HPE Edgeline EL8000 Converged Edge Systems for telecommunications and media edge

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1. Definition, use cases, and requirements of telecommunications and media edge

Ever growing demand for connectivity services and promise of new business models drive massive technological transformations in telecommunication industry. One of the key recent technical trends, enabling highest network flexibility as well as new revenue streams for communication service providers, is decentralization of compute resources based on standard general-purpose x86 architectures and their deployment at the very edge of a telecommunication network, often referred to as edge compute or telecommunication edge.

Telecommunication edge infrastructure is critical enabler for number of key modern technological initiates in telecommunication networks:

**New core network architectures (CUPS, 5G network slicing, and distributed core)**

In the 5G world, a network should be ready to serve traffic with very diverse and dynamically changing signaling versus payload profiles—ever increasing throughput requirements as well as the growing need for lower latency. With that in mind, new architectures of core network have emerged, where the user plane functions of packet core (for example, S/PGW-U, UPF) are decoupled from signaling functions and have moved from fixed centralized location closer to the edge of the network.

Ability to provision packet core functions in flexible, dynamic way at the edge and core locations as required by a use case is the main enabler of 5G network slicing paradigm, and this unlocks new business models and efficiencies. That however requires high-performance standard x86 infrastructure to be available on demand at the edge locations of the network. For these workloads, edge compute infrastructure should be able to host well-defined technological stacks of NFV (for example, NFV-I layer) as well as support relevant technologies (for example, DPDK, SR-IOV).

**Multi-access edge compute (MEC)**

Higher degree of network flexibility, enabled by the previously mentioned new core architectures, unlocks the potential of having new revenue streams and addresses new business models via introduction of end-user and enterprise applications within the fabrics of a network. This capability is often called MEC. Examples of applications most benefitting from deployment within telecommunication edge might be those requiring low latency (for example, AR/VR), demanding extremely high bandwidth (for example, video analytics, facial recognition), or that are sensitive to security or regulatory demands (for example, mission-critical services).

Deployment of MEC applications at the edge of telecommunication network requires data center-like and cloud-like infrastructure resources and services to be available there on demand. For these workloads, edge compute infrastructure should be able to provide cloud-like experience and infrastructure services (for example, container environments) as well as specialized resources for the needs of concrete application (for example, GPU acceleration for AI and deep learning-driven apps).

**vRAN and CRAN architectures**

New trends are emerging that decouple functions of Radio Access Networks in underlying special-purpose hardware and implementing those functions as software on standard x86 infrastructure. With new developments in decoupling functions of Radio Access Network from underlying special-purpose hardware and implementing them as software running on standard x86 infrastructure (often called vRAN or Virtual RAN), as well as centralizing some of these functions at aggregation edge locations (often called CRAN), edge of the network should be ready to provide standard x86 resources for hosting these vRAN and CRAN functions. For these workloads, edge compute infrastructure should be capable of providing the highest compute power of general-purpose CPUs, as well as potentially accommodate hardware accelerators for portions of vRAN stack (for example, FPGA, Smart NICS, ASIC accelerators, and others).

Hewlett Packard Enterprise envisions a telecommunication edge environment, where all of the previously mentioned as well as yet-to-be-discovered use cases and workloads are sharing same unified underlying infrastructure (example of that vision is illustrated in Figure 1).
Next practical aspect of telecommunication edge is the notion of vastly different types of edge locations a telecommunication operator has. It ranges from small rooms or even outdoor cabinets of RAN sites, to telecommunication central offices, to regional POPs and smaller data centers. Figure 2 illustrates different types of facilities available to host edge infrastructure.

Aspects of the edge workloads, use cases, and realities of physical environment of telecommunication edge define very specific requirements for an edge-optimized x86 infrastructure platform.

**High performance and high degree of flexibility in the types and amount of compute resources**
The platform should be ready to accommodate top performance, general-purpose CPUs and special purpose accelerators and cards as needed (for example, GPUs, FPGAs, Smart NICs, and such).

**High degree of modularity on hardware level**
Hosting vastly different environments (network core, network RAN, enterprise applications) on the same underlying platform implies that the platform should provide adequate mechanisms to separate security, load, and failure domains all the way down to hardware level.

**Compact form factor and high density**
Realities of edge sites demand from the platform, the features such as being compact and ready for mounting in diverse, space-constraint places (for example, shallow half-depth racks, cabinets, compact telecommunication enclosures, standing against a wall without real access, and others). The compact form factor should not jeopardize the performance and compute density of the platform.

**Running in tough environments**
Operational environments of edge locations are far from what is typically observed in a data center. Telecommunication industry typically expects more robust operational characteristics from equipment with standards such as NEBS; however, edge-optimized x86 platform should be ruggedized to work in tougher-than-NEBS environments (for example, running within extended temperature ranges continuously without performance degradation).

**Security and manageability implemented from the ground up**
Edge compute enables deployment of critical functions such as components of mobile core and application logic at sites, which can’t boast the same level of physical and cybersecurity of a data center. If not properly addressed, this significantly increases the susceptibility of attack on a network; therefore, security of an edge-optimized compute platform becomes a mandatory requirement. Deployed over thousands of edge location, edge compute environment should not only be secure but manageable as well—at locations without on-site human presence, interconnected via potentially unreliable backhaul links.

With those requirements in mind, HPE designed an industry-unique, edge-optimized compute product, HPE Edgeline EL8000, which specifically addresses all the challenges of the telecommunication edge while providing all the benefits of standard x86, production-ready, scalable IT platform.
2. HPE Edgeline EL8000 for telecommunication edge

2.1. Overview and key features

HPE Edgeline EL8000 is a unique general-purpose compute platform designed to provide the highest compute power in harsh conditions of edge locations. This platform is specifically developed to address unique challenges of massively distributed edge deployments of telecommunication edge with following key features:

- **Ultra-compact and dense form factor**, perfectly suited for space- and power-constrained environments of deep edge
- **Uncompromised performance** with top-line Intel® Xeon® Scalable processors
- **Full ruggedization and enhanced environmental specifications**, going above and beyond industry toughest standards (telecommunication industry standard being NEBS Level 3)
- **Modularity and flexibility** to provide right compute resources for diverse mix of workloads at the edge
- **Manageability and security** enabled by HPE state-of-the-art HPE iLO 5 technology, crucial for production-grade edge infrastructure deployment and operation from day zero

HPE Edgeline EL8000 allows deployment of up to four HPE ProLiant e910 server blades in a single 5U chassis. Each HPE ProLiant e910 server blade features single-socket top-line Intel Xeon Scalable processor, built-in high throughput networking, and optional additional accelerators (for example, FPGA, GPU).

Figure 3 illustrates 5U HPE Edgeline EL8000 chassis, equipped with HPE ProLiant e910 server blades.

![Figure 3. HPE Edgeline EL8000 with HPE ProLiant e910 server blades](image)

5U version of HPE Edgeline EL8000 chassis accommodates one of the following:

- Up to 4 x 1U HPE ProLiant e910 server blades
- Up to 2 x 2U HPE ProLiant e910 server blades
- A mix of 2 x 1U and 1 x 2U HPE ProLiant e910 server blades

HPE Edgeline EL8000 chassis provides physical accommodation, redundant cooling, 1+1 redundant power supply, and aggregated management for HPE ProLiant e910 server blades, which otherwise are separate, independent, hot-pluggable compute nodes.
Figure 4 illustrates detailed views of HPE ProLiant e910 server blades, 2U and 1U version.

Figure 4. HPE ProLiant e910 server blades, 2U and 1U versions

The following section provides detailed technical specification for HPE Edgeline EL8000 chassis and HPE ProLiant e910 server blade.

### 2.2. Technical specifications—HPE Edgeline EL8000 chassis

#### Table 1. HPE Edgeline EL8000 chassis technical specifications

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dimensions</strong></td>
<td>5U&lt;br&gt;• 8.63&quot; height x 8.7&quot; width x 17.0&quot; depth (two chassis side-by-side fit in standard 19 or 23 inches rack)</td>
</tr>
<tr>
<td><strong>Weight (single 5U chassis, equipped with 2 x 2U server blades, not including PCIe cards)</strong></td>
<td>45 lb</td>
</tr>
<tr>
<td><strong>Cooling</strong></td>
<td>Front-to-back, back-to-front reversible airflow</td>
</tr>
<tr>
<td><strong>Power supply</strong></td>
<td>• 1+1 redundant PSU, 1500W each, 36 to 72 VDC or 95 to 265 VAC&lt;br&gt;• 400W maximum power envelope per 1U in a chassis</td>
</tr>
<tr>
<td><strong>Environment specification</strong></td>
<td>Continuous operation 0˚C to 55˚C; storage −40˚C to 70˚C; 8% to 90% operational humidity noncondensing; 5% to 95% nonoperating humidity noncondensing</td>
</tr>
<tr>
<td><strong>Network</strong></td>
<td>Chassis supports optional dual 10GbE unmanaged switches. Each switch accepts a single 10GbE link from each server blade. Chassis implements a single 1GbE switch that accepts a single 1GbE link from the x86 processor on each server blade. A RJ-45 port is provided on the front of the chassis controller and this network also connects to the chassis management processor. This is the in-band maintenance network. Chassis implements a single 1GbE switch that aggregates the Ethernet link from the HPE iLO 5 chip that is located on each server blade. A RJ-45 port is provided on the front of the chassis controller, and this network also connects to the chassis management processor. This is the out-of-band management network.</td>
</tr>
<tr>
<td><strong>Management and security</strong></td>
<td><strong>Chassis level:</strong> Built-in, dedicated silicon for out-of-band management for common chassis elements and optional aggregated management of individual server blades, full Redfish compliance, hardware root of trust for chassis management. The chassis controller can also communicate with both the in-band maintenance network and the out-of-band management network to support chassis-level functions and wireless connectivity. <strong>Server blade level:</strong> Individual HPE iLO 5 chips onboard of each server blade—full Redfish compliance; chassis provides isolated network for aggregating out-of-band management from server blades to single physical port off the chassis. HPE iLO 5 has hardware root of trust and the host processor supports TPM 2.0</td>
</tr>
</tbody>
</table>

* The reference for “C” is Celsius.

HPE Edgeline EL8000 chassis can be deployed in a shallow 2-post or 4-post rack, in a cabinet, on a wall, or any horizontal surface—with deployment of two HPE Edgeline EL8000 chassis fitting side by side in a standard 19" space.
Figures 5 and 6 illustrate examples of deploying 5U chassis in 19" space.

In Figure 5, the following examples are illustrated (from left to right):

- Two 5U HPE Edgeline EL8000 chassis side by side with total of 8 x 1U server blades
- Two 5U HPE Edgeline EL8000 chassis side by side with mix of 4 x 1U server blades and 2 x 2U server blades
- Single 5U HPE Edgeline EL8000 with mix of 2 x 1U server blades and 1 x 2U server blade

2.3. HPE Edgeline EL8000 differentiation for telecommunication edge

HPE Edgeline EL8000 is designed with a goal of converging network workloads (for example, CUPS, UPF, vRAN) with enterprise workloads (for example, video analytics, AR/VR, and such) and run those on a common, open, general-purpose x86 compute platform. In addition to must-haves of telecommunication edge (NEBS Level 3 compliance), it brings the following unique features to address requirements of converged, telecommunication edge cloud:

- **Modularity:** With different network stacks (vRAN, core network functions) and enterprise stacks (MEC applications) sharing underlying common infrastructure, ability to segregate failure, load, and security domains within this infrastructure becomes critical. HPE Edgeline EL8000 is designed as a modular platform, which can complement SW-based mechanisms of domain isolation (for example, using virtual machines, containers) with hardware-level domain isolation, based on independent, hot-swappable server blades.

- **Flexibility:** Different network and enterprise stacks sharing underlying common infrastructure might require a totally different mix of resources and capabilities from that infrastructure. HPE Edgeline EL8000 provides configurable mix of CPU for general compute needs with open PCIe-based plug-ins for acceleration and offloading of specific tasks. For example, FPGA for telecommunication network function acceleration, GPU resources for graphics processing or AI/ML acceleration of enterprise workloads, and wide range of NICs for simultaneous support of packet acceleration techniques (DPDK, SR-IOV, offload of specific packet processing task to NIC hardware). These capabilities can be provisioned by HPE Edgeline EL8000 as needed for particular mix of workloads at the telecommunication edge.

- **Low latency:** HPE Edgeline EL8000 is designed to increase performance and reduce latency on most telecommunication workloads like vRAN. Low latency is made possible on HPE ProLiant e910 blade by using high-bandwidth x16 PCI lanes between CPU and PCIe accelerators. Up to 12 DIMMs of high-bandwidth memory and pass-through networking on each server blade further enable low latency.

- **Security and manageability:** Telecommunication edge cloud is characterized by massive scale of physical distribution—with tens of thousands of unmanned edge locations within a network. Deployment of telecommunication edge cloud at that scale demands baked-in security and manageability from the underlying platforms. HPE Edgeline EL8000 addresses that on multiple levels:
  - **HW-based root of trust**, allowing to anchor complete software stack and ensure its integrity and authenticity
  - **Dedicated HPE iLO 5**, allowing to provision and maintain the edge infrastructure via open RESTful APIs fully compliant with Redfish specification
  - **End-to-end solution** for edge-to-core management and orchestration, with reference turnkey implementation of zero-touch provisioning, assurance, and lifecycle management, as well as open API-driven framework for integrating solution into broader telecommunication management stack (in partnership with OasisWorks™)

- **Operations and maintenance:** HPE Edgeline EL8000 is compliant with toughest NEBS Level 3 specifications and goes well beyond them. It is able to continuously operate in temperature range of 0 °C to 55 °C without performance degradation, tolerate higher vibration levels, and tolerate shocks on par with traditional telecommunication edge appliances. Hence, the telecommunication operators can leverage existing logistical practices for delivering equipment to deep edge sites. Modular design, 1+1 reservation of power supplies, and smart design of fans (pooling fans on chassis level so failure of a fan does not interrupt working server blades or affect their performance and reversible airflow with single-pass cooling of elements) enable the highest MTBF and reliability of the system.
• **Power consumption:** HPE Edgeline EL8000 provides best-in-class power efficiency without compromising performance. It leverages functionalities such as Dynamic Power Savings Mode, Static Low power Mode, Power Capping on Chassis allowing to secure lower overall power consumption for a given load.

With the previously mentioned unique differentiators, Hewlett Packard Enterprise believes that HPE Edgeline EL8000 is positioned to help telecommunication operators to build production-grade, reliable, and future-proof edge compute infrastructure at massive scale.

### 3. Edge-to-core management and orchestration

#### 3.1. Challenges of edge management

Today's management and automation solution stacks are typically designed to operate in a single data center and assume equipment colocation and direct networking adjacencies to functions and elements. Tens of thousands of remote sites with intermittent connectivity bring unique challenges for its management.

- No skilled personnel are available at edge sites for executing any of standard IT operations.
- Edge compute sites lack any auxiliary systems to support infrastructure provisioning (for example, PXE server, DNS/DHCP services, NAT services, firewalls, and such).
- Edge compute sites lack the footprint to dedicate hosts to heavyweight automation frameworks or have no host resources for automation tools to even exist at all.
- Edge location is an untrusted zone—no external trusted elements to bootstrap.
- Intermittent connectivity with high-latency and multihop L3 routing to core.
- Edge locations require overall topology awareness and visibility across thousands of sites.
- Existing automation solutions require dedicated environments with complicated installation and configuration.
- Separate tools for each automation layer (hardware, OS, virtualization, applications)—often several tools for each layer.
- Operating such constellation of tools require developer savvy organizations to do workflows in complicated domain-specific languages.

Dealing with end-to-end layered integration in these new highly distributed network architectures requires manageability built from ground up. This means from dedicated silicon for out-of-band management and hardware-based root of trust at edge locations to software stack designed to work with the current breed of automation tools—yet assembling them in a more holistic way.

#### 3.2. HPE strategy for edge-to-core management

HPE envisions distributed edge compute infrastructure, which is provisioned, managed, and operated in a way consistent with centralized data center infrastructure. It does not require any specialized IT skills from the people delivering edge compute platforms to the edge locations while giving the overall visibility, manageability, and security from edge to core.

To realize this vision, HPE addresses manageability and security of HPE Edgeline EL8000 on multiple levels.

**Server blade—hardware level:** Leverages HPE iLO 5 technology with each server blade being equipped with its own dedicated HPE iLO 5 chip. HPE iLO 5 addresses server blade manageability via long list of functionalities simplifying

1. Edge deployment (for example, virtual power, virtual media, integrated remote console, Redfish RESTful APIs)
2. Management (for example, server health monitoring, agentless management, health and management logging, user account management)
3. Security (for example, firmware verification and recovery, hardware-based root of trust and TPM 2.0, 2-factor authentication, validation of firmware during boot and run time)

One of the key challenges for deploying edge compute in a secure manner is the ability to have a root of trust by default untrusted and insecure physical locations. With embedded TPM 2.0 as well as HPE iLO 5 based hardware root of trust, HPE Edgeline EL8000 server blades and chassis itself provide a source of trust to bootstrap security features of higher software layers and ensure that the UEFI and application environments are not compromised, and then, they detect and mitigate potential security breaches.

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1 HPE Edgeline EL8000 is NEBS certified.
4. **HPE Edgeline EL8000 chassis**—hardware level: Leverages HPE Edgeline EL8000 Chassis Manager, with each chassis equipped with its own HPE Edgeline Chassis Manager for out-of-band management of common chassis elements (PSUs, fans, overall thermals), provides chassis-level hardware root of trust with TPM 2.0, as well as optionally aggregating communication toward HPE iLO chips of server blades hosted within the chassis; and provides value-added functionalities important for edge (for example, chassis-level power capping).

5. **Abstraction and API**—exposure level: Management functionalities of chassis and server blades are exposed via industry-standard open Redfish RESTful API, facilitating integration with existing infrastructure management tools as well as new emerging ecosystem of edge management and automation frameworks. This is done so that the edge compute infrastructure can be provisioned and operated in an automated programmatic way enabling the ability to have a common and uniform view of the infrastructure that is deployed from the edge to core.

6. **Ecosystem of software frameworks**: HPE brings to the table traditional tooling for infrastructure management and automation leveraging Redfish native APIs exposed by HPE Edgeline EL8000, as well as partnerships to address edge-specific challenges of management and automation software.

### 3.3. Edge-to-core management: HPE Edgeline EL8000 and OasisWorks

HPE in partnership with OasisWorks provides a reference out-of-the-box implementation of edge-to-core management and automation of telecommunication edge infrastructure, as well as software environments and workloads leveraging this infrastructure. This solution is called Edgeline HPE EL8000 and OasisWorks.

HPE Edgeline EL8000 and OasisWorks provide a distributed automation solution aimed at simplifying the provisioning, packaging, deployment, and operation of edge-to-core infrastructure and software environments. The solution is organized as a distributed automation framework designed to run as a hierarchy of nodes that leverage a common data model. The node hierarchy acts as a unified system with a common northbound API and modular web user interface that can be hosted in public clouds or as an on-premises implementation on a customer site.

HPE Edgeline EL8000 and OasisWorks provide the following functionalities:

- **Object modelling of components of overall edge-to-core environment, including hardware and software components.**
- **Transactional workflow engine to perform system actions.** It is model driven with a workflow schema that defines workflow steps and stages. Workflow engine implements logic of end-to-end automation task, leveraging the model of all objects edge-to-core and their relations.
- **Acquisition, aggregation, and processing of events, statistics, notification, and logs.**
- **Intuitive 3D graphical user interface, providing the simple click, drag-and-drop interface for every automated task of edge-to-core environment.**
- **Automation adapters**, which provide a southbound abstraction layer defined as a variety of adapters to third-party hardware and software. HPE Edgeline EL8000 and OasisWorks currently have the following adapters:
  - Custom hardware devices
  - Operating systems
  - Container frameworks
  - Configuration databases
  - Logging frameworks
  - AAA systems
  - Off-the-shelf servers
  - Virtualization frameworks
  - Public cloud APIs
  - Message buses
  - Time-series databases
  - Custom applications

Each adapter is defined as a separate model with its own schema. The schema for an adapter is specific to the interface of the third-party component. A variety of adapter models is possible and might represent RESTful API calls, NETCONF/YANG models, web sockets, CLI commands, or RPC calls as examples.
High-level illustration of nodes hierarchy is provided in Figure 6.

Examples of automated tasks for edge-to-core environments include following:

- Zero-touch provisioning of infrastructure and software stacks from edge to core
- Managing lifecycle of servers and software stacks over large number of edge to core locations
- Health assurance of servers and software stacks over large number of edge to core locations

Figures 7, 8, and 9 illustrate some of the GUI screens for these use cases.
Figure 7. Edge-to-core environment visualization

Figure 8. Workflow of single-touch provisioning at edge site
Figure 9. KPI assurance of edge-to-core environment

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