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# Mobile Edge Computing

# Architectural considerations when milliseconds matter

By Peter Cohen

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## Introduction

Soon after it established the term "mobile edge computing" (MEC), the European Telecommunications Standards Institute (ETSI) amended the definition to include the broader term "multi-access edge computing." Early efforts around MEC were grouped to help improve the performance of internet software like web browsers and video and audio streaming on resource-constrained mobile devices, but MEC applies much more broadly. While the mobile/multi-edge nomenclature still creates some confusion it's an important distinction. It tacitly acknowledges that MEC is not limited to mobile networks. Indeed, the future of both mobile and IT networks blurs the lines between them. MEC itself is already proving to be a foundational technology that's driving forward innovation in both IT and telco spaces, but what is it?

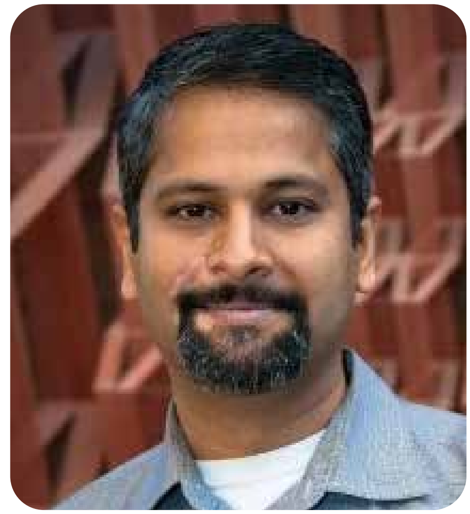
MEC, put simply, takes compute and storage functions out of a data center and moves it elsewhere on the network. Instead of requiring every bit of data in the cloud to be returned to a central point for processing and distribution, resources at the network edge analyze, process and store the data. By collecting and processing that data closer to the user, network operators can, in some cases, dramatically reduce round-trip latency and provide higher bandwidth and throughput for more demanding applications.

Looking at it another way: "If you don't care where it is, you're doing cloud; if you do care and know, you're doing edge," said industrialist Jason Hoffman, the former president of MobiledgeX, a Deutsche Telekom-funded edge software pioneer acquired by Google earlier this year.

Decentralized computing and storage certainly isn't a new idea in the Information Technology (IT) or cloud worlds—people have been trying to figure out how to move data processing and computational functionality out of the data center literally since data centers were first invented.The entire history of corporate, personal and mobile computing is punctuated by repeating cycles of this type of expansion.

Edge computing in 2022 can trace its existence back to the development of content delivery networks (CDNs) like Akamai. Developed originally as a business incubation project at the Massachusetts Institute of Technology in 1998, Akamai launched commercially in 1999 and has been a cornerstone of the CDN marketplace ever since. Early in its development, Akamai's primary focus was to relieve Internet-based businesses of the burden of supporting and hosting the infrastructure and resources needed to distribute audio and video content globally.

For end users, the CDN experience is seamless and transparent: One enters a URL for a web site or service hosted on a CDN. On the back end, hashing

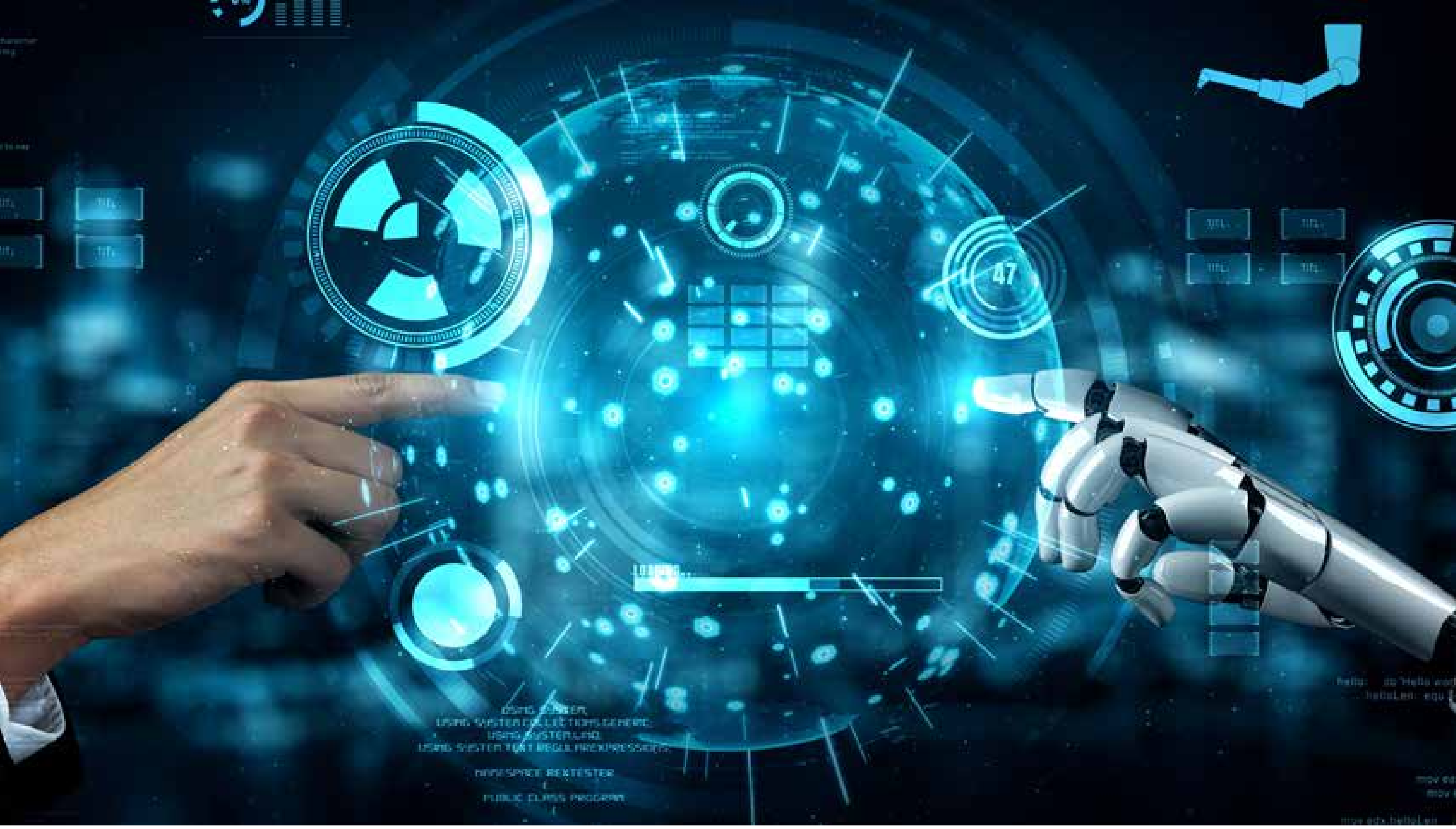


"3GPP R16 and R17 introduce event and charging triggers that CSPs can actually monetize."

***Dheeraj Remella, Chief Product Officer, Volt Active Data***

algorithms and DNS caching seamlessly and instantly assign the user to an edge server location nearby, which hosts the requested files. For users on the edge, it means less waiting and better interactivity. For operators of edge services and their clients, it means less network congestion, and more effective management of the resources needed to deliver content to customers where and when it's needed, instantly and on-demand.

Akamai kicked off a global revolution in how content was delivered over the Internet. Akamai may have been a pioneer in the space, but it has no specific provenance over edge computing in general. But it's interesting to note that



in 2021, Akamai reorganized itself into two internal groups, one focused on security technology, the other on edge. That served as an important bellwether to signal the changing role of Akamai specifically, and CDNs more generally, in the modern IT and cloud services landscape — no longer focused on the mere delivery of audio and video content, but a foundational technology to drive the distribution of computing and storage resources across multiple cloud domains, for many different purposes.

## State of MEC

In 2022, MEC looks very different than it did in 1999 when CDNs were still a novel concept. MEC is emerging as a cornerstone technology from hyperscalers and telcos, but it's still in its early stages. Revenue estimates for MEC today vary widely depending on the source, but there are a few takeaways: MEC revenue was nonexistent only a couple of years ago, but it's growing now, estimated to be billions within the next few years, and some analysts expect it to be a trillion dollar market for IT and telco within a decade.

MEC focuses computational capacity where it's needed the most, providing the foundation for future growth and scalability as public and private needs for high speed, low-latency communication continue to develop and demand continues to grow exponentially. Another area where MEC is vital is the burgeoning IoT market. Relocating compute, storage and data processing to the edge of the network enables a new class of lightweight, low-power devices that rely on edge services to do the heavy lifting.

"IoT is really where it's going to be when it comes to density," said Dheeraj Remella, chief product officer at Volt Active Data. "You can't pack a million people into a square kilometer but you can certainly pack a million things, all communicating on a 5G network."

But MEC also faces headwinds. Hyperscalers and telcos are deploying MEC on a gradual basis and experimenting with different uses of it, yet it's still not widespread, and certainly not ubiquitous. Dave Bolan, Dell'Oro Group research director, explained some of the factors.

"The big thing to think about is the ecosystem," he said. "One: 5G standalone deployments have been slower than anticipated; and two: most Standalone networks are (now based around) 3GPP Release 15," he said. Later 3GPP releases expose additional edge location discovery and communication functionality, which is seeing industry uptick on a gradual basis. But it takes time for hardware equipment vendors and software developers to adopt those changes, some of which have to take place at the silicon level in order to be used.

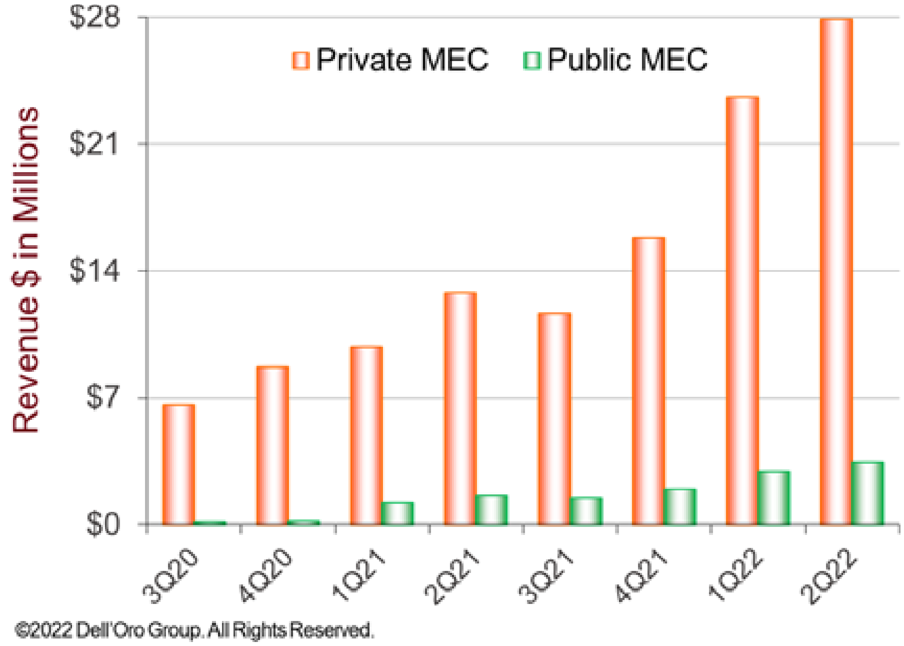
For the past couple of years, cloud, telco and IT industries have faced difficult supply chain challenges related to repeated COVID-19 pandemic shutdowns, which have broadly affected China's ability to manufacture the parts MEC manufacturers need. In the second half of 2022, manufacturers are reporting a light at the end of the supply chain tunnel: Constraints on chips and other manufactured equipment are beginning to abate. It may be some time before industries are back up to speed, and it may take some adjustment to the "new normal," but it appears, at least for now, that the worst of supply chain constraints are behind us at least for now.

As user equipment and network hardware and software evolves, Bolan sees end-to-end edge services enabling functionality like network slicing as more broadly adopted and supported. But it's ultimately a waiting game as the tech has to cycle through, from silicon to software.

"I don't think anyone has a Release 17 network yet," said Bolan.

"3GPP R16 and R17 introduce event triggers and charging triggers that CSPs can actually monetize," said Remella.

**MEC – User Plane Function Revenues**




"The future is already here, it's just not evenly distributed," is a quote apocryphally attributed to science fiction author William Gibson. Regardless of whether he said it or not, it smacks of enough truth to have stuck around in the public consciousness for decades. The same sort of idea seems to apply to MEC.

Globally, MEC distribution is wildly uneven. Distributed computing requires those physical resources to get closer to users, and that doesn't happen without infrastructure buildout. China outpaces the rest of the world for MEC deployments and revenue growth, noted Bolan in a report published by Dell'Oro over the summer. Bolan explained that MEC deployment in China is being driven by the need for efficiency. China Mobile, he said, has 1,700 MEC locations already operating in the country.

"The reason that China Mobile was so aggressive from day one in deploying public MEC is because they don't own any long distance traffic capability. So they actually implemented MEC to save on backhaul costs," he said.

Geography and population density plays a critical role in the successful distribution of public MEC.

"In South Korea, when SK Telecom launched their 5G Non-Standalone network, they lit up 11 MEC nodes. That put every consumer within 100 kilometers of a MEC node, because it's a tiny country, obviously, and gave them fantastic latency," said Bolan.

While China is a vast country, the massive population density around


7,645.05
210.95
12,411.80
149.16
27,752.93
23.26
1.41%

megacities enables the carriers operating there to tap into potential markets of tens of millions of consumers and hundreds of thousands of businesses, a scale difficult to achieve elsewhere.

Another factor affecting public MEC buildout worldwide is data sovereignty. Making sure data stays where it is supposed to is increasingly top of mind for government officials, CIOs and cyber security professionals around the world. But this presents complications for hyperscalers and telcos operating in those regions, who only a few years ago, might have consolidated operations more regionally. The net result is that hyperscalers and telcos alike are spinning up ever-more local MEC points of presence to accommodate.

"The problem in Europe is the countries are so small, they don't have multiple availability zones in each country," said Bolan. "And for data sovereignty, they have to put multiple availability zones in every country to get by the regulatory requirements."

Volt Active Data's Remella sees the evolution of MEC as key for CSPs to break out of the "dumb pipe" model.

"I'm talking about building industry vertical platforms that CSPs can sell to specific participants in those industries. A CSP can really get above the fray of being a utility provider to become an active digital transformation enabler, so to speak," he said.

## Monetizing MEC

In the U.S., Verizon and Amazon Web Services (AWS) have established an early lead in the still-nascent public 5G MEC market through the establishment of AWS Wavelength zones, physical locations in cities throughout the U.S. that combine Verizon's 5G service with AWS compute and storage services. The companies currently operate 19 such locations with more planned. The rollout has been a template AWS has followed with service providers in other regions, as well—AWS now operates Wavelength locations in partnership with carriers in Canada, South Korea and Europe.

While public MEC is still a future play, the current heat and light on MEC is in private 5G network deployments, according to Verizon CEO Hans Vestberg.

"Private networks are the gateway to mobile edge compute, which can deliver game-changing customer outcomes, including revenue growth, new customer experiences and cost savings," Vestberg told investors on an earnings call in late July. "This trend will continue to create growth opportunities for us across a range of industries, as we are a market leader in 5G private networks and in mobile edge compute."

Srinivasa Kalapala, Verizon SVP and Chief Product Development Officer, offered some perspective on how MEC is being used to solve enterprise problems today.

"People seem to tend to get fixated on latency," Kalapala said. "And I want to make sure this becomes a bit more clear. Latency is definitely one of the factors, but it's not the only factor."

The discussions around MEC and latency often come within the context of the tech as an enabler of richer and more detailed Virtual Reality (VR), Extended Reality (XR) and Mixed Reality (MR) experiences. And over the course of the past year and a half, MEC has also taken center stage in metaverse discussions. Those are certainly use cases where MEC is vital—in order to make such devices wearable and lightweight enough for everyday use, much of the heavy lifting of computation, storage and data processing needs to move to the network.

But consumer use of MEC is still a way off, as the technology continues to simmer and develop. Lightweight headsets and other devices to use MEC technology to drive richer and more immersive user experiences remain on the horizon. Meta (née Facebook) and its ambitious metaverse play may be still years away from inception, if its demands for symmetrical bandwidth and massive distributed computing power are to be met.

In the interim, Kalapala points to MEC's benefit to enterprises and what Verizon calls "collective intelligence." MEC is helping businesses gather data from lightweight, low-power IoT sensors to help drive decision making. This enables real-time data gathering, he said.

"And in that case, you can't put the compute right on the edge of the sensor, because it only knows about itself, it doesn't understand the rest. So you need to get the data to a closer location and process that at the edge," he said.

Another strong factor for growth in the industrial space, said Kalapala, is virtualization.

"The same way we went through virtualization, other industries are going through virtualization," he said. "Their factories, too. Gone are the days when you had sensors for one particular thing, and you had to go physically deploy and connect with a wire."

The future of industrial automation is closely linked to MEC, said Kalapala, because it's the most effective way to collect, process and analyze data in real time, and it's less expensive than hauling that data back to a central location for further processing and analysis.

"Latency is definitely one of the factors, but it's not the *only* factor."

***Srinivasas Kalapala, SVP and Chief Product Development Officer, Verizon***

Old mariners note that rising tides raise all boats. The same sort of analogy applies to 5G MEC, thinks Kalapala. We're still in the early stage of developing the networks needed to deliver MEC at scale.

"We really didn't see mobile applications take off until 4G became, you know, a good 4G, delivering the bandwidth. We see 5G and related technologies like MEC the same," he said.

Ritesh Mukherjee, SVP and general

manager of Inseego Corp., sees enterprise 5G MEC as an important growth market. Inseego makes fixed and mobile wireless solutions for large enterprise verticals and service providers. Mukherjee said that beyond latency, MEC offers CSPs other strong benefits.

"One, if they bring things closer to the MEC, they localize that traffic. So they don't carry all that traffic in their core. Secondly, it improves security because now everything is localized. If a disruption happens, you can still keep working. You don't have to worry about other locations, your security posture has been improved by being localized," he said.

Over the summer Inseego delivered 5G SD Edge, a Fixed Wireless Access (FWA) solution for businesses that delivers secure 5G connectivity through an edge appliance. But he underscored something else: the biggest current market for MEC isn't in industrial or the traditional enterprise market. It's in retail.

"I would say obviously, that just by the nature of the deployment, the retail deployments tend to be large. The SD-WAN (Software-Defined Wide Area Network software) vendors, they all gravitate towards retail because obviously they have a large number of distributed sites. More sites means more distributed connections to compete to connect," said Mukherjee.

Broad workforce changes over the past few years have changed the landscape of MEC deployments in many businesses, said Mukherjee. Workers choosing to work from home, or engaged in "hybrid work" scenarios that split their time between home and office. But that comes at a cost in dramatically increased Virtual Private Network (VPN) traffic, and it increases the potential security risk, as well.

"Even though the VPN client is

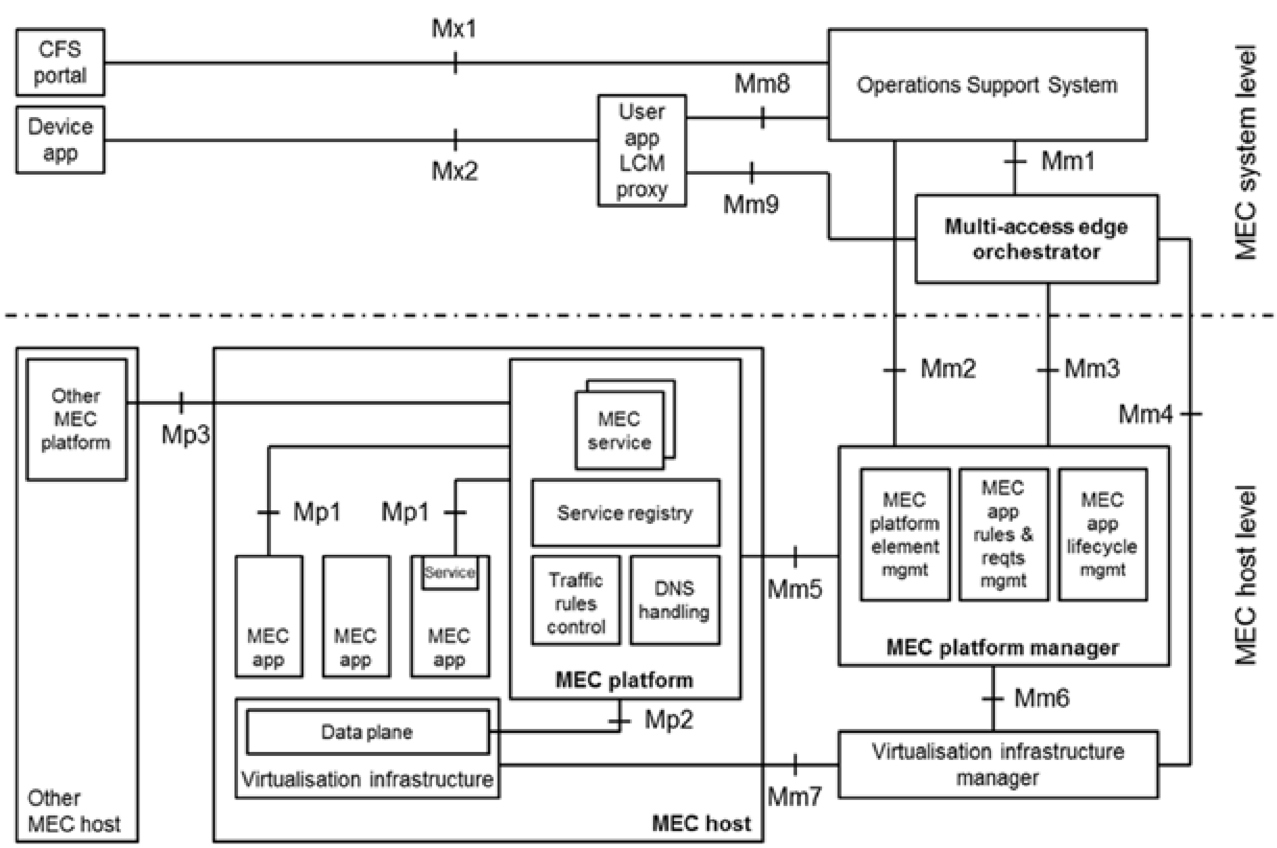



*Image courtesy of ETSI*

MEC reference architecture

encrypting the traffic, these other devices at home, obviously, are not highly secure. And they don't have enterprise grade security," he said.

Employing effective tunneling, advanced SD-WAN functionality and modern security protocols such as zero-trust network access (ZTNA) can be managed through edge appliances sitting between the end-user and the corporate data they need, with guaranteed Quality of Service (QoS) levels, he said.

## Understanding MEC

"Multi-access Edge Computing enables the implementation of MEC applications as software-only entities that run on top of a Virtualisation infrastructure, which is located in or close to the network edge," said ETSI.

ETSI divides the MEC framework into three distinct blocks: system, host, and network. Each domain provides separate levels of functionality. ETSI provides some flexibility for different MEC deployment strategies, technology requirements and use cases, so individual topologies and configurations may differ from what's described here.

At the system level, the MEC Orchestrator (MEO) is responsible for maintaining an overall view of the MEC system, onboards application packages and checks their integrity, validates rules and requirements, adjusting them to comply with operator policies, keeps records of those onboarded packages and prepares the Virtualization Infrastructure Manager (VIM) or VIMs to handle the apps. It also selects the appropriate MEC host based on latency, available resources and services, and it triggers app relocation as needed.

Also at the system level, the Operations Support System (OSS) receives requests from Customer-Facing Services (CFS) and from device applications. Requests that are granted are then forwarded to the MEO for further processing. When supported, the user application Lifecycle Management (LCM) proxy keeps track of system and hosts, what resources and services are available, checks authenticity and system integrity and validates rules and requirements. It also triggers app instantiation and termination.

At the host level, the MEC platform manager and virtualization infrastructure manager provide the storage, compute and network resources to run MEC applications. MEC applications themselves are instantiated on the virtualization infrastructure of the MEC host. The MEC platform manager and virtualization infrastructure manager handle specific MEC functionality.

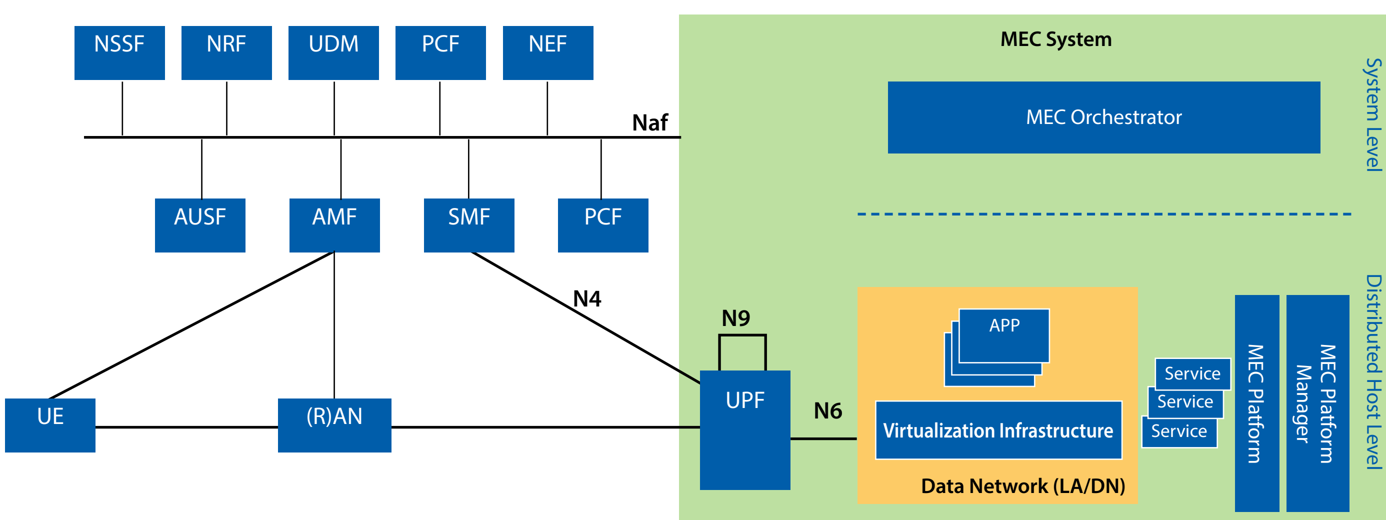



*Image courtesy of ETSI*

Integrated MEC deployment in a 5G network

# How does 3GPP R17 enable MEC applications?

The 3GPP R15 specifications completed in 2018 provided the not only the foundations for 5G architecture, but also the basics for 5G MEC deployment as well. R16 provided features and functionality aimed at additional use cases, including edge computing, cellular IoT, and Ultra-Reliable Low Latency Communications (URLLC), which are intimately intwined with MEC enablement. Release 17 provides even more integrated MEC functionality through the definition of an architecture to enable edge apps.

"In Release 17, we aim to provide native support of Edge Computing in 3GPP networks," wrote Suresh Chitturi, 3GPP Working Group SA6 Chair.

The functionalities defined in Release 17 combined the efforts of several 3GPP working groups focusing on application layer architecture, core network enhancement, security, media processing, and management aspects.

R17 defines an enabling layer for edge computing that bridges communication between Application Clients (ACs), or apps running on user equipment (UE), and Edge Application Servers (EAS) deployed on the MEC data network. This includes service provisioning and EAS discovery functionality.

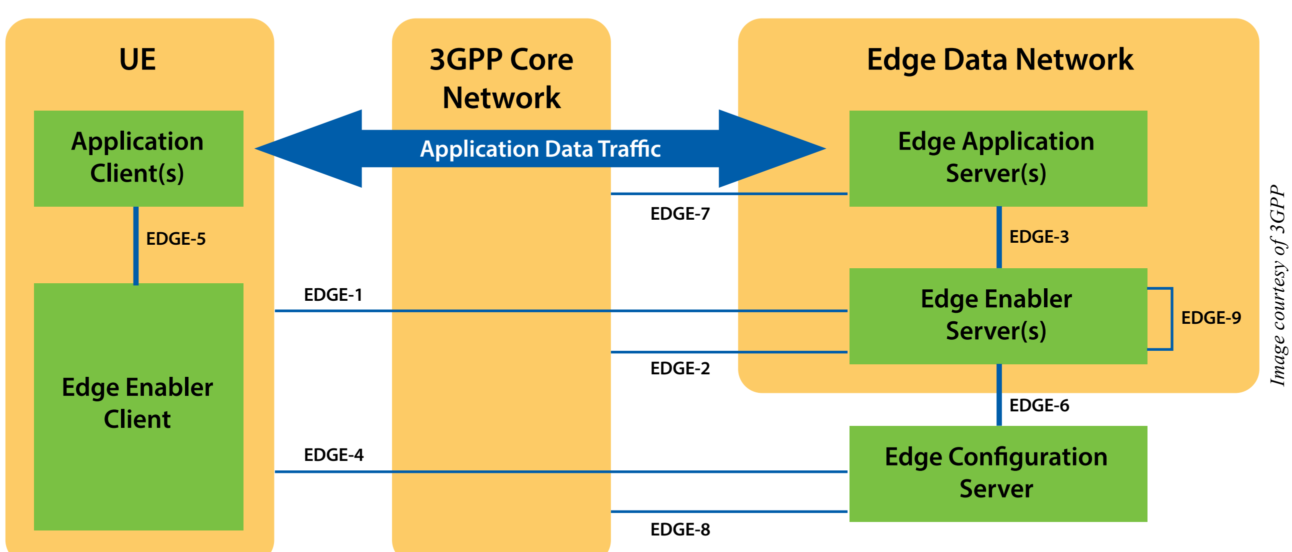
According to Chitturi, the application architecture is based on five guiding architectural principles:

- **Application Client portability:** Changes in logic of AC to interact with EAS, compared to existing cloud environments, are avoided.
- **Edge Application Server portability:** Changes in logic of application servers when edge-resident, compared to an existing cloud environment, are avoided. An EAS should be able to run in hosting of multiple edge computing service providers (ECSPs), without any modification.
- **Service differentiation:** The CSP can provide service differentiation (e.g., by enabling/disabling the MEC features).
- **Flexible deployment:** There can be multiple ECSPs within a single Public Land Mobile Network (PLMN) operator network. The MEC can be a subarea of a PLMN.
- **Interworking with 3GPP network:** To provide MEC features, already developed or to be developed in 3GPP network (features like location service, Quality of Service (QoS), application function traffic influence), to the EAS, the application architecture supports interworking with 3GPP networks using existing capability exposure functions such as Network Exposure Function (NEF) and Policy Control Function (PCF).

It also defines an Edge Application Server Discovery Function (EASDF) to support MEC session breakouts. Within the functionality of the EASDF is Domain Name Service (DNS) resolution to the UE, thus resolving to application servers closer to the UE's physical location.

The 3GPP's SA6 working group says that its architectural principles provide benefits both for "edge-aware" and "edge-unaware" apps operating on MEC environments. With the support of the enabling layer exposed in R17, the 3GPP notes native support for several MEC-related capabilities:

- **Rich discovery:** On-demand service provisioning by the Edge Configuration Server (ECS) and the support of query filters on the Edge Enabler Server (EES) to allow rich discovery.
- **Dynamic availability:** EAS capabilities can vary for multiple reasons, including deployment changes and UE mobility. The UE can subscribe to such dynamic changes to fine tune the services offered to the AC.
- **Network capability exposure:** The EASs can utilize service Application Programing Interfaces (APIs) exposed by the EES, which in turn are built on the capabilities of northbound NEF APIs, enabling EASs to access 3GPP network capability exposure functions.
- **Support for service continuity:** With UE mobility, the serving MEC or cloud instance may change or become more suitable for serving the AC. To enable continuity of service in such scenarios, the architecture supports transfer of the UE's application context between MEC for seamless service continuity.




Release 17 defines how edge computing exchanges data with 3GPP networks.

Within the host, the MEC platform combines, as ETSI describes, “the collection of essential functionality required to run MEC applications on a particular virtualization infrastructure and enable them to provide and consume MEC services.”

MEC moves computing, storage and data processing resources out of the data center, closer to the user. Shortening the physical distance between the user and the data reduces latency and segments network traffic more effectively. Virtualized Network Functions (VNFs) replace Physical Network Functions (PNFs), legacy network appliances running on proprietary hardware.

At a cursory level, these may sound like different aspects of cloud computing operations, but they work in concert. In fact, ETSI readily acknowledges that the portability present in Network Function Virtualization (NFV) is closely mated to MEC, and provides architectural variants in its MEC framework to accommodate.

“MEC and Network Functions Virtualisation (NFV) are complementary concepts. The MEC architecture has been designed in such a way that a number of different deployment options of MEC systems are possible,” said ETSI.

ETSI also provides flexible variation for inter-MEC system communication, or MEC federation, providing a framework for interconnection between disparate MEC systems and non-MEC systems as well.

## Getting MEC ready for business

Monetizing MEC is a popular discussion that often takes the form of ideation: What will make customers pay for it? As a cornerstone technology to drive low-latency, high-bandwidth communication, many discussions around MEC monetization start with use cases such as Virtual Reality (VR) and the growing discussion around “metaverse” concepts.

But any discussion around MEC monetization needs to focus at least initially on more mundane issues: How to actually keep track of what’s happening on the edge which customers are paying for. MEC requires some fundamental operator rethinks at the operational and business system layers, according to experts.

Susan White heads strategy and portfolio marketing for Netcracker, a developer of operations and business system software. MEC demands that network operators adopt a very different strategy around the business support systems they use, said White.

"We're moving from what was before a very centralized service model to this hugely distributed model," said White.

To maintain quality of service, operators have to know what's in the edge and on the edge in real-time, she added.

"Because if you don't know what capacity you've got, what kind of latency you're able to provide, and other attributes like location you're not able to give any guarantees. You have to maintain that real-time view."

"We're moving from a very centralized service model to this hugely distributed mode."

***Susan White, Head of Strategy and Portfolio Marketing, NetCracker***

Volt Active Data's Remella agreed.

"What used to work in the cloud won't work at the edge, at least not effectively. In the cloud, you have scale, almost a virtually unlimited amount of hardware footprint available. But at the edge, you have limits: limited hardware, network and storage," he said.

Titanium Platform, née NetNumber, makes core network apps with a focus on signaling, routing, subscriber data management and security. One problem Rosenberg says surfaces with Titanium Platform's customers is the feature creep present in the edge.

"Carriers are starting to make a decision: What do we absolutely want to put at the edge, versus what are the things we want to go back to the mothership for," said Titanium Platform President Matt Rosenberg.

"They want to do more stuff at the edge, so it becomes bigger than they originally designed," he explained.

Understanding how edges are operating is one challenge; another is scaling to provide more capacity during peak demand.

"You have to spin something up at an additional edge that then has to have the right capabilities and requirements," White said.

"Another big challenge is to be able to react instantly to changes you want to make. Everything's got to be instant. And that's obviously quite a difference than what happened in the past," she added.

"The key with the charging function is to be able to have flexibility for service providers to be able to charge for things in many, many different ways. Latency is a big piece, but it can be throughput processing. It can be location, it can be all sorts of things," said White.

"If we think of edge services, and especially related to latency sensitive services, it may be that you want that charging function to physically be located at the edge as well," she said.

The proliferation of services and functions operating at the edge requires operators to consider a unified edge domain orchestration strategy, said White.

"You might have all or parts of the 5G core hosted on the edge, and security applications like SD-WAN, video analytics, VNFs, CNFs, all sorts of other things. Our customers were concerned about having different processes for each one," she said.

By employing unified edge domain orchestration, leaning on zero-touch network automation (ZTNA), White said, operators can simplify the deployment and management of edge resources.

"To do all those things and make them dynamic requires you to have a very high level of automation across your entire network. Not just at the edge, but in the RAN, and the core and the transport layer. To be able to see services end-to-end across the entire

network," she said.

Determining MEC architecture and the relationships needed to deploy the edge remains what IBM's Stephen Rose calls "massively strategic consideration" for CSPs. Rose is IBM's GM of Global Telco, Media, Entertainment and Distribution Vertical.

"We've got to move away from the notion that [CSPs] can operate in silos. Even when [CSPs] are, there are still major considerations around the orchestration and automation layer and whether that is sufficiently lateral or not, to be able to then orchestrate and automate with greater optionality between various cloud players," he said.

"Because if you don't, you end up deploying services with different types of automation. And you have an inconsistency of service across your edge domains because of the real estate consideration and OEM or cloud provider," he added.

"When we're talking about orchestration, and Service Assurance functions, most of them are considered at the element layer, and then the aggregate outwards, but at some point or another, then you have to go from that into edge application management.

Rose fears that CSPs which aren't mindful will run into increasing complexity as more edge services are activated.

"What we're starting to see is that some customers that initially were going in with best of breed architectures are starting to realize that the cost of doing so is to then have to then build all the way back into the orchestration layer that can actually manage all of those things. That technological constraint makes it harder to achieve a defined outcome," he said.

## Securing MEC

MEC brings with it a host of new concepts to the telco cloud: Broadly distributed computing platforms spanning the data center to the near edge and the far edge; the disaggregation of network functions from specialized physical network hardware to virtualized network functions and cloud-native functions operating as microservices; and the move towards support of open standards and Application Programming Interfaces (APIs). Both telcos and their customers must consider these issues and others in terms of their security posture, our experts agreed.

"We've done a lot of research about various aspects of cellular and wide area networking," said Todd Krautkremer, CMO of Cradlepoint, which makes wireless edge networking gear managed through Cradlepoint's NetCloud cloud services. The company is in the process of iterating new features into NetCloud, beginning with Secure Connect, a zero trust-based "VPN-like" service that enables more secure connections with less complexity than traditional offerings. Improving security while making the best use of limited human capital is a recurring theme for many companies in the MEC space.

"It's solving the higher-level problems that might be introduced in many organizations deploying 5G," he said. "The greatest asset of SD-WAN is that it makes our networks more cloud-like, and it requires fewer humans to provide more connections."

"We found that [IT decision makers'] mindset around security has changed. It's no longer something they add to their network as another project and yet another effort. It's really in the core decision criteria now. They're making decisions about 5G and security at the same time. Is 5g going to help or hurt my security posture? And what technology allows me to do that? So that's why you see us start to elevate security with 5G as well, because we think the market's changed and everybody is concerned about security," Krautkremer said.

"Security is of paramount concern," said IBM's Stephen Rose. CSPs and other stakeholders must have the portfolio and the expertise to figure out operational technology and network technology. How does it come together?

"Once you understand that time and motion, how do you and *where* do you infuse security, so that you can manifest the type of secure experience customers are looking for," he asked.

Titanium Platform's customers are focusing their MEC attention on managing security and subscriber data management, said Rosenberg.

"So they've collected the data, but now it gets somehow abused or infiltrated," said Rosenberg. Using public cloud services can also lead to costly security issues.

"And then you have things like GDPR issues," said Rosenberg, referring to the European Union data protection and privacy framework. "You may have privacy issues with some of this data, some countries have different rules than other countries and how you export and import that data can be very cumbersome."

"[MEC] improves security because now everything is localized."

***Ritesh Mukherjee, enterprise networks VP and GM, Inseego***

Rosenberg readily acknowledges that there is no one size fits all solution yet.

"But it's getting better, we see the management of data becoming better: They can extract certain pieces of that data in a very quick manner, while keeping the bulk of the other data on the edge in a secure fashion, so they don't have to move it," he explained.

Rosenberg and Krautkremer both see advancements in network automation as key to solving this, since throwing more bodies at the problem is not a viable solution at a time when the number of open network security positions vastly outpaces the available applicant pool. Artificial intelligence (AI) and machine learning (ML) algorithms can help alleviate some of that tension.

"The advancements in AI are allowing us to kind of do little data mining instead of doing big data mining," said Rosenberg. "As the core moves to the edge, and the edge becomes more multifaceted with a range of services, it requires some level of intelligence to make decisions in a very real time, millisecond type of manner. We're working on some of our future roadmaps, where we can incorporate some AI that allows the edge to communicate back to the core, and make certain decisions that help affect and protect data and subscribers."

Rosenberg said that carrier security posture can get complicated.

"Each carrier has their special sauce of their data in certain silos that they want to protect behind a firewall," he said. "So we see an awful lot of investment going on right now in signaling firewalls, and the rules that allow them to manipulate data."

"I think in all honesty, the complexity of building the applications is easy. The complexity of orchestrating and automating is hard. Every single carrier wants to do it differently. So as a vendor, you almost—by default—have to build a bespoke solution every single time. Because not everybody wants to do it the same way. And that is a big onus on vendors. Vendors can't build 900 different variations of their product. And so the lack of standards and the complexity of orchestration and automation and manual intervention, I think will continue to be a very complex solution that probably doesn't have an easy answer for a couple of years," he said.

## Conclusion

As a foundational technology for advanced 5G features like low latency communications and network slicing, MEC will become more commonplace in the years to come. But challenges for MEC deployment and management abound, across the ecosystem. Telcos, system integrators, independent software vendors and others must tackle challenging logistical, security and technical problems in order for it to work.

When it comes to both public and private telecom, MEC is still very much in a nascent phase, only available in select areas and for select purposes. There's no question that's changing, however. MEC unlocks the true potential of 5G, enabling functions like ultra reliable low-latency communication and network slicing. What's more, MEC will be a core network requirement as we move into 6G and the era of the metaverse.

We're still at the beginning stages of MEC deployment, and getting MEC working well and across multiple domains will take time. The 3GPP continues to roll forward with iterative new specifications that expose new MEC-specific functionality and to improve network capacity in preparation for MEC. The process to get those specs into working software happens quickly, but hardware—beginning at the silicon level—lags behind, especially at a time when supply chain issues have profoundly affected semiconductor manufacturing and other high-tech products.

Gartner predicts that by 2025, more than half of all enterprise-managed data will reside outside the data center. What's more, Gartner predicts by then the big driver for MEC adoption won't be low latency, but will be the reduction of bandwidth cost. That trend is already apparent in burgeoning MEC markets like China, where MEC provides carriers with mitigation against excessive backhaul charges.

The landscape of and market for MEC is changing on an almost daily basis. The decisions telcos make today — what to put on the edge, how to manage, deploy, and iterate it, how the edge will be used and for what — will help to determine how successful MEC will be.

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