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GET STARTED

INNOVATION AT THE TELCO EDGE

A BLUEPRINT FOR BUILDING TELCO EDGE CLOUDS

Defining the Telco Edge

New technologies, new business models, new competition—the world of communications service providers (CSPs) is evolving much faster than anyone imagined. With massive growth in bandwidth demand and device proliferation, CSPs are building deeper and closer to edge of the network in order to meet the bandwidth needs and low-latency requirement for delivering high quality user experiences. Meanwhile, 5G also brings the promise of delivering 10x faster broadband and mobility services that are ultra-reliable and low-latency, creating new use cases and revenue opportunities. CSPs are racing to compete with the same customer set, both residential and enterprise customers, with faster and better services.

Network virtualization and cloud technologies are no longer new to CSPs, especially at the core datacenter. CSPs can apply the same principle and operational processes to extend the core network to the edge for expanding their network.

Edge computing also drives more innovations for ultra-low latency and high-performance applications and services. Edge computing is necessary for emerging applications, such as autonomous/robotic operations, AI and ML real time analytics and intelligent insights, video processing, live/drone surveillance, object/gesture recognition, location/geo-spatial services and AR/VR gaming and learning—wherever data is being generated, processed, and consumed at the edge.

However, it is not a simple task for CSPs to be able to deploy these new services quickly, securely, and at scale at the edge of the network. Deploying and operating such a distributed cloud environment is complex and requires significant enhancements in the cloud architecture, networking approach, and operations management. This requires cloud-first architecture and a strategy to plan, design, and build an agile, scalable, manageable, and secure platform in order to cost-effectively extend their reach, grow revenue and market share, and meet their business objectives at the telco edge.

This paper looks at these complex requirements, and discusses how CSPs can combine the computing power of the cloud with intelligence at the edge of their networks to create a framework for building impactful user experiences.

AT A GLANCE

VMware takes a policy-driven approach to deliver a telco edge architecture that enables operators to develop an end-to-end architecture to service applications across core and edge clouds. The platform is optimized to deliver enhanced telco services using both traditional and microservices-based applications and extend the operator network to third-party applications.

Edge Cloud: A Business Imperative

CSPs have several different priorities in their network transformation efforts. Some are modernizing their existing architecture and infrastructure as they evolve toward modern, cloud-first principles, while others are innovating with business models and applications. Whatever the intent and business use case, they all share the objectives of greater responsiveness and readiness for the needs of their business.

The objectives for edge clouds can be categorized broadly under the following business challenges:

DRIVE BUSINESS AGILITY AND INNOVATION

Combining agile infrastructure with edge clouds can accelerate business innovation. An agile development platform requires CSPs to collaborate with vendors on differentiated offerings and rapidly add subscriber features and functionality in response to market opportunities. An agile edge computing infrastructure enables rapid scaling that benefits clustered multi-user games or experiences that share context, such as player location and orientation among players located close to one another. Another example is personalized applications enabled by local context. CSPs are also looking at alternative business models such as providing a PaaS platform for third-party applications. A modern infrastructure is key to such opportunities, as they require the creation of developer-centric edge ecosystems that let developers tap into telco edge APIs—and the algorithm economy to help them create innovative and disruptive edge applications.

MODERNIZE MULTI-CLOUD NETWORK OPERATIONS

There is an acute focus on increasing the speed of change and improving operational resilience. An integrated operational intelligence framework provides advanced service lifecycle capabilities, monitoring and resilience, and improved operational efficiency by providing an integrated view of infrastructure, services, and applications. Similarly, efficient workload placement requires real-time load and available capacity along with collaboration between CSPs and software ecosystem partners, mainly Virtual Network Function (VNF) and Containerized Network Function (CNF) vendors. A prescriptive set of steps must be followed to package and deploy VNF/CNF, with the VNF/CNF vendor providing the prerequisites for successful VNF/CNF onboarding. This includes the VNF/CNF format, east–west and north–south connectivity, routing and security policy, and performance requirements. This also requires fine-grained resource allocation and control where consistent resource allocation at the edge and core data center ensures that tenant resources are provisioned and made available as and when required by the business.

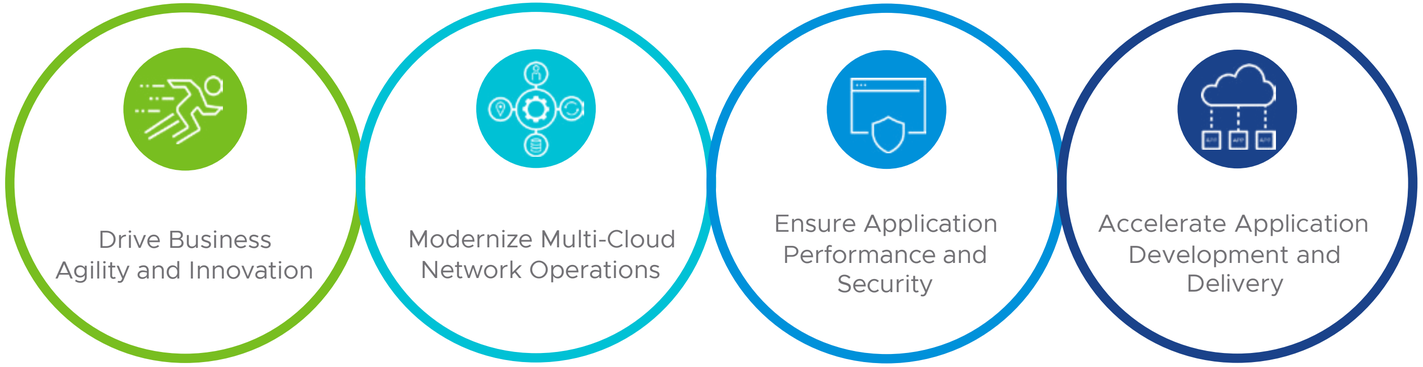


FIGURE 1: Top Business Challenges Faced by Communications Service Providers

ENSURE APPLICATION PERFORMANCE AND SECURITY

Use of hardware accelerators and DPDK-based workload acceleration greatly enhances application performance and creates differentiated customer experiences. Edge computing, however, also greatly expands the number of potential access points across the network, and CSPs need tools to provide higher levels of protection. This requires the use of secure cloud gateways, micro-segmentation, and an ecosystem of VNF and CNF solutions for networking and security across workloads and tenant switching and routing fabric. Another aspect that impacts overall security and performance is the necessity to provide resource isolation and resource guarantees across applications. This requires a secure multi-tenant environment with dynamic resource allocation. Finally, robust business continuity requires edge cloud components to implement high availability by default while allowing applications to leverage platform capabilities and extend their availability.

ACCELERATE APPLICATION DEVELOPMENT AND DELIVERY

Increased speed of application delivery has become a fundamental business imperative. The industry is coalescing around the use of containers as a unifying platform across development, operations, security, QA, and other teams. With a DevOps approach, teams are embracing CI/CD practices and container-based automation to accelerate the app delivery cycle. CSPs can no longer just build edge cloud infrastructure and hope for adoption—they must actively promote software innovation with applications optimized for a decentralized cloud ecosystem. By providing application developers with the tools needed to tap into the distributed edge infrastructure, CSPs can promote innovative solutions that offer enhanced customer experience and better service. Edge solutions, discussed later in this document, are a critical part of this effort.

Driving Revenue and Value at the Edge

CSPs are in prime position to offer their customers the required telco infrastructure that matches the requirements of applications and industry verticals being targeted. Deployment of applications will be based on whether the application requires ultra-low latency/high-bandwidth characteristics, or whether data or resource-intensive applications will require being placed in a centralized data center.

A typical telco edge architecture site can be visualized as a three-layer stack consisting of the virtual infrastructure, orchestration and automation layer, and application layer. End-user services can run either on top of the application layer or directly on the virtual infrastructure. By running on top of the application layer, end-user applications can leverage the underlying infrastructure and provide customized services (such as location-based services) to users. The VMware telco edge also allows applications to run directly on the virtual infrastructure. A typical use case would be a video broadcasting application that pre-processes video from a live event before uploading it to the central media distribution site. Here, we discuss a few use cases that are seeing widespread telco interest and adoption.

SOLUTION HIGHLIGHTS

- 5G-ready platform designed for high-bandwidth, ultra-reliable, low latency applications with support for a large volume of connections, fixed-mobile network convergence, and a cloud-native stack
- Hierarchical distributed cloud that supports resource pooling, hierarchical cloud management, business continuity and service localization
- Simplified manageability and hierarchical operations for fully remote lifecycle management, capacity planning, issue isolation and closed-loop optimization across shared cloud infrastructure
- Advanced edge cloud networking with hybrid cloud interconnect, latency-optimized connectivity, dynamic workload chaining, and N-VDS for user plane functions

DISAGGREGATED CONTROL AND USER PLANE

5G aims to enable applications that consume a large amount of data (e.g., live streaming), provide low-latency immersive experiences (e.g., AR/VR), and provide network connectivity to billions of devices (e.g., IoT). These goals necessitate upgrading both the radio network as well as mobile core. On the radio network, there are significant advancements in spectral efficiency and increased data. In the mobile core, there is a push to separate the data plane from the control plane and to deploy the user plane as close to the device as possible to handle massive amounts of data traffic.

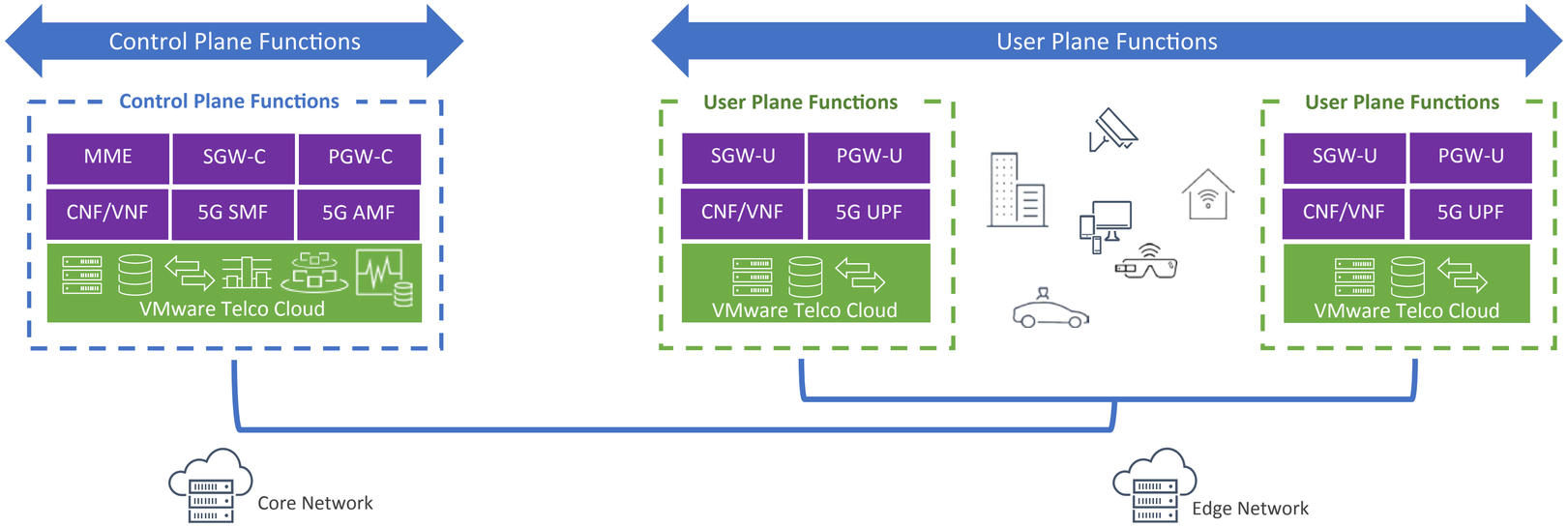


FIGURE 2: Control and User Plane Separation Using VMware Telco Edge

Mobile User Plane Using VMware Telco Edge

For the CUPS (control plane and user plane separation) architecture realized with a VMware telco edge, 4G EPC and 5G positions the control plane in an aggregation site, and the user plane is distributed to the edges. Low latency and low cost of backhaul/core transports are critical for supporting massive bandwidth and device density, and mobile operators are looking at distributing control plane functions to a few regionally distributed clouds. This model provides operators with a good balance between simpler topology and efficient processing. Typically, the user plane functions would be located at the edge sites while management and control plane functions would be hosted at a core data center.

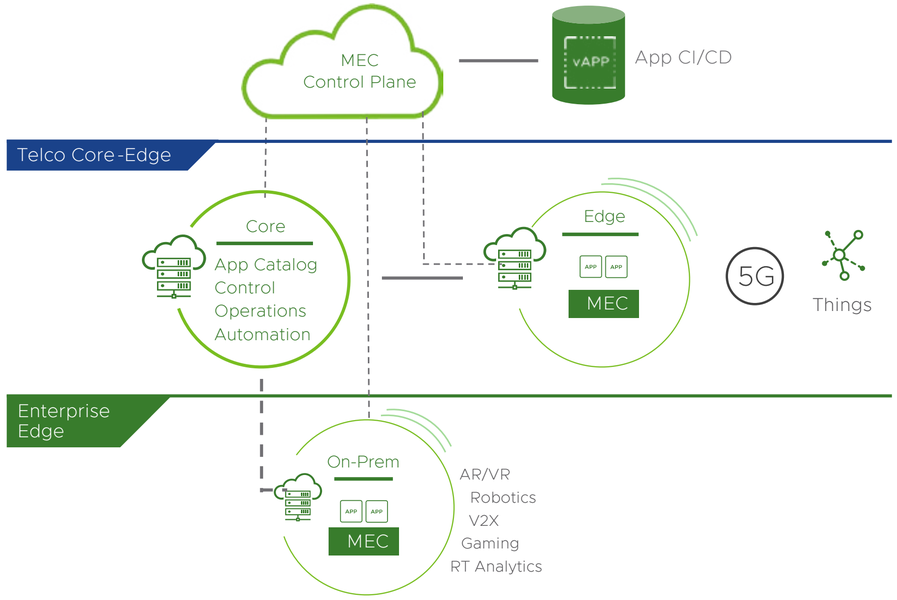


FIGURE 3: Telco Edge and MEC

PRIVATE CELLULAR NETWORKS

Enterprise applications such as industrial manufacturing, transportation, and smart cities have traditionally relied on Wi-Fi and fixed-line services for connectivity and communications. These networks have been unreliable and costly while also being difficult to scale. This creates a monetization opportunity for CSPs to offer private cellular networks for business and enterprise markets.

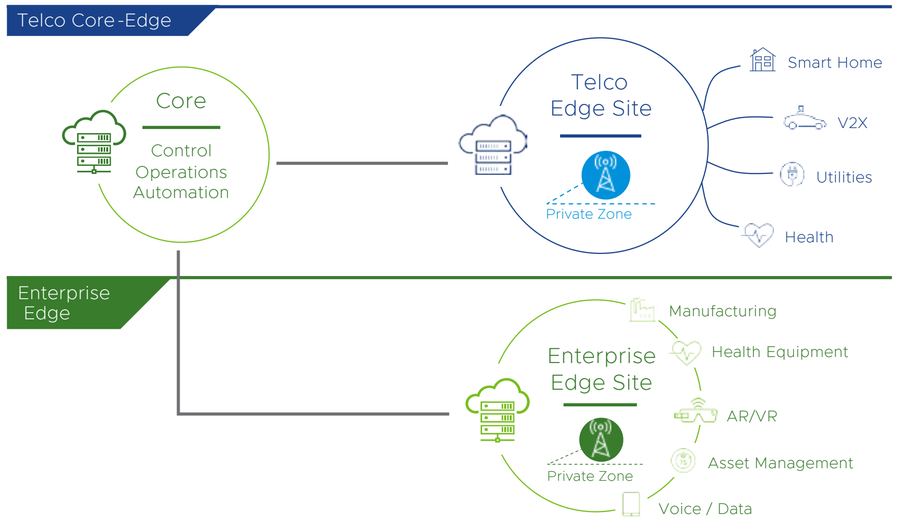


FIGURE 4: Telco Edge and Private Cellular Network

CSPS are deploying dedicated mobile networks (4G and/or 5G) at the enterprise site to overcome connectivity challenges.

Private Cellular Network Using VMware Telco Edge

As real-time analytics and automation become increasingly common in manufacturing, reliable and scalable wireless communication is becoming critical to the business. Enterprises have so far relied on Wi-Fi based technologies to meet their needs. Wi-Fi, however, presents several challenges in such an environment, including issues with in-building coverage, uninterrupted roaming, and session continuity from inside the premises to outside.

CSPs are deploying dedicated mobile networks (4G and/or 5G) at the enterprise site to overcome connectivity challenges. Making the site completely self-sufficient requires enterprise deployments to include all data plane and control plane components needed to manage a scaled-out telco network where mobile sessions do not leave the enterprise premises unless necessary. In addition, enterprises may deploy additional applications at the edge site with the option to connect the edge directly to the enterprise IT cloud. For example, a factory floor can be automated to provide private cellular network services to robotics equipment, remote operations, and content storage and distribution with the same consistent VMware Telco Cloud Infrastructure and capabilities.

A Path to Deploying Telco Edge Clouds

VMWARE TELCO EDGE DESIGN PRINCIPLES

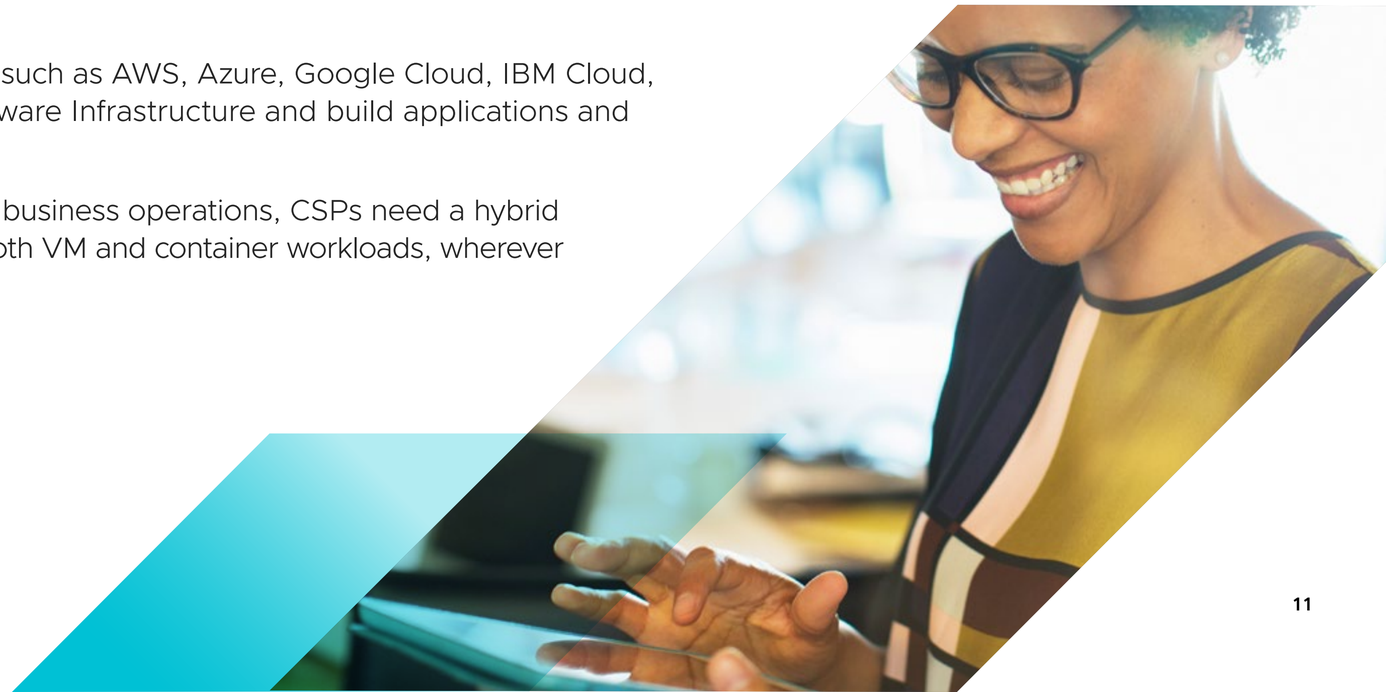
This section highlights the VMware key design principles that enable CSPs to build, run, manage, connect, and protect any app on any Cloud for telco edge. Based on VMware Telco Cloud, VMware telco edge is designed to support mission-critical, ultra-reliable, low-latency, and high-performance applications running on in a distributed cloud model.

Multi-Cloud Flexibility

CSPs should have the freedom and flexibility to choose, change, and migrate their cloud deployment model when and where they see fit. The VMware Telco Cloud enables CSPs to have the freedom to build and deploy modern applications in any cloud, from the data center to multiple cloud and edge environments.

VMware supports broad hybrid cloud options, delivered with key partners such as AWS, Azure, Google Cloud, IBM Cloud, and Oracle Cloud. CSPs can access to the hyperscalers within proven VMware Infrastructure and build applications and services that can deploy and manage across multiple clouds.

In order to increase the agility, flexibility, and portability of applications and business operations, CSPs need a hybrid cloud platform that can deliver consistent infrastructure and operations for both VM and container workloads, wherever workloads are deployed.



Centralized Management and Consistent Platform for Hybrid Cloud

VMware provides a flexible deployment architecture based on a consistent infrastructure, automation, and operations platform that is optimized for deployments across the core data centers to the edge. With centralized management and a single pane of glass for monitoring network infrastructure across the multiple clouds, CSPs will have consistent networking, operations and management tools, policy, and process across their cloud infrastructure.

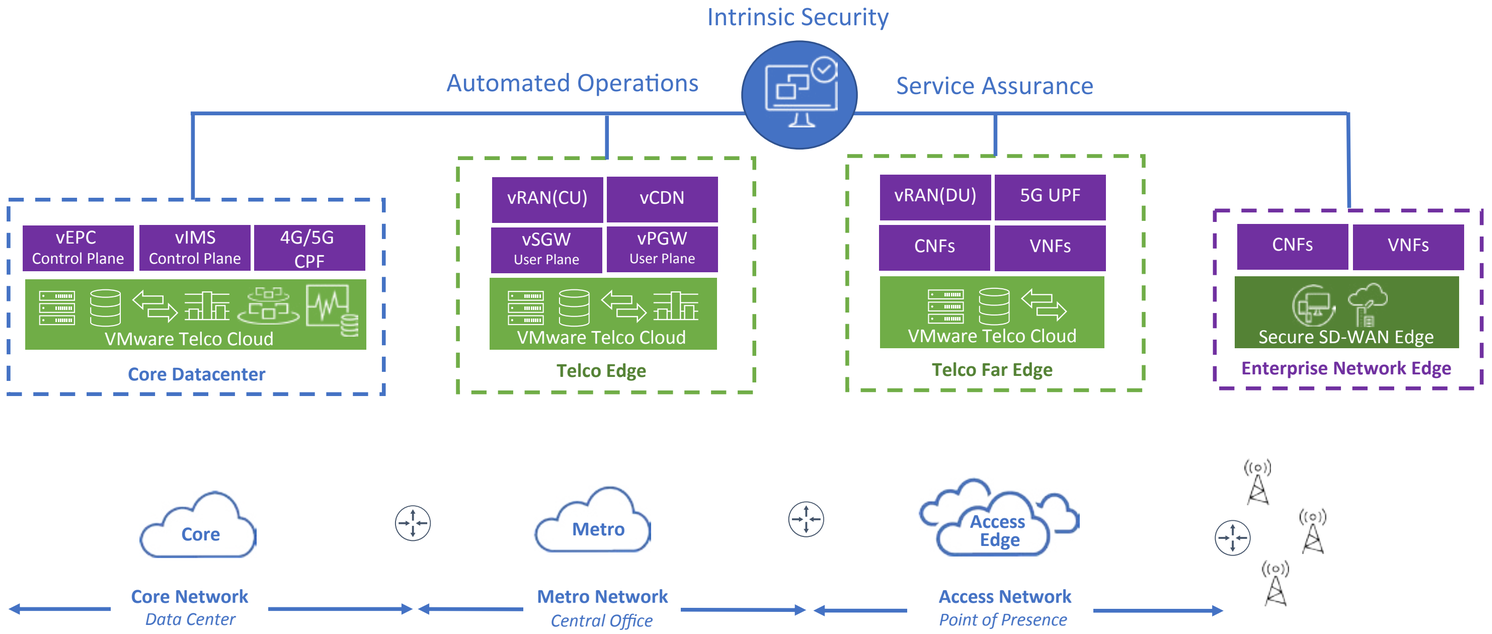


FIGURE 5: Consistent Telco Cloud from the core network to the edge

In a distributed and disaggregated edge architecture where the control plane is in the core and the user plane at the edge, centralized VMware Integrated OpenStack, as virtual infrastructure manager (VIM) at the core data center, enables orchestrating the infrastructure and deploying VNFs without needing and having any OpenStack instances at the edge sites.

Similarly, Kubernetes clusters, as well as CNFs, can be deployed and managed from a centralized core data center with automation by using VMware Tanzu. By centralizing management and governance for Kubernetes clusters, VMware Telco Cloud simplifies the operation of Kubernetes for multi-cloud deployments with VMware telco-grade CaaS enhancements such as:

- Multus to attach multiple container networking interfaces to Kubernetes pods through its plugins
- Topology Manager to optimally allocate CPU memory, and device resources on the same NUMA node to support performance-sensitive applications
- Kubernetes cluster automation to simplify deployments and management of Kubernetes master and worker nodes
- Extensions to support automated cluster configuration and provisioning
- Profile based worker node dimensioning to optimize usage and performance

This enables CSPs to take advantage of telco-grade Kubernetes platform from VMware to address emerging edge and 5G use cases, and gain massive improvements in network manageability, upgrades, and scale—while reducing operational overheads.

Multi-Layer Automation

In addition, VMware Telco Cloud Automation enables ubiquitous knowledge of resources and states of all distributed sites without connecting to them individually, increasing operational consistency and efficiency. VMware Telco Cloud Automation unifies the multi-cloud management of VM or container workloads, Kubernetes clusters, and the underlying virtual infrastructure to seamlessly scale operations of multiple edge sites. It streamlines the edge sites' deployment with zero-touch provisioning capability by accelerating edge site readiness, faster time to market, and reducing the edge overall rollout OPEX.

Efficient Network Function Onboarding and Placement

Once a VNF/CNF is onboarded, the tenant admin deploys the VNF/CNF to either the core data center or the edge data center, depending on the defined policies and workload requirements. VMware telco edge offers dynamic workload placement, ensuring the VNF/CNF has the correct number of resources to function efficiently.

Multi-Tenancy and Advanced Networking

VMware telco edge can support a multi-tenant environment with isolated resources to each tenant. With the isolated multi-tenant environment, each tenant also has an independent view and control of their overlay network, resource capacity, and overall management of their own logically separated infrastructure. In addition, the support of overlay networking at the edge sites enables CSPs to offer simple configuration of the connectivity and security with the zero trust principle using micro-segmentation from VMware NSX.

Superior Performance

By leveraging VMware NSX Managed Virtual Distributed Switch (N-VDS) in Enhanced Data Path (EDP) mode, together with elastic resource scaling across vSphere clusters, VMware Telco Cloud delivers superior data plane performance, continuous service availability, and simplified management to the edge sites.

In a distributed and disaggregated edge architecture, data plane workloads can be deployed in data plane-intensive clusters. By using VMware N-VDS in EDP feature, it can assign dedicated CPU resources to improve network performance for meeting low latency and higher throughput requirements at the edge sites if, or when, it is needed.

End-to-End Automated Service Assurance

The ability to locate, isolate, and provide remediation capabilities is critical given the various applications and services that are being deployed at the edge. In a distributed cloud environment, isolating an issue is further complicated given the nature of the deployments.

VMware telco edge uses the same operational model as is deployed in the core network, and has an end-to-end automated service assurance especially for those mission-critical ultra-reliable use cases and applications. VMware Telco Cloud Operations, a real-time automated service assurance, spans across multiple layers of the network, analyzing and correlating the virtual services with the underlying infrastructure. It provides comprehensive visibility and automation with integrated performance analytics based on machine learning and automated fault analysis. CSPs can leverage VMware Telco Cloud Operations to proactively avoid problems and simplify their network operations through holistic monitoring and performance management, for both core data centers and distributed telco edge.

Intrinsic Security

Security risks and vulnerabilities increase dramatically as more valuable data and applications are generated and consumed at the edge in a distributed software and cloud-based architecture. CSPs need to rethink cloud security to include security at the workload level and design their telco edge with intrinsic security in mind.

VMware emphasizes intrinsic security that is built into the software and infrastructure to make security programmable, automated, adaptive, and context- aware. For security at the edge, VMware NSX implements network and security services such as security groups, firewalling, and micro-segmentation, enabling a least-privilege model for an edge site. NSX security groups, tags, policies, and other capabilities can isolate virtual workloads in edge trust domains which can then be managed by the corresponding risk and sensitivity levels. In multi-tenant environment, VMware Telco Cloud separates services through NSX micro-segmentation with fine-grained access controls for administrators, secure integration with the VIM, delegated role-based access control, tenant-level operations management and visibility, and cross-vCenter security policies that empower operators to apply security policies consistently on objects across multiple VMware vCenter services.

6 Steps to Edge Cloud Readiness

Edge clouds provide an environment where CSPs can build secure and powerful cloud solutions that address the limitation of traditional infrastructure. However, moving from centralized to edge cloud architectures can be complex. Here, we describe a set of initiatives a CSP should undertake to evolve to a cloud architecture that maximizes the impact of edge clouds.

1. Establish Clear Objectives. Establish clear objectives and use cases for developing edge clouds over the short and long term. You should be able to articulate the business value, and clearly identify capabilities and tasks for moving forward.

2. Understand Your Application Landscape. Analyze the requirements of your applications to identify those best suited for an edge cloud environment. Consider the need to refactor your on-premises applications for deployment on edge cloud platforms. Applications that are flexible and service oriented can typically leverage the scale-out edge cloud architecture, especially cloud-native applications that are easy to automate, move and scale.

3. Formulate a Resource Allocation Strategy. Analyze your entire network to form a geographical distribution strategy for your edge clouds and application workloads. This includes identifying the number of end users in each edge geography that are expected to subscribe to edge services and scaling the edge cloud capacity accordingly. The goal of this exercise is to avoid system complexity and poor resource utilization by aligning resource allocation with expected usage patterns and application characteristics such as the use of VMs and containers.

4 **Align People, Processes and Technology.** Bring together business, development, and operations and think in terms of people, processes, and technology. What needs to change and why? What would be the effects of migrating an application or group of applications to edge clouds? What changes in staffing or workflows would be required to support this new edge cloud environment? Create a solution architecture that describes how the solution should look when it's fully implemented. The goal is to align and guide those working on the project. Also consider embracing organization-wide agile methodologies that include the engineering, product management, business development, cloud operations, IT, software delivery and customer support teams.

5 **Architect for Scale and Application Availability.** A key advantage of deploying edge clouds is increased application availability and higher service resilience. Clearly articulate an availability and disaster recovery strategy and use integrated operations designed for virtual environments. Focus on automating policies across clouds such that you have a single standard set of policies applied automatically to each cloud. Ensure that the policies cover such areas as data storage, workloads, traffic flows, virtual servers, compliance, security and reporting and that changes and updates propagate seamlessly from one cloud to another.

6 **Deploy and Maintain Strategic Focus.** Deploy your cloud resources including applications across the edge clouds while maintaining a unified end-user experience. Implement strategies for monitoring capacity utilization and scaling the edge sites dynamically to future-proof the network. And finally, continue to remind those working on the project what the end goal is, why it matters, and how this project contributes to the organization's strategic goals.

FIGURE 6: Six Steps to Edge Cloud Readiness

Resources for Your Edge Cloud Journey

Learn more about how VMware can support your edge cloud journey.

For insights, sizing tips, and detailed design and deployment considerations:

VMware Edge Reference Architecture

VMware Telco Cloud Infrastructure solution brief

VMware Telco Cloud Platform datasheet

VMware Telco Cloud Operations

Intrinsic Security for Telco Clouds white paper

Learn how VMware technologies are enabling the telco cloud at: **telco.vmware.com**

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VMware, Inc. 3401 Hillview Avenue Palo Alto CA 94304 USA Tel 877-486-9273 Fax 650-427-5001 vmware.com