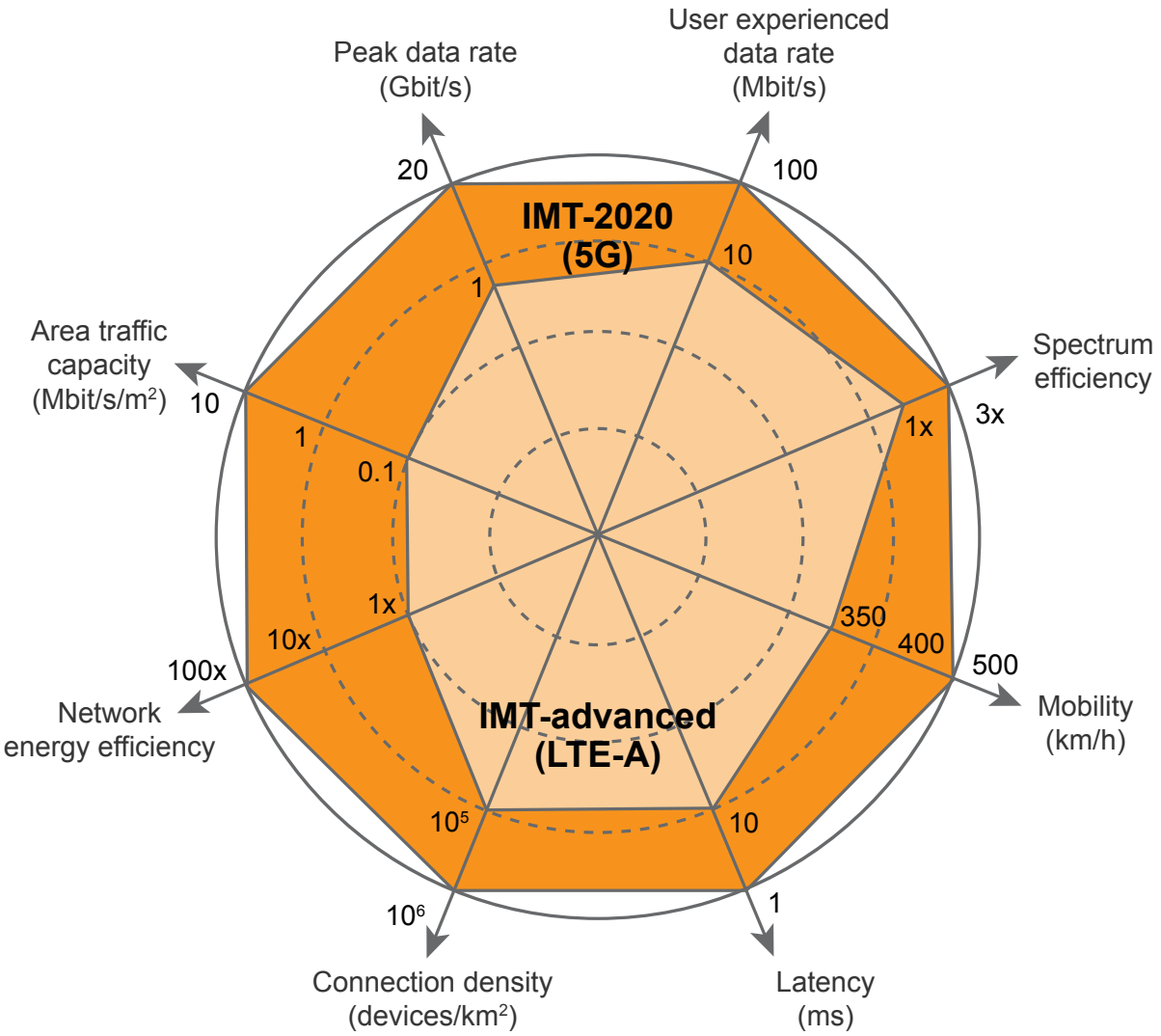
GIGABYTE™

5G iMEC Networking Platform

In order to upgrade their infrastructure to meet the latency and Quality of Service (QoS) requirements of 5G while reducing costs, commercial or private network operators can implement a Multi-Access Edge Computing (MEC) architecture, and utilize Network Functions Virtualization (NFV) together with general purpose servers to implement Virtual Evolved Packet Core (vEPC) technology, replacing expensive proprietary hardware and software. ITRI's iMEC (Intelligent Mobile Edge Computing) platform combined with GIGABYTE servers provide an effective way to implement this solution.

The Challenge of Implementing 5G

5G - the next generation of mobile telecommunications technology, is on the horizon and promises to deliver a myriad of new services and capabilities such as Enhanced Mobile Broadband (eMBB) and Ultra Reliable Low-Latency Communications (URLLC) for massive IOT and Mission Critical Communications (MCC). A new band of the radio frequency spectrum between 30 – 300GHz has been opened for use, and a new telecommunications standard for 5G has been defined encompassing network speed, latency, the number of devices that can be connected, QoS and other conditions.



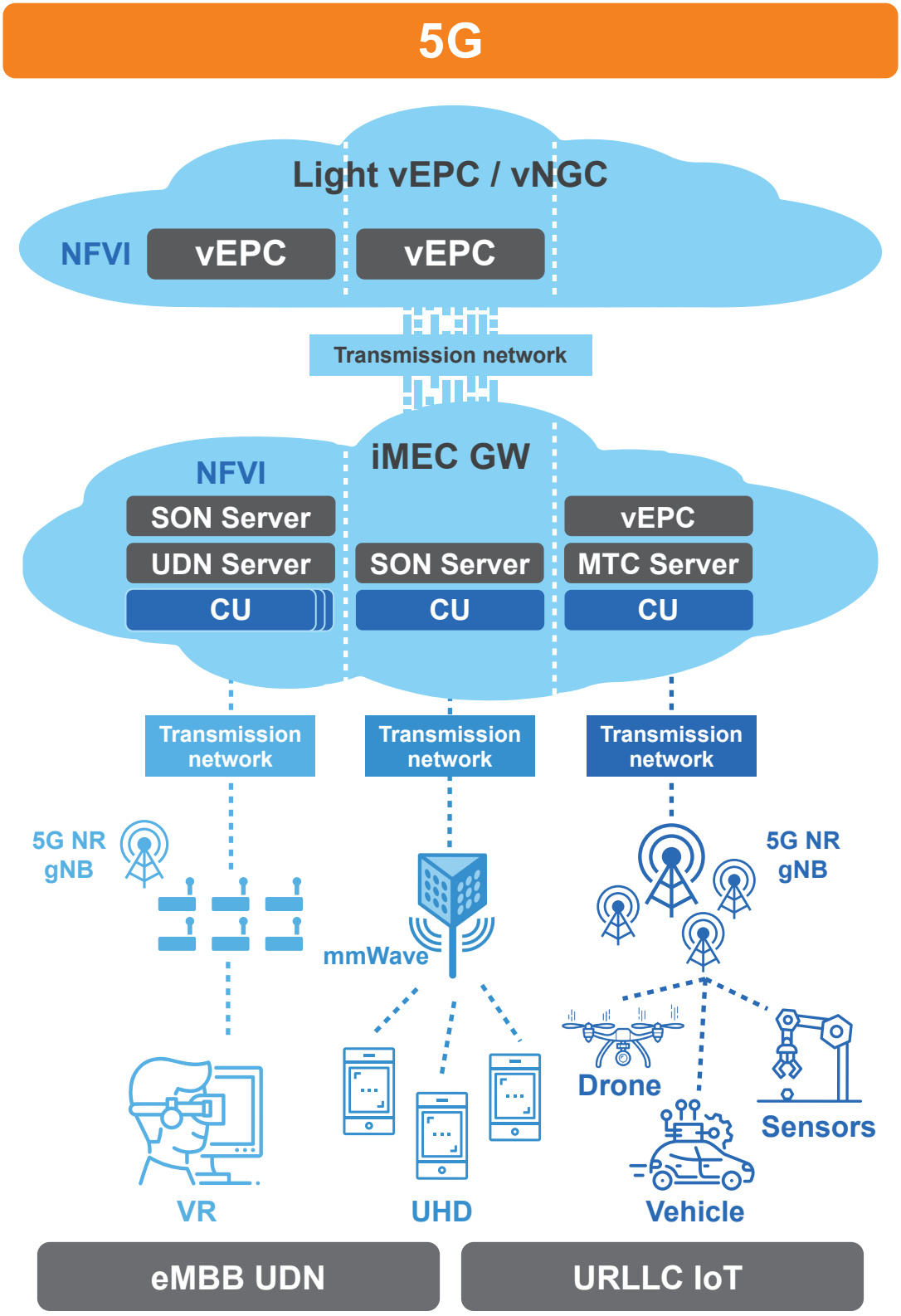
4G LTE vs 5G Specifications

However, enabling 5G technologies requires not just a simple upgrade of User Equipment (UE) with a 5G modem and front end Radio Access Network (RAN) equipment. To meet the specifications of 5G such as speed, end-to-end latency and QoS, network operators will need to upgrade their entire front to backend network topology. Upgrading this network infrastructure to enable technically complex 5G service could be extremely costly. In addition to the spectrum purchase cost, infrastructure investment costs will be huge: the number of base stations required for deployment will be four times that of the past, and construction costs will be 10 to 20 times higher than that of the 4G period.

Adopting iMEC to Meet These Challenges

Taiwan's Industrial Technology Research Institute (ITRI), founded in 1973 and one of the world's leading technology R&D institutions as well as an ETSI Associate Member, has created iMEC: a platform that combines Network Functions Virtualization (NFV) and cloud virtualization technology to minimize mobile backhaul bandwidth requirements and provide an ultra-low latency edge cloud.

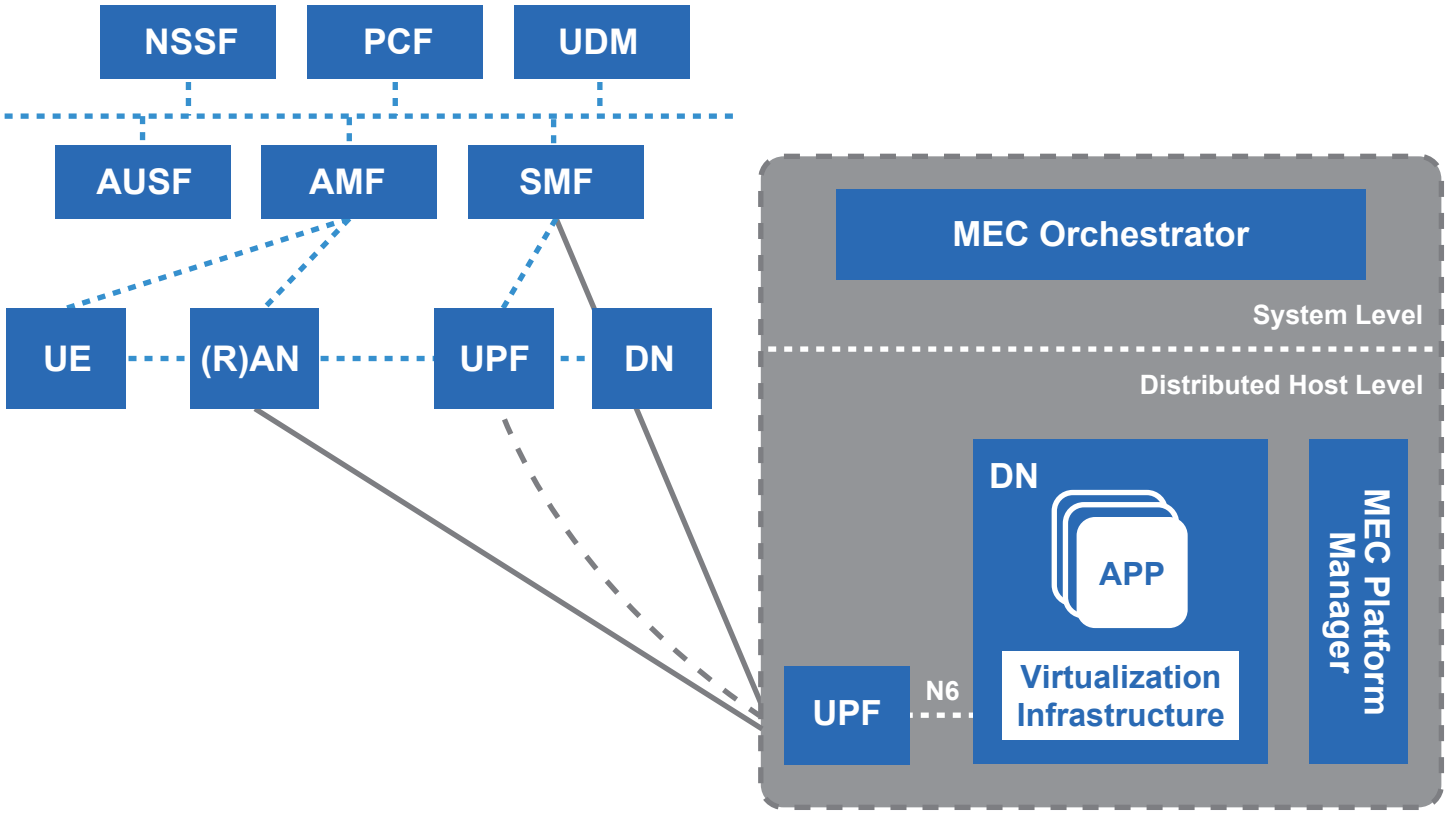
Adopting iMEC together with GIGABYTE servers to replace propriety hardware and software is an ideal way to reduce infrastructure costs while enabling network operators to successfully transform their 4G network to support 5G technology.



5G E2E System Architecture

iMEC can support a heterogeneous configuration of ultra-dense 5G RAN with various vertical services, serving as an ingress point from the RAN to the core network as well as performing Self Organization Network (SON) functionality for the RAN, and local traffic breakout to offload traffic toward the core network. iMEC is designed to minimize end-to-end delay, perform QoS negotiation/management with the RAN and the Software Defined Networking (SDN) / NFV based core network, and also manage some virtualized RAN functions.

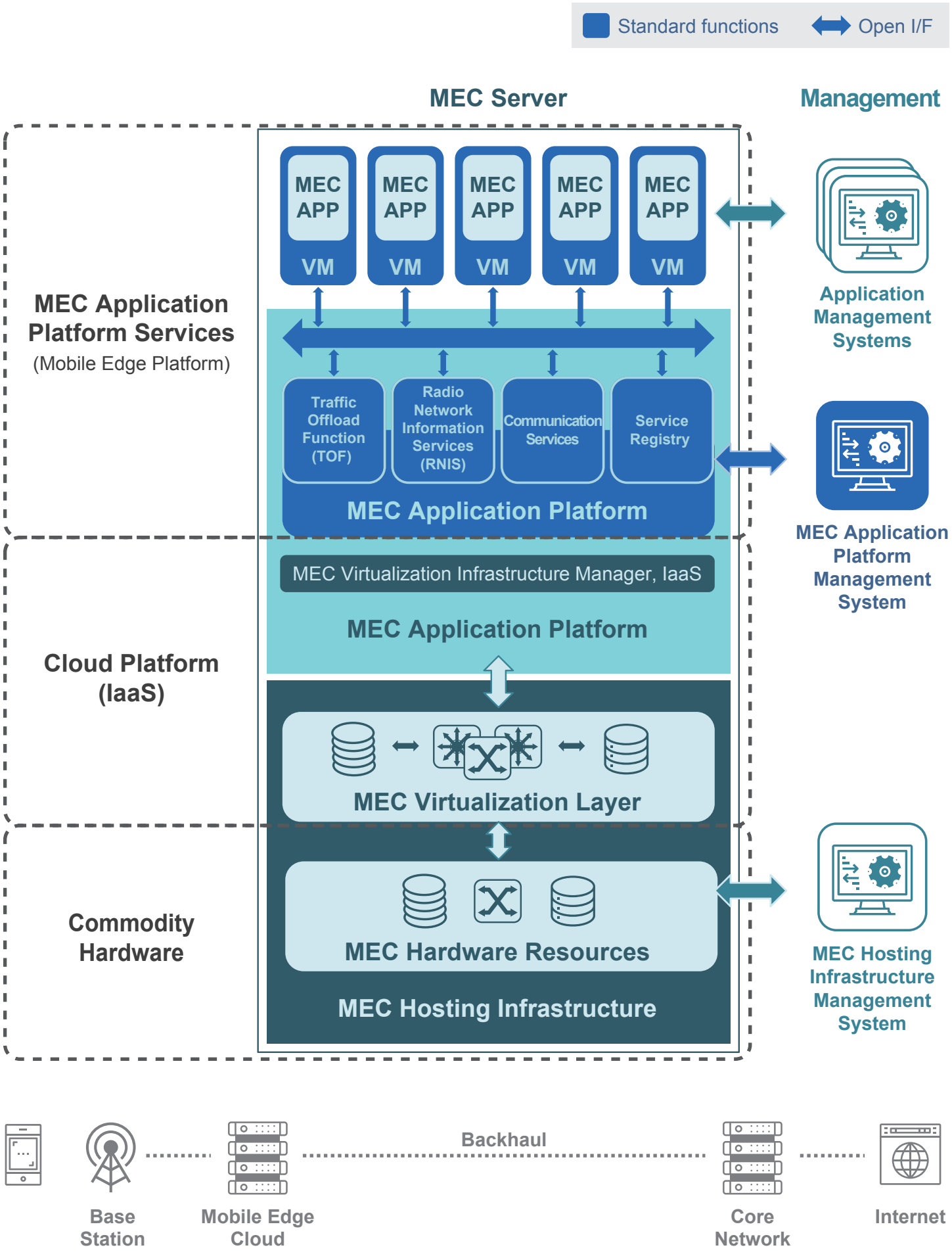
iMEC in 5G



NSSF	Network Slice Selection Function
PCF	Policy Control Function
UDM	User Data Management
AUSF	Authentication Server Function
AMF	Access & Mobility Management Function
SMF	Session Management Function
UE	User Equipment
(R)AN	Radio Access Network
UPF	User Plane Function
DN	Data Network

Due to the rapid deployment capabilities of virtualized / cloud computing, the network entity setup / configuration period for the core network can be greatly shortened using iMEC. Virtualized devices can also be easily scaled out according to additional demand and remotely & dynamically updated, ensuring a greatly reduced system maintenance burden. Furthermore, the load balancing capabilities of cloud computing further improves QoS. In addition to the migration and re-generation ability of Virtual Machines (VMs), a hot standby feature (in addition to the main VM, a redundant spare will also be available to take over) ensures a high level of network reliability.

iMEC Platform Features



ITRI's iMEC platform includes the following features:

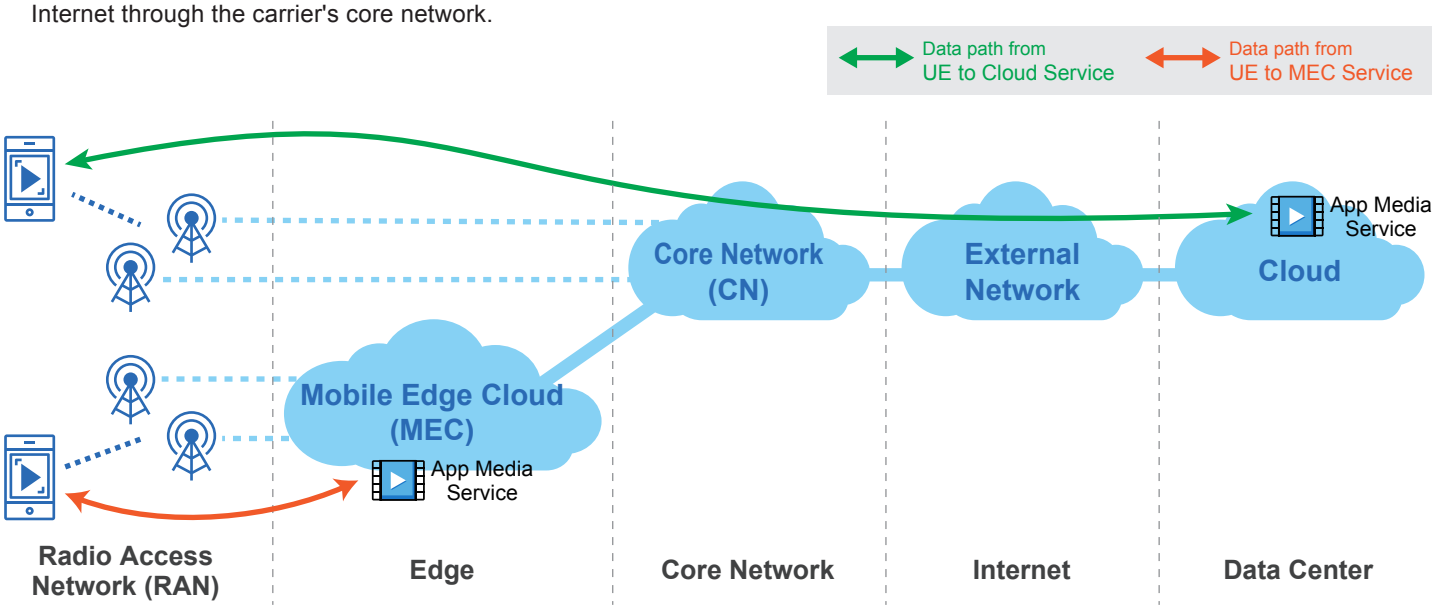
Hypervisor-Based and Container-Based Hybrid NFV Functions

iMEC can support both OpenStack NFV (OPNFV) and Kubernetes NFV Infrastructure (NFVI) solutions, providing a unified management interface for virtual machine and container application services, and providing application services for easy and quick deployment.

Service / Traffic Offload

Acting as a System Architecture Evolution (SAE) gateway, iMEC provides dynamic path judgment and can support the following usage scenarios:

- Traffic offload function for the specified Access Point Name (APN)
- If the user uses the iMEC service, the packet is directed to the NFV platform of iMEC.
- If the user is not using the iMEC service, the packet is directed to the Packet Data Network Gateway (P-GW) and connected to the Internet through the carrier's core network.



Seamless Service Redirection

Seamless Service Redirection can work with various cloud platforms such as AWS, Google Cloud etc. to meet the low latency requirements of 5G application services. The application service can seamlessly run on the iMEC platform, and the user application can connect to the application service of the iMEC platform without any modification needed.

Multiple Region Management

- Support for login and deletion of iMEC region via RESTful API
- Single management Graphical User Interface (GUI)
- Displays the management chain of iMEC in multiple regions, including edge platform, OpenStack and Kubernetes.
- Support for service racking and management of iMEC in multiple regions
- The service racking part can support VMs and Containers.

Just-In-Time Service Initiation

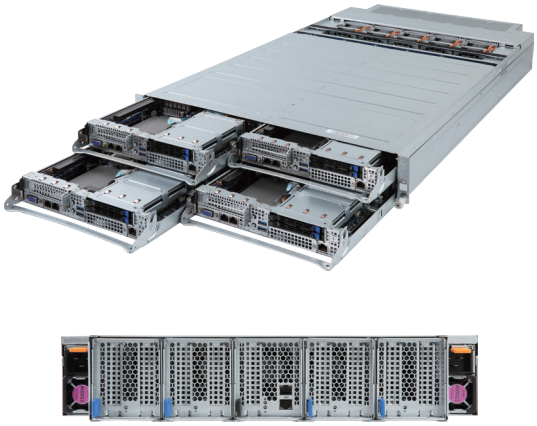
iMEC is a distributed cloud platform with limited system resources, as opposed to a more traditional data center cloud. Therefore, in order to make more effective use of these limited resources, iMEC features Just-In-Time Service Initiation technology, so that application services can start dynamically when needed and shut down when not in use, reducing resource idleness. A containerized application service can be dynamically launched within 1 second.

Supports ETSI MEC API Specifications

- Radio Network Information Service API
- Location API
- UE Identity API
- Bandwidth Management API

GIGABYTE Servers as the Hardware Base of iMEC

GIGABYTE's H281-PE0 Hyper-Converged System is an ideal hardware base for iMEC, using a 2U 4 node chassis design with dual 2nd Generation Xeon Scalable Processors per each node, offering extremely dense compute performance capabilities optimal for NFVI. In addition, the H281-PE0 features a high level of expansion slot availability, providing up to 30% more capacity than competing models in the same class. Furthermore, the fully redundant design features of the H281-PE0, from the component level such as redundant hot-swap PSUs and fans, to the cluster level such as hot swap nodes, ensures 24-7 availability for an uninterrupted full time 5G service experience.



H281-PE0 Specifications:

- Dual 2nd Generation Intel® Xeon® Scalable Processors
- 6-Channel RDIMM/LRDIMM DDR4, 96 x DIMMs
- Supports Intel® Optane™ DC Persistent Memory
- 8 x 10Gb/s BASE-T LAN ports
- 4 x Dedicated management ports
- 1 x CMC global management port
- 8 x 2.5" SAS/SATA hot-swappable HDD/SSD bays
- Ultra-Fast M.2 with PCIe Gen3 x4 interface
- 12 x PCIe Gen3 x16 expansion slots
- 4 x OCP Gen3 mezzanine slots
- Aspeed® AST2500 remote management controller
- 2200W 80 PLUS Platinum redundant PSU

GIGABYTE's H281-PE0 also features a variety of powerful remote management tools such as a Chassis Management Controller (CMC) in addition to each node's Baseboard Management Controller (BMC), as well as a complimentary remote management suite, GIGABYTE Server Management (GSM), providing wide-area, large-scale deployment and management convenience.

Combined together with ITRI's iMEC, this system delivers a fully carrier-grade platform for service offload & bandwidth management together with low-latency application processing.

GIGABYTE also has a range of other server solutions available or in development highly suitable for network and cloud virtualization including to be used as an iMEC platform, such as the G291-Series (G291-280 / G291-Z20) GPU server series for an edge computing platform that can support AR / VR applications, or our upcoming H242 edge server series.

Device	uCPE	Edge Appliance	NFV Server	NFV / Cloud Server	Cloud Server
Location	Customer	Edge	MEC Cloud	Core Cloud	Data Center
Workload	uCPE	Radio / Optical access, vCPE, vCDN	vEPC, vSeGW, vBNG, vPE, vCPE, vDPI, vCDN	vEPC, vBNG, GiLAN, CGNAT, vRouter	Video, IMS
CPU platform	Atom	Skylake-D, GPU, FPGA	Skylake-SP, GPU, FPGA	Skylake-SP, GPU, FPGA	Skylake-SP, GPU, FPGA

GIGABYTE will continue to focus on the development of products with a modular design that are suitable for iMEC, providing a system with a more flexible configuration that operators can adapt to their needs, and that can be deployed in a 5G network as a RAN node, aggregation node or core network node.

Benefits of GIGABYTE & ITRI's iMEC Solution

Reduction of Infrastructure CAPEX and OPEX

- The market size of general-purpose server equipment is much larger than that of dedicated telecommunications equipment. Therefore, the initial purchase cost will be lower, and performance / price ratio will be higher. iMEC can help reduce Capital Expenditure (CAPEX) for building a 5G network.
- Using a MEC network topology, the data uplink / downlink between the base station and the core network will no longer be needed to support such a heavy load of local IP traffic. Therefore, private lines or dark fiber leases can be changed to general internet access links, allowing more competitive operating expenses (OPEX).

Better Service Quality

iMEC features Virtualized Evolved Packet Core (vEPC) functionality, allowing the UE to have inter-base station handover without being routed back to core network . Only after the successful handover will the necessary information be returned to the core network. This can improve network service quality, especially when the user is moving at high speed.

High Reliability

iMEC provides redundancy at the infrastructure level with NFVI, without relying on physical modules. The abstract nature of cloud virtualization resources ensures the virtual network functions (VNF) running on it will not be affected by service interruptions due to physical server or network connection errors. For example, Mobility Management Engine (MME) VMs can run multiple copies with hot standby technology. If the main VM fails, the standby VM can take over within a fraction of a second, without the user feeling the EPC service has been temporarily interrupted.

Network Maintainability

5G Standards include specifications for a wireless IoT - Machine Type Communication (MTC) - which places a huge burden on a network's Evolved Packet Core (EPC) in terms of system scale and scalability. iMEC can form a QoS policy through the Policy and Charging Rules Function (PCRF) network entity. The Software Defined Networking (SDN) controller will convert this policy to a ruleset that will be published to the topology of the switch that groups traffic, and will use a Virtual Local Area Network (VLAN) to manage operations.

High Scalability

Virtualization technology allows iMEC to flexibly increase or decrease resource usage according to demand, so as to effectively utilize the overall resources. And in addition to the above-mentioned aspects of providing redundancy protection in NFVI, virtual resources and VNF can be dynamically managed, including the addition and removal of VMs, ensuring that every vEPC running can maintain proper configuration and operation.

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