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# Enabling MEC as a New Telco Business Opportunity

*A Complete MEC Solution from Wind River, Saguna, and Dell EMC for Deploying New Revenue-Generating Services*

WHEN IT MATTERS, IT RUNS ON WIND RIVER

## EXECUTIVE SUMMARY

Multi-access edge computing (MEC) creates virtualized cloud computing environments in access networks that enable communication service providers (CSPs) to improve the delivery of content and applications, generate new service revenue, improve network efficiency, and deliver next-generation services. Wind River®, Saguna Networks, and Dell EMC have joined forces to create a complete, end-to-end MEC solution that is pre-integrated and validated to mitigate deployment risk and accelerate time-to-market. The joint solution delivers the low latency and high bandwidth expected of MEC implementations as well as the flexibility, performance, carrier grade reliability, and security that CSPs require.

The complete MEC solution from Wind River, Saguna, and Dell EMC drives top-line revenue growth through the creation of new services, reduces operating costs, and minimizes deployment risks so that CSPs can get started today.

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## INTRODUCTION

In the digital era, the only constant is change. We are now entering the next phase in our connected world, the Internet of Things (IoT). From connected cars and drones to augmented reality and robotics, connecting these devices will pose many challenges requiring fast and reliable communication links. This is an opportunity waiting to be seized by communication service providers (CSPs). The IoT is a new growth engine that enables CSPs to expand beyond offering commodity communication links to playing an active role in these new and exciting services with a cloud-computing environment at the edge of their networks.

Multi-access edge computing (MEC) promises to unlock this opportunity for CSPs. MEC creates virtualized cloud computing environments within the access network, close to where mobile subscribers and devices are. The proximity to end devices, along with distributed processing power, opens a world of service and network optimization opportunities for CSPs. MEC also leverages the principles of Network Functions Virtualization (NFV) and Software-Defined Networking (SDN), which enable operators to build flexible, scalable networks with increased service agility.

By distributing virtualized cloud computing resources in the access network, rather than relying on a centralized architecture in the core network, CSPs can accelerate the delivery of content and applications. MEC enables the delivery of new low-latency, high-bandwidth services, many of which were not previously possible due to the limitations of mobile and fixed network architectures. MEC also provides access to real-time network conditions, which provide valuable analytics and insights that inform how content should be modified and applications optimized for best performance on the network.

The implementation of MEC turns the access network into a service environment for CSPs as well as third parties. With the attributes of low latency, high bandwidth, and access to real-time network analytics, MEC presents application developers with a veritable gold mine of opportunities for new service creation.

By distributing processing, analytics, and service delivery to the edge of the network, MEC also relieves congestion in the core network and conserves capacity in backhaul transmission networks. MEC contributes to higher network efficiency and reduced operating costs.

Momentum for MEC is building. In September 2014, a group of six operators and vendors (Huawei, IBM, Intel, Nokia Networks, NTT Docomo, and Vodafone) published their vision for MEC in an introductory technical white paper and launched a specification group within the European Telecommunications Standards Institute (ETSI). The ETSI MEC Industry Specification Group now has more than 60 members and participants. The group published the first set of standard application programming interfaces (APIs) to support edge computing interoperability.

But, as with any new networking capability, there are business and technical challenges. MEC is uncharted territory for many telco equipment manufacturers and CSPs, and the use cases involve new types of services that they have not provided before. There is clearly a need for a validated, pre-integrated MEC solution that delivers the promise of low latency and high bandwidth with the flexibility, performance, and carrier grade reliability that CSPs require. This paper explores how the MEC solution from Wind River, Saguna, and Dell EMC addresses the business and technical challenges, enabling CSPs to deploy and start delivering new services today.

## MEC USE CASES

CSPs are considering a wide variety of MEC use cases. The following examples provide a snapshot of the types of services that are possible.

### Enterprise Small Cell Services

Mobile service providers increasingly deploy small cells to improve indoor coverage and boost capacity at office complexes, industrial facilities, or large venues such as stadiums, where there is typically a high concentration of users.

Service providers can use MEC to leverage these small cell deployments to offer enhanced data and video services. For example, during a large-scale sports event, venue owners can use the real-time video from multiple cameras to supplement security surveillance. CSPs, meanwhile, can offer personalized content to the tens of thousands of fans in the stadium to make their experience more enjoyable and memorable. With multiple live camera angles, instant replays, and real-time video from drones, event attendees can view enhanced content to supplement the live event. CSPs can also team with event sponsors and advertisers to present coupons or special offers to attendees.

### Real-Time Services

Augmented reality, virtual reality, and IoT represent a sea change in the types of services CSPs can offer. But they require fast response times from the network and lightweight devices with long battery life to enable high-quality, real-time experiences. With local processing near end users, CSPs can significantly reduce the time it takes to conduct image analytics and retrieve augmented reality data. Likewise, the end user devices can offload computational tasks to the local MEC data center, which reduces power consumption and the need for sophisticated processing and memory components in the device.

The potential new services go beyond the realm of gaming and entertainment and include applications that will make real improvements to people's lives, such as performing remote surgery and diagnosis or servicing sophisticated industrial equipment. There are also opportunities to realize efficiency gains. Ultra-low latency and automation will expand the use of robotics in manufacturing, particularly where high throughput and precision are required.

### V2x Communication Services

Vehicle-to-vehicle and vehicle-to-infrastructure communication services have the potential to ease road congestion, prevent accidents, and promote proactive maintenance. But today's networks with centralized computing are not capable of providing the ultra-low latency and fast reaction times that such applications require. MEC enables vehicle-to-infrastructure services on today's 4G networks by locating distributed cloud computing environments closer to where vehicles are operating. For example, sensors and cameras can be installed along busy motorways and congested urban streets to monitor traffic and other environmental conditions. The data collected is analyzed in the local MEC data center and alerts are sent to vehicles to warn drivers about hazards, help them navigate through congestion, or even help them locate nearby available parking. To improve road safety, MEC enables real-time data processing.

### Mobile High-Definition and 4K Resolution Video Services

A poor-quality video experience often results in dissatisfaction for CSP customers. According to recent data from video platform specialist Ooyala, a one-second rebuffering event during a 10-minute on-demand video clip results in a 43% drop in user engagement.

MEC enables CSPs to improve video service quality and use network resources more efficiently. Because MEC stores content closer to where users are, CSPs can serve up video faster over mobile networks, which reduces long wait times for videos to start. MEC platforms provide bandwidth guidance so that content can be optimized to suit the subscriber's network quality. Using Radio Network Information Services (RNIS), MEC platforms also tap into real-time network conditions such as cell congestion and subscriber location, which ensures that the content can be optimized for delivery.

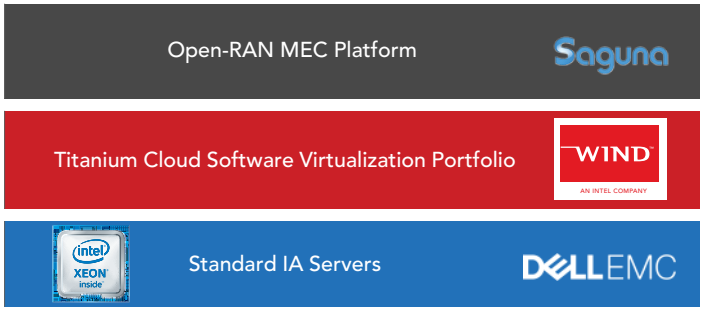


*Figure 1. An end-to-end solution for MEC*

## COMPLETE MEC SOLUTION

Wind River, Saguna, and Dell EMC have joined forces to create a complete MEC solution with all of the components needed for CSPs to implement small MEC data centers at the edge of the network and introduce new services. The solution delivers on the business and technical benefits associated with MEC by ensuring ultra-low round-trip latency and high bandwidth, with guaranteed high availability and robust security as well as a comprehensive software stack.

- **Wind River Titanium Cloud™** is the industry's only fully integrated, ultra-reliable, and deployment-ready family of software virtualization platforms that enable service providers to deploy virtualized services faster, at lower cost, and with guaranteed uptime. The portfolio includes Wind River Titanium Core, which is designed for CSP data centers, central offices, and points of presence (PoPs); and Wind River Titanium Edge and Wind River Titanium Edge SX, which are designed for small footprint telco edge applications and which support dual server and single server configurations respectively, making them ideal platforms for MEC implementations. In addition, Wind River Titanium Control supports industrial control applications.

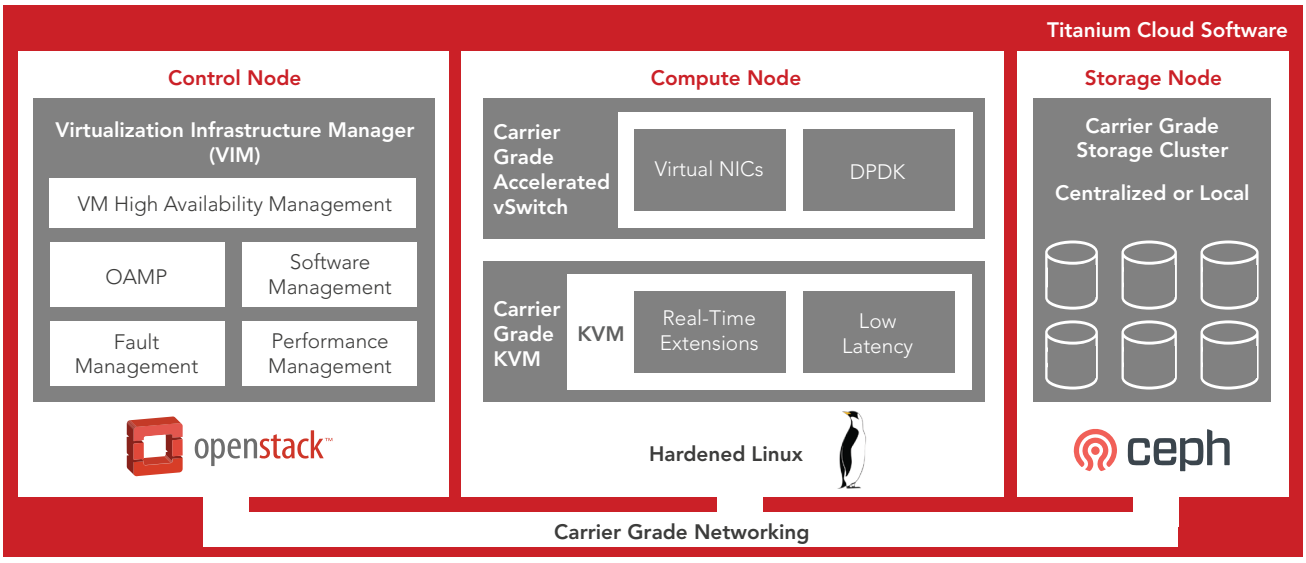


*Figure 2. Wind River Titanium Cloud architecture*

- **Saguna Open-RAN** MEC platform creates a standards-based cloud-computing ecosystem inside the access network that allows CSPs to increase network monetization while reducing CAPEX and OPEX. The platform comprises three elements: Saguna vEdge multi-access edge platform creates an open cloud computing "cloudlet" for MEC applications and provides multi-access edge services such as registration and certification, traffic offload function (TOF), and real-time RNIS. Saguna vGate resides in the core network and preserves core functionality for access-generated traffic, including lawful interception, charging, and policy control. And Saguna OMA is the management and automation layer within the MEC host. It supports lifecycle actions and MEC-specific operational requirements for Saguna vEdge and mobile edge applications.

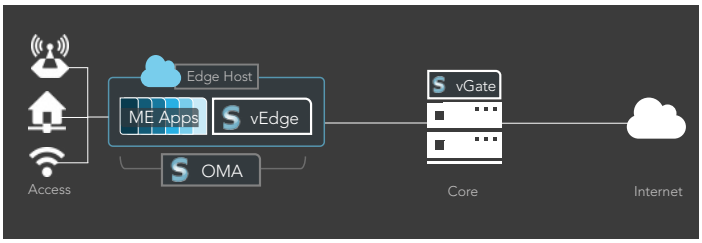


*Figure 3. Saguna Open-RAN architecture*

- **Dell EMC Infrastructure** is the best-in-class server, storage, and networking solution designed for high performance in any condition. The Dell EMC portfolio has standard servers from its PowerEdge product line, which are designed for any enterprise and service provider use case. They scale from short-depth one-rack units to full hyper-scale, high-density environments. This portfolio includes NEBS compliant servers, storage, and networking. Dell EMC also has an Embedded PC product line that is designed to withstand harsh environmental conditions. These fan-less units can operate at 0–50 degrees Celsius and are designed to MIL-STD-810G. Micro Modular Data Center (MDC) is an extension of current MDCs designed primarily for CSP use cases such as MEC, next-generation central offices, and PoPS. They are small, nimble data centers that enable edge computing. The Micro MDC ranges from one- to three-rack units that are customized to fit a variety of indoor or outdoor installations, providing local compute, storage, and networking as well as integrated power and cooling. The pre-integrated solution is built to CSP requirements and features fast installation to speed the storage, processing, and analysis of nearby data at the network edge.

### Optimized for Ultra-Low Latency

The combined Wind River–Saguna–Dell EMC solution is optimized to ensure ultra-low latency for MEC applications and

services. In a typical mobile network, round-trip latency—that is, the time it takes for data packets to go from an end user device to the mobile core network and back—is approximately 60–100 milliseconds, which varies depending on the network architecture, air interface technology, backhaul transmission, type of application being transmitted, and even the time of day. By moving compute and storage resources from data centers in the core network out to the access, network latency is greatly reduced to about 10–30 milliseconds.

The latency reduction is achieved by processing content and applications in the MEC cloud computing environment in the access network, rather than transmitting them to the core network. The MEC architecture eliminates from the application's path many of the components that can each add latency to mobile services, such as long fiber hops, fiber rings, routers, switches, and various evolved packet core (EPC) network elements.

In addition to the significant latency reduction inherent in moving compute and storage capabilities to the network edge, each element of the combined solution is designed to speed packets through the platform as fast as possible to support real-time MEC applications. Within the Wind River software virtualization platform, the time it takes to deliver packets to guest virtual machines (VMs) is a critical factor in app performance. All Titanium Cloud platforms feature a low-latency compute profile and comprehensive enhancements to the integrated KVM hypervisor, which deliver an average interrupt latency of just three microseconds to guest VMs.

The latency enhancements to Titanium Cloud underpin Saguna vEdge platform, which delivers the MEC functionality in a lightweight virtualized software layer operating on the user plane. Architected using Data Plane Development Kit (DPDK), the Saguna solution is optimized to minimize latency. Furthermore, the underlying server hardware from Dell EMC is powered by the latest Intel® Xeon® processors and optimized to run low-latency applications at the edge of the network. Dell's modular server components in the Micro MDCs have the same powerful processing as those found in hyperscale data centers, which allows service providers to speed storage, processing, and data analytics at the network edge.

Given that edge deployments dramatically reduce overall network latency, the MEC solution itself cannot add a substantial amount of latency to applications served from the network edge. To maximize the benefits of MEC, system latency should be limited to 1–2 milliseconds; otherwise, the advantages of edge deployments would be minimized. Together, Wind River, Saguna, and Dell EMC have created a solution that achieves ultra-low latency to support MEC applications and services.

### Carrier Grade Reliability and Security

Standard IT-grade equipment and open source software are not designed for the stringent requirements of carrier networks. Most MEC applications, such as vehicle-to-infrastructure apps, are mission critical and require high availability. Depending on the applications supported, a lack of carrier grade reliability and security in MEC implementations could result in more severe consequences than merely poor service quality for subscribers or service level agreement (SLA) penalties for service providers. The combined MEC solution from Wind River–Saguna–Dell EMC provides the carrier grade reliability and security that service providers demand across any size deployment.

Titanium Cloud delivers six nines (99.9999%) guaranteed uptime, which results in less than 30 seconds of service downtime per year. This is achieved through numerous features in the software stack, including automatic failure detection and recovery and fast, live VM migration. For example, Titanium Cloud can detect a VM failure within 500 milliseconds, whereas an enterprise-class platform takes more than a minute to detect VM failures. Likewise, Titanium Cloud detects the failure of a compute node in 1 second, compared to more than a minute for enterprise platforms. In fact, Titanium Cloud can recover from a full compute node failure with zero service downtime and no impact to services.

Carrier grade security is also imperative for MEC deployments. Since the MEC solution is deployed close to users in remote locations, the physical housing and the software components need extra protection from potential intrusions or attacks.

The Titanium Cloud platform has fully integrated carrier grade security. The virtualization platform supports AAA access control, protects system integrity through monitoring and recovery, and protects data through secure storage and encryption. In addition, Titanium Cloud includes a comprehensive suite of security features and tools to mitigate threats from any point of origin.

The security features include:

- Unified Extensible Firmware Interface (UEFI) secure boot
- Cryptographically signed images for host protection
- Virtual Trusted Platform Module (TPM) device for high-security VM deployments
- Transport Layer Security (TLS) with certificate storage in TPM hardware
- Secure keyring database for storage of encrypted passwords

To ensure high availability, Saguna Open-RAN can be deployed in a fully redundant hot standby configuration that uses Virtual Router Redundancy Protocol (VRRP) to accelerate recovery and minimize downtime. The solution also provides low-latency Internet Protocol Security (IPsec), including mutual authentication, local encryption, and decryption of the data plane.

Dell EMC's Micro MDC also provides monitoring and security features for its hardware. MDCi management software remotely monitors the condition of the physical unit as well as the status of the IT systems running inside the unit. Service providers receive alerts in real time when problems occur.

The combined solution is hardened for MEC deployments to deliver new services with guaranteed network uptime and maximum security.

**Best-in-Class Manageability**

Whether deployed for delivering augmented reality applications or mobile high-definition video, service providers need MEC solutions that can be easily managed to ensure service continuity and limit OPEX.

The Wind River Titanium Cloud family features industry-leading service manageability.

- A comprehensive fault detection and alarming system instantly notifies operators of issues that could impact service, with highly visible on-board notification and off-board reporting systems. This system feeds directly into an existing operations support system (OSS) or business support system (BSS).
- A powerful patch delivery and orchestration engine independently manages the rollout and activation of product updates across all nodes.
- Upgrades from one major product release to the next are managed in place, with no systems outages or service downtime.
- System debugging and problem investigation are accelerated through powerful log analytic tools and clear graphical visualization facilities.

Building on the capabilities of the Wind River virtualization platform, Saguna OMA features management and automation components that are critical to maintaining service quality in highly distributed MEC architectures. Operating at the MEC host level with the MEC platform and local MEC applications, Saguna OMA supports the lifecycle actions of a VNF manager (VNFM) and the MEC configurations of a multi-access edge platform manager (MEPM), which are both compliant with ETSI NFV and ETSI MEC specifications. Saguna OMA is also responsible for integrating with the NFV orchestrator, virtual infrastructure manager (VIM), and OSS to automate large-scale deployments and to streamline operations.

Dell EMC further enhances the solution's manageability with its MDCi software, which allows service providers to manage multiple Micro MDCs as a unified software-defined environment. Service providers can monitor the power and cooling, security, and IT performance across all data centers worldwide from a "single pane of glass." Service providers can easily monitor temperatures inside and outside the Micro MDCs, track power consumption, receive real-time security alerts, and track the system's health and utilization levels. Coupled with an analytics engine that assists service provider decision making, MDCi provides efficient management capabilities.

**Maximum Resource Utilization and Performance**

To enable the widest variety of new services and features, MEC applications require the best possible system resources to operate efficiently and with high performance. When running on the Titanium Cloud family of virtualization platforms, Saguna's vEdge MEC platform has more cores available to it per processor than on any competing virtualization platform. The network throughput for MEC applications supported by Saguna vEdge is greater on Titanium Cloud as well.

Titanium Cloud includes an accelerated virtual switch (AVS) built from the ground up for NFV deployment. Based on the DPDK, the AVS achieves line rate virtual switching performance using fewer CPU cores than any other virtual switch. This frees up more cores per CPU than competing solutions, enabling a greater density of

VNFs and ultimately ensuring that service providers are deriving the greatest number of services possible out of their platform investment.

A further advantage of the AVS architecture is that Saguna vEdge achieves a much higher network throughput than on standard, open vSwitch (OVS)-based systems. Depending on the application, AVS throughput is 15–40 times higher than OVS throughput. The Saguna vEdge MEC platform takes full advantage of multi-socket and multi-core processors and DPDK support for maximum use of underlying hardware resources, resulting in excellent performance and throughput.

Titanium Cloud has been uniquely optimized for use on Intel architecture CPUs, resulting in consistent and predictable application performance. Enhanced Platform Awareness (EPA) features are deeply embedded into Titanium Cloud, which ensures that operators can tune the Saguna vEdge MEC platform to deliver exactly the degree of performance required.

With an optimized software architecture that uses DPDK, Saguna vEdge supports high traffic throughput with low latency and security. The TOF engine optimizes traffic steering to and from the local MEC applications according to their individual settings.

At the hardware level, Dell EMC's Micro MDCs are built on DSS 9000 rack-scale infrastructure, which allows service providers to automatically scale different ratios of shared resource pools depending on workload requirements. DSS 9000 is based on Intel's rack-scale architecture, comprising disaggregated compute and storage resources that can be dynamically configured so that service providers always have optimal resources to support a variety of workloads.

*Figure 4. Dell EMC Micro MDCs provide ultimate flexibility while being managed as a unified software-defined environment*

Only MEC implementations with Open-RAN running on Titanium Cloud and Dell EMC Micro MDCs can deliver these advanced resource utilization and performance benefits.

**Flexible Deployment Options**

The MEC solution can be deployed in a variety of locations, depending on the use case as well as on the service provider's existing network architecture. For enterprise services in stadiums, shopping malls, or airports, for example, the MEC solution will likely be deployed on the customer premises. In other use cases, service providers will look to leverage their existing network footprint for ideal locations in the access network or between the access network and the core network, such as base station sites, base station aggregation sites, or IP aggregation sites.

The Titanium Cloud family offers the flexibility service providers require to support the Open-RAN MEC platform in their choice of location. For larger scale deployments in data centers, central offices, or PoPs, Titanium Core can scale seamlessly from four to 100 servers in geographically dispersed locations. For smaller footprint deployments, Titanium Edge has all the features of Titanium Core and runs on two servers. And for remote deployments, Titanium Edge SX delivers the performance and carrier grade security of the Titanium Cloud family to support edge applications on a single server.

Saguna Open-RAN can support traffic from multiple eNodeBs in a single platform. This provides CSPs with deployment flexibility while reducing costs.

The underlying infrastructure is equally flexible and easy to deploy in the MEC solution. With a physical footprint about the size of half a parking space, Dell's Micro MDCs can be located almost anywhere, whether next to a base station or in an office park. The Micro MDCs are fully customizable so that service providers can tailor them to meet requirements of indoor or outdoor locations. They can select the number of racks required and mix and match how those racks are outfitted with IT, power, and cooling. For example, service providers can opt to use outside air for cooling or a pre-integrated cooling solution.

**Open Standards and Open APIs**

As the industry shifts from deploying physical network functions to implementing virtual network functions, service providers are

looking to break free from vendor lock-in and adopt standardized solutions across the network. Wind River, Saguna, and Dell EMC are each committed to supporting openness and choice. Their combined MEC solution implements standard interfaces and open APIs.

MEC creates cloud-computing "cloudlets" at the network access edge. The goal of the ETSI MEC standard is to enable CSPs to create open edge computing ecosystems inside their networks and thus better serve privacy, low-latency, and edge-analytic applications.

To achieve this goal, Saguna Open-RAN is based on ETSI MEC standard APIs and reference architecture. With Saguna, CSPs can attract a community of application developers and take an active role in the value chain of exciting industry trends and profitable services.

Saguna Open-RAN MEC platform and the Titanium Cloud platforms are software solutions, each fully independent of any underlying infrastructure or hardware device. While the MEC solution runs on Dell EMC hardware, Wind River and Saguna also support a broad range of physical servers from the industry's largest suppliers, including major telco equipment manufacturers and enterprise IT leaders.

Saguna's Open-RAN is based on the ETSI MEC standard, while Wind River Titanium Cloud also adheres to ETSI NFV specs. This ensures that both solution components have common architectural underpinnings, which creates a solid foundation for deploying MEC apps.

Open interfaces and APIs are supported at every solution level, including standard management and orchestration APIs offered over REST, SNMP interfaces for OSS/BSS systems, and standard logging interfaces for problem investigation and troubleshooting. Should new or unforeseen application needs arise, Titanium Cloud supports a broad catalog of pre-integrated applications, so that operators can add functions to their MEC solution as needed.

**Pre-Integrated Solution Versus Build-Your-Own**

Some companies may prefer to develop and build their own MEC solutions rather than working with trusted partners. While this may seem attractive in the short term, the costs can be significant in terms of direct expenditure as well as lost market opportunity.

Together, Wind River, Saguna, and Dell EMC have dedicated teams of architects, software engineers, and validation specialists who have deep experience in designing, building, and maintaining carrier class virtualization platforms, MEC platforms, network functions, and physical servers. These individuals are involved in standards groups and industry-leading open source projects and forums, helping to advance the state of the art in their respective fields.

It is estimated that choosing a pre-integrated infrastructure solution offers a 12- to 24-month advantage over in-house development, even when the in-house team has the necessary expertise in Linux, KVM, DPDK, OpenStack, virtual switching, security, and myriad other networking stacks and protocols.

Customers choosing to deploy Wind River–Saguna–Dell EMC solutions can focus their own resources on accelerating customer trials, deploying new revenue-generating services, and getting to market as quickly as possible.

**Titanium Cloud Ecosystem for MEC**

In addition to developing solutions that are ready for deployment, Wind River works with a variety of suppliers through its Titanium Cloud Ecosystem partner program. Solutions in the partner program have been validated and pre-integrated with Titanium Cloud, providing more choice for service providers when evaluating MEC options.

The ecosystem spans four NFV product categories: OSS/BSS systems, NFV orchestration solutions, VNF providers, and standard server platforms.

## COMPLETE MEC SOLUTION DELIVERS BUSINESS BENEFITS

The complete MEC solution from Wind River, Saguna, and Dell EMC delivers the flexibility, performance, and carrier grade reliability that service providers require. Providing business value that includes lower OPEX, ensured revenue, and faster time-to-market, the advantages include the following:

- The most advanced MEC solution on the market based on open standards enables CSPs to create an edge-computing "cloudlet" and create an expanding application ecosystem inside their networks.
- With virtual switching performance that is up to 40 times faster than OVS, VM density is maximized to allow service providers to serve more customers from the same server, which reduces operating costs. Titanium Cloud is optimized so that its accelerated vSwitch uses fewer cores for switching traffic, while Saguna's Open-RAN MEC platform has more cores to use per processor than any competing platform.
- The solution's carrier grade reliability enables service providers to maintain service uptime and guarantee SLAs for enterprise customers, which protects service revenue. The combined solution delivers six nines availability (less than 30 seconds of downtime per year), which is facilitated by the ability of Titanium Cloud to perform hitless upgrades and patches, automatic fault detection and recovery, accelerated VM migration, and telco-grade security.
- With the fully integrated solution comprising the virtualization platform, MEC platform, and server hardware, service providers can increase time-to-market by shortening development time frames and focusing on services.

## CONCLUSION

MEC represents a significant opportunity for service providers to grow service revenues, gain market share, and reduce operating costs. In the MEC architecture, cloud computing resources are distributed to the edge of the mobile network so that content and applications are processed closer to end users, which dramatically reduces network latency and saves costs in the backhaul transmission network. With the ability to deliver low-latency, real-time services for the first time, MEC will be a catalyst for service providers to develop new revenue-generating services, serve additional customer segments, and expand into different markets.

The pre-integrated MEC solution from Wind River, Saguna, and Dell EMC is designed to help service providers get started by mitigating deployment risk and accelerating time-to-market. Optimized for ultra-low latency, the solution delivers the flexibility, performance, carrier grade reliability, and security that service providers require to launch new services and scale with demand. And as MEC will be a key component of 5G networks, the solution lays the foundation for new services today as well as in the future.

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