Building applications for the edge

eBook

verizon | aws

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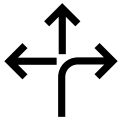
Cloud + mobility = innovation

For application developers, the arrival of cloud computing represented an important innovation. The on-demand nature of clouds, coupled with scalability and the rich set of available services accelerated application development. When cloud computing combined with ubiquitous 4G LTE networks, innovative apps were created: ride sharing, mobile games, social media, video conferencing, and more.

With 5G and edge computing, we expect a new wave of innovation by application developers. Verizon and AWS have partnered to bring developers this eBook designed to help them understand how mobile edge computing (MEC) can address today's application challenges, improve end-user experience, and enable innovation.

5G helps businesses level up

Verizon 5G Ultra Wideband brings high speed, low latency and massive capacity to mobile networks. These new capabilities help businesses unlock value in multiple ways.



Improving business intelligence.

5G handles more IoT devices than 4G LTE, generating business intelligence in near real time from IoT data feeds. This insight drives better decisions and can create business efficiencies.

Evolving customer experiences.

5G transforms the customer relationship by empowering businesses to design experiences that are immersive, connected and elevated. Engaged customers are more loyal and can contribute positively to revenue growth.

Enabling agility via automation.

Emerging sense-and-detect technologies and robotics combine with 5G and MEC to create efficiencies, increase agility and accelerate innovation from the factory floor to retail and beyond.

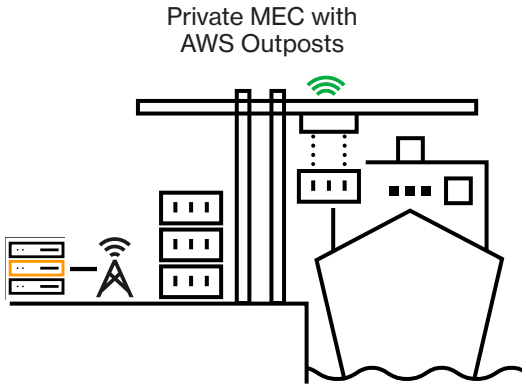
Enhancing workforce productivity.

5G helps keep the remote workforce productive through reliable, fast connectivity and enables augmented reality, virtual reality and new interactive platforms that can improve collaboration.

Public and private 5G

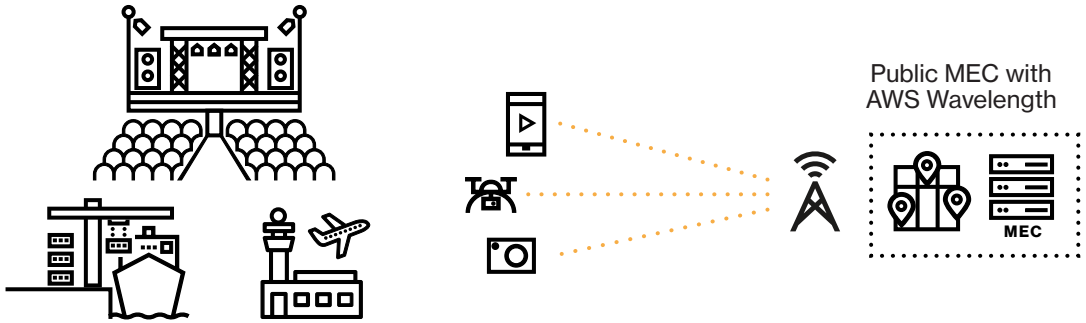
5G technology is applicable to both public networks and private networks. Private 5G networks on enterprise premises enable improved coverage, consistency, security, and reliability.

The increasing popularity of private 5G networks and widespread roll-out of public 5G networks bring new opportunities for application developers.



Private 5G networks can be deployed within the confines of the enterprise premises, both indoor and outdoor. Utmost privacy and control can be ensured by the new generation of private enterprise networks powered by cellular technologies.

Public 5G networks[1] can power applications that need wide, robust coverage and reach consumers and business users and devices across multiple locations.



1 5G Ultra Wideband available in select areas. 5G Nationwide available in 2,700+ cities.

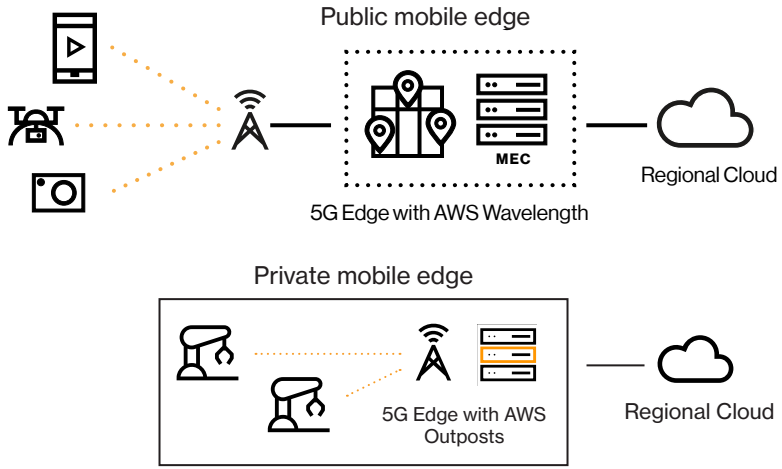
The 5G edge

Concurrent with 5G has been interest from application developers in bringing computing and storage closer to the source of generation and consumption of data. This enablement of mobile edge computing or MEC can unlock exciting new classes of applications through improved performance.

Content Delivery Networks (CDN) that serve video, image, and other content to end users are in wide use today, and represent a class of MEC workloads. The new generation of MEC being deployed will provide greater computing power, bring artificial intelligence/machine learning (AI/ML) and new capabilities to the mobile edge.

Verizon 5G Edge with AWS Wavelength is a public MEC offering that brings AWS cloud services to the edge of Verizon's mobile network, while Verizon 5G Edge with AWS Outposts is an on-premises private MEC solution for the enterprise.

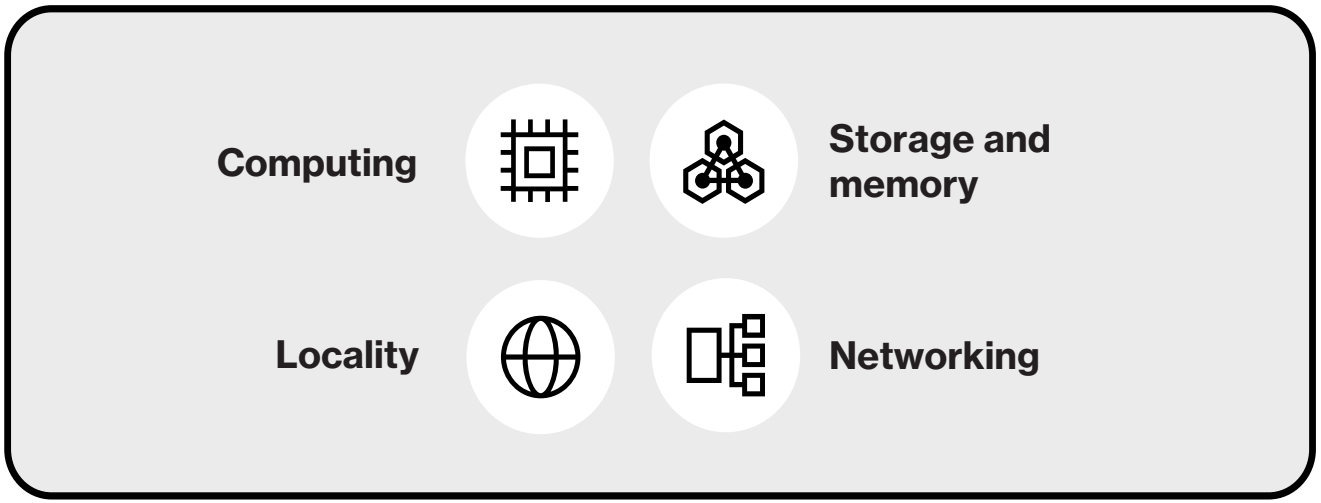
With both solutions, cloud services are physically located as close to the edge of the 5G network as is feasible, ensuring the least network hops between MEC resources and network devices and users. In a private deployment, both the 5G network and MEC are typically colocated on premises.



Examining 5G MEC

MEC represents the next level of optimization available for applications. For developers to understand the application classes that can benefit, we provide four lenses through which they can view edge computing.

Four lenses for MEC



Next, we will delve into each of the lenses separately. However, most applications will benefit from more than one aspect of the edge. Therefore, we ask that developers take this into context. We'll highlight the most prominent attribute through a lens, but readers should recognize that other attributes will come into play.

For example, the networking proximity and low-latency advantage will feature across almost all applications, but an extended reality application will rely heavily on computing resources for graphics rendering.

With that, let's get started with the drill down.

I. Computing

Computing resources a short distance away from where data is being generated and consumed can improve the user experience, and help bring intelligence to devices with constrained footprints and limited power budget.

Even though the edge has less resources and space than regional cloud data centers, the edge can still host substantial computing capabilities with specialized hardware for AI/ML, processing video, images, graphics, and large data sets.

Classes of applications that benefit from computing resources located at the edge include:

Extended reality (XR) and spatial computing applications including: augmented reality (AR), virtual reality (VR), mixed reality (MR) applications. XR and mobile gaming applications can leverage computing and graphics processing units (GPU) at the edge for assisted rendering when the local device has insufficient computing power.

Computer vision and diagnostics applications including crowd control and industrial safety.

Movie graphics and animation rendering using edge-hosted GPU to provide animation studios with greater workflow flexibility.

Consumer, commercial, or industrial Internet of Things (IoT) applications that require fast ingestion of massive data streams, running data reduction algorithms or prior to streaming data to regional clouds. Similarly, AI/ML inferencing can be applied to incoming data to render immediate decisions.

II. Storage and memory

Storage resources located nearby can allow rapid download of in-demand content. This is similar to CDNs, but MEC differentiates by providing the opportunity for increased intelligence and real-time content processing or transcoding.

Fast uploads can be facilitated, using the edge as an interim staging area for further up-streaming of bursty traffic, or for subsequent processing. Likewise, nearby pools of memory can host in-memory databases that enable near real-time lookups for key information.

Types of applications that for which this is advantageous include:

Advertising applications that benefit from in-memory lookup and fast serving of contextual and personalized content.

Mobile games that can use MEC-based storage to quickly serve up in-game assets like video, music, and images.

Authentication functions that leverage nearby storage and memory to quickly pull up identity information and look up user attributes.

Content delivery applications for streaming video, AR/VR experience, quickly serving up video, images, and other content.

Venue-based interactive content that can use the edge to store and rapidly process concert or sports content, powering personalized multi-views and immersive entertainment experiences.

III. Networking

The shorter networking path to MEC resources brings lower-latency, increased consistency in performance, and improved reliability due to reduced hops, and lowered incidence of packet drops and congestion.

These network characteristics enable the reliable low-latency access we touched on when looking through the lenses of computing and storage.

However, there are classes of applications that are particularly sensitive to network conditions, including:

Critical communications applications that cannot tolerate losses in transmission and need timely delivery of data packets.

Control applications including industrial autonomous mobile robots (AMR)/ autonomous guided vehicles (AGV), manufacturing robots on production lines, and drones, for which a loss in connectivity could be disastrous.

IV. Locality

MEC, by definition, is local — computing and storage resources placed at the edge of a mobile network.

Public MEC resources are usually tied to a metropolitan area while private MEC resources are on site, in private facilities like factories, mines, shipping ports, airports, sports or concert venues. This locale-specificity can provide context for applications while allowing for location-specific optimization of content resources.

Beyond these four lenses through which to view MEC-enabled applications, edge computing can be useful in situations when the harshness of the local environment precludes having on-premises computing and storage.

Types of applications benefiting from locale-specificity include:

Automotive applications (cellular vehicle to everything or C-V2X) that provide local high-definition maps, traffic conditions, and road and pedestrian safety

Virtual tourist applications that host location-specific high-quality and immersive AR/VR content for famous landmarks, museums, and other tourist spots in proximity.

Event-based interactive and immersive applications for sports, concerts, operas, live music performances that need fast access to rich and sizable content.

Architecting and refactoring for the edge

Now that we have an idea of MEC application classes, we will discuss how to modify existing mobile applications or architect new mobile applications to reap benefits of the edge.

Step 1. Decompose functions and features into logical modules

Step 2. Categorize into application classes and identify modules that can benefit from:
- Nearby computing capabilities, including GPUs
- Rapidly-accessible intelligent storage
- Near real-time, low-latency, reliable connections
- Location-specificity

Step 3. Rearchitect existing or architect new applications to separate out MEC modules that can benefit from running at the edge from application modules that could be hosted in regional cloud services like AWS Regions. Developers need to take into account that regional clouds will have a richer set of service offerings than may be available at the edge.

Modern cloud-native applications that conform to microservices architecture will be easier to separate into distributed components that can be hosted in different locations. For existing applications, there will be development work required to extract edge-hosted modules and create new APIs that facilitate communication and orchestration of these modules.

As part of application deployment and ongoing management, developers will want to coordinate with DevOps teams on how best to orchestrate both edge and regional cloud components. Likewise, application development and DevOps teams will need to develop a joint understanding on how to scale applications up or down in both regions and edge.

Planning for the edge

Building a roadmap

Some workloads at the edge, like CDNs, aren't new, but 5G coupled with cloud-managed on-demand edge computing, is novel and can foster creativity and new apps. 5G public and private edge sites are rolling out globally, application orchestration is increasing in sophistication, and we're seeing architectural blueprints evolve to accommodate distributed applications.

Verizon and AWS anticipate the developer community will take creative advantage of edge capabilities as they gain familiarity. The following are recommendations on engaging the edge, both today and tomorrow.

Step 1 — Immediate—the basics

Public mobile networks

Just as CDNs improved user experience for streaming apps and web content, edge computing resources can be leveraged to provide further improvements to today's apps.
Refactor existing applications to take advantage of the mobile edge in locations where available.

Leverage Verizon APIs like edge discovery service with AWS Wavelength to add edge location-awareness to existing applications, answering questions like "which edge should the application be connecting to?"

Start with CDN-type use cases but layer in more dynamism and intelligence to improve application response times and user experience.

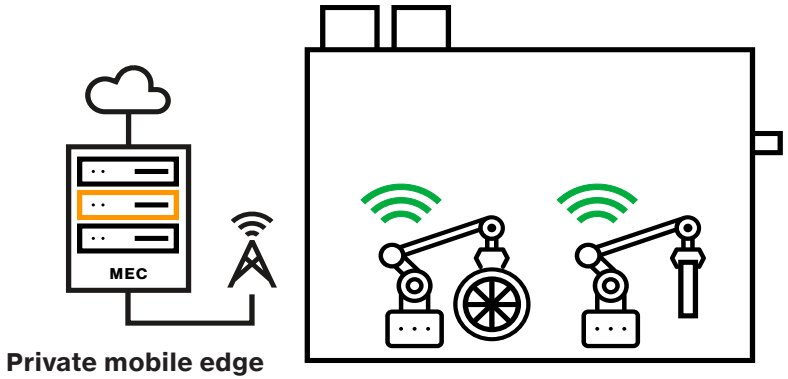
Private mobile networks

Modernize legacy applications by moving them into a cloud-managed and cloud-native infrastructure while maintaining on-site network performance and keeping sensitive data on-premises.
Work with Verizon to implement Verizon On Site 5G for a high-performance on-premises mobile network.

Examine existing VM-based applications and determine if a lift-and-shift for these applications onto Verizon 5G Edge with AWS Outposts can bring OpEx benefits while avoiding unnecessary CapEx upgrades for aging infrastructure.

Step 2 — Near-term — AI/ML assist

After reaping the basic advantages of edge computing, application developers can consume new edge-based services like AI/ML, or leverage high-performance edge computing through using GPUs. Whether in private or public mobile networks, these edge services can help up-level and create new user experiences.



Private mobile edge

Improved user experience: For example, adding new modes of interaction with text-to-speech functions, or supporting natural language processing (NLP) while maintaining fast response times by leveraging edge computing. Or incorporating image or video recognition through creating AI/ML models with Amazon Sagemaker, and then deploying them on Verizon 5G Edge, either on public or private networks.

Disaggregation and offload: Simultaneously, developers can look at disaggregation of devices on both public and private networks and offload computing functions to the edge, reducing the cost and power consumption of these devices, increasing computing power, and potentially increasing their useful life. There are successful early trials with offloading some compute from AMR/AGVs in factories.

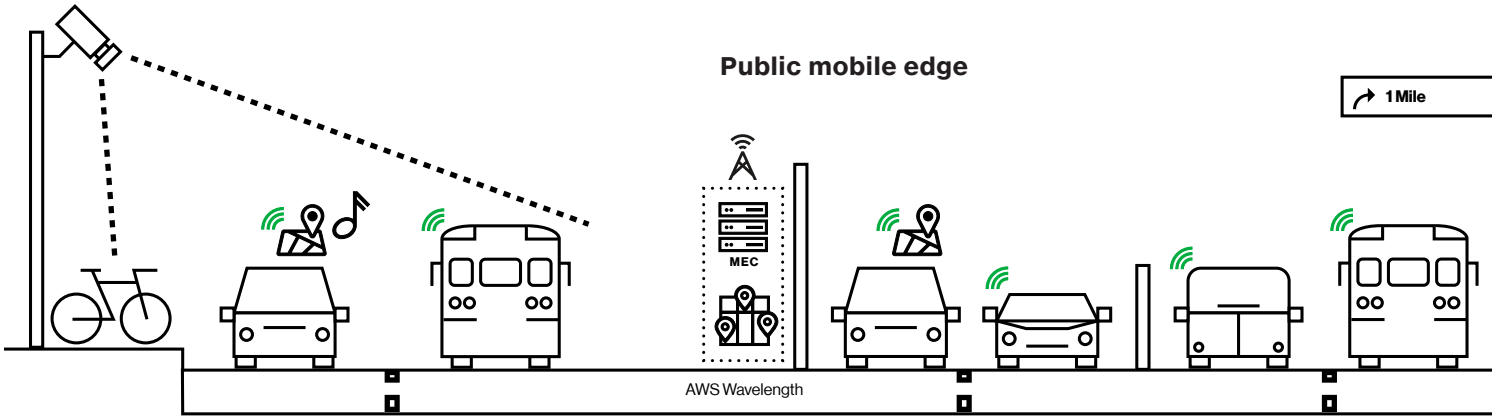
Step 3 — Longer term—leveraging the ubiquitous edge

Distributed apps: Over the longer term, as the edge becomes pervasive, applications can and will become more distributed. Developers should investigate the use of functions-as-a-service frameworks as they become supported at the edge. These frameworks (e.g., AWS Lambda) allow for increased granularity and facilitate highly-distributed applications that can scale across multiple edge locations.

Network APIs: Likewise, developers will be able to take advantage of network APIs that provide context around network conditions, as well as access to configuring service-level properties of underlying networks, which may, in the future, include 5G network slices (or slicing).

Orchestration and scalability: Developers will want to plan by starting to build and invest in sophisticated orchestration and management functions that can accommodate the scale of edge deployments.

We expect to see wider availability of automotive applications (C-V2X) and massively-distributed IoT applications for smart cities, taking advantage of the ubiquitous availability of edge computing.



Getting started

Achieving immediate value with the edge

Verizon and AWS's joint edge computing offers provide a powerful combination of trusted networking and proven cloud services. Regardless of which edge option you pick, you benefit from a set of options that combine Verizon's high-performance 5G network with AWS cloud services.

Verizon 5G Edge with AWS Wavelength, and Verizon On Site 5G and 5G Edge with AWS Outposts, support common infrastructure, services, APIs, and tools across enterprise cloud and on-premises environments. Enterprises with DevOps toolchains on existing AWS Regions can seamlessly extend them to edge infrastructure and services.

Verizon and AWS joint edge offers are available today. With an increasing number of Wavelength sites deployed across the United States, enterprises can immediately transform existing business applications or build novel applications on a proven, scalable, high-performance edge foundation.

To learn more about Verizon and AWS edge offerings, check out the Verizon 5G Edge Developer Portal, or visit our resource sites on 5G Edge with AWS Wavelength and 5G Edge with AWS Outposts.

Your Verizon Business account team will also be glad to answer any questions you have.

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