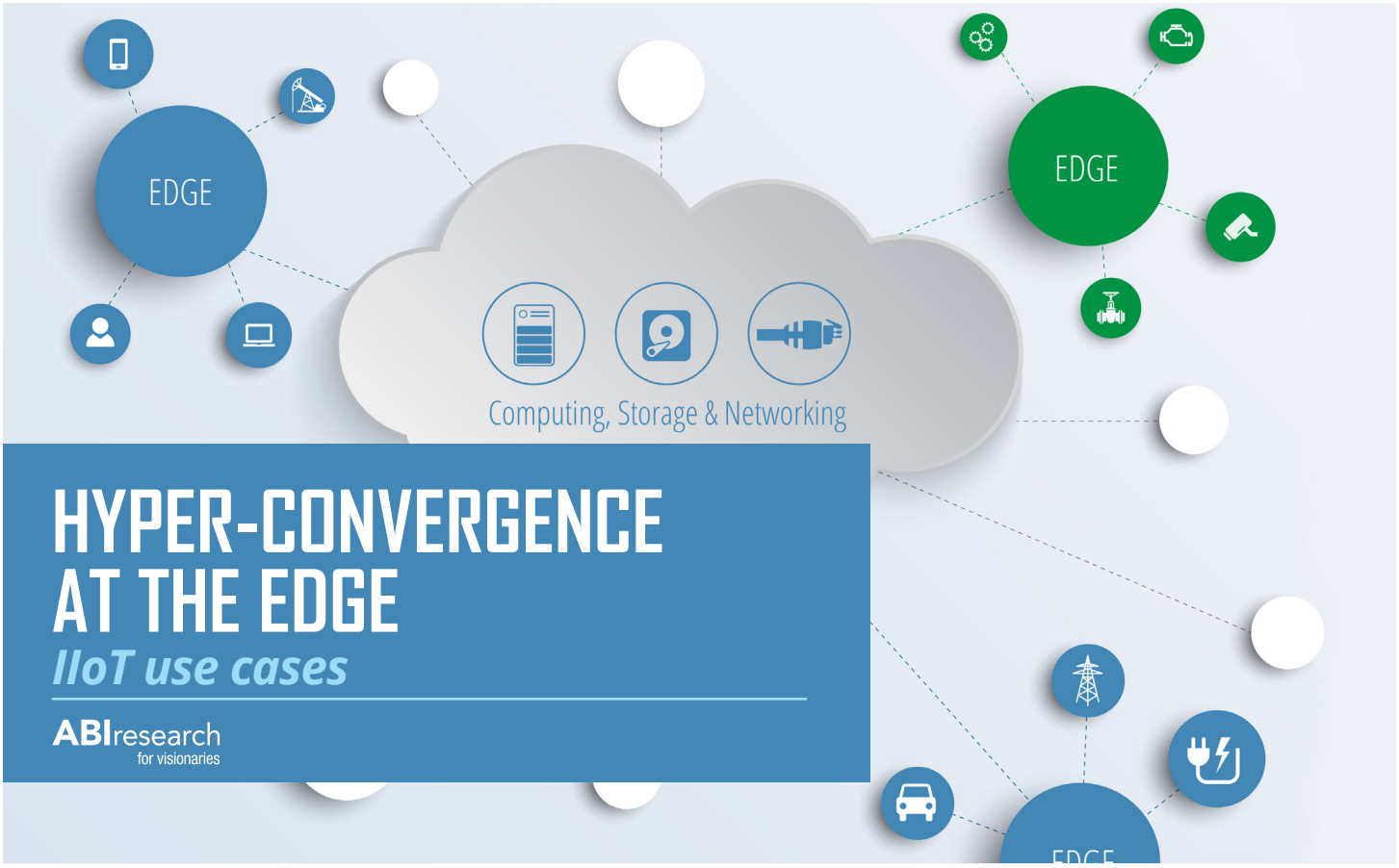

HYPER-CONVERGENCE AT THE EDGE

IIoT use cases

ABIresearch for visionaries

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Introduction

The Industrial Internet of Things (IIoT) has barely started to grow in terms of connecting devices to the cloud, and already, performance constraints, bandwidth costs, and latency requirements have forced end users and vendors to move toward more computing, analytics, and functionality distributed to the edge. This trend demands hyper-convergence and virtualization on edge gateways and servers. Hyper-convergence will empower end users to standardize multiple services, systems, and applications for near-real-time analytics.

DEFINING VIRTUAL MACHINES, HYPERVISORS, AND HYPER-CONVERGENCE

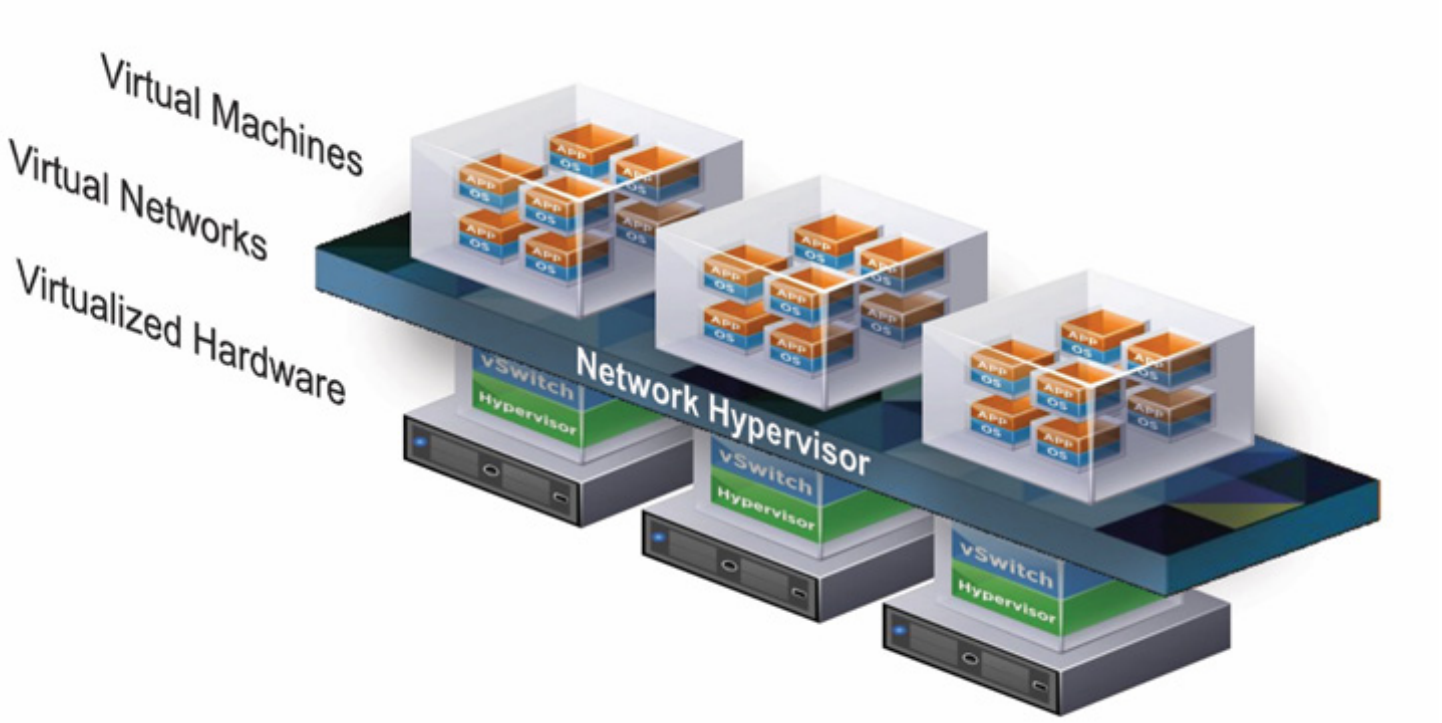
Enterprises started implementing hyper-converged infrastructure in data centers half a decadeago. Hyper-converged infrastructure combines software-defined storage (SDS) in a virtual storage area network (vSAN or VSAN) and networking with virtualized computing over a hypervisor all on commercial, off-the-shelf (COTS) servers. SDS and VSAN empower end users to manage data independent of underlying hardware and pool storage devices and capabilities.

Network virtualization software, such as VMware's NSX, empowers end users to create IT networks in software and embed them in the hypervisor layer, abstracted from the underlying physical hardware. All network components can be provisioned in minutes, without the

need to modify the application in gateways or edge servers. NSX also delivers micro-segmentation and granular security across the network and to the individual IoT application.

A hypervisor or virtual machine monitor (VMM) creates and runs virtual machines (VMs). VMs execute multiple operating systems (OSs) on the same physical server or machine. Hypervisor software, such as VMware's vSphere, presents a single administrative platform to run the VMs. Therefore, hyper-converged infrastructure enables a single administrative platform to manage data from multiple VMs on COTS servers.

Figure 1. Hyper-converged infrastructure



Source: VMware

Hypervisors come in two types: Type 1 and Type 2. Type 1 hypervisors, also called bare-metal hypervisors or hardware virtualization engines, run directly on hardware. Type 2 hypervisors run as an application on top of an existing OS. Type 1 hypervisors run more efficiently because they devote almost all the hardware resources to the VMs.

Hyper-convergence at the edge essentially combines network virtualization, SDS, and a Type 1 hypervisor on an edge gateway or server instead of back in the data center. Hyper-convergence at the edge helps solve operational business problems in manufacturing, transportation, and retail by integrating siloed applications on ruggedized hardware, integrating managed data flows into a single architecture and implementing analytics with minimal bandwidth costs and low latency.

THE ROLE OF EDGE COMPUTING

As end users of IIoT solutions in various verticals collect more data and more types of data in changing environments, they need more edge computing and edge analytics. Virtualized or hyper-converged edge systems enable end users to capture and process data from multiple, previously siloed, applications in multiple protocols, learn from live streams of data coming off devices, reduce bandwidth, and lower response time. Consolidated computing in the cloud can find more long-term trends and coordinate operations across departments and geographies, but edge computing helps solve problems at the source, in near real time.

Chief information officers (CIOs) need to integrate and manage data from end-to-end, data source-to-data center. To do that, they need to control data at the edge. No single vendor has a true end-to-end solution, but hyper-convergence at the edge can help simplify the IIoT ecosystem and stakeholder puzzle.

CLOUD VERSUS EDGE

In general, the balance of consolidated (cloud) computing and distributed (edge) computing swings back and forth like a pendulum over the years, as each side innovates at a faster or slower pace. As recently as 2017, the pendulum peaked on the cloud side. Today, we see it swinging back toward the edge.

Although cloud-based platforms provide solutions for finding long-term trends and strategic planning, they also face several challenges. As end users connect more and more devices and sensors, sending sensor readings to the cloud results in enormous bandwidth and storage costs. Also, cloud computing cannot provide actionable insights in the low latencies needed in the field, on the road, or on the plant floor. Finally, shipping more data off-premises inherently presents more security risks.

Hyper-convergence and edge computing empowers end users to implement useful and actionable applications on-premises, while filtering the data that are sent to the cloud through edge analytics. It simply does not make sense to send every sensor reading to the cloud. Virtualized or hyper-converged edge systems can store sensor data and even use artificial intelligence (AI), machine learning, and physics-based simulations on the data streams coming off any asset or process at any single location.

Strategic guidance for CIOs of end users

CIOs cannot rely on existing infrastructure or cloud computing alone to handle the continuously growing deluge of data and IIoT applications. CIOs need to integrate and manage data from end-to-end, data source-to-data center. To do that, they need to control data at the edge. No single vendor has a true end-to-end solution, but hyper-convergence at the edge can help simplify the IIoT ecosystem and stakeholder puzzle. To take on the computing challenges of the IIoT, CIOs must:

- **Solve Problems at the Edge with Partners Who Understand IT, OT, Gateways, and VMs**: Implementing hyper-converged architecture at the edge requires working with partners who understand both the IT and OT worlds. Companies that know the OT side include Eurotech,

Siemens, and PTC's Kepware. Companies that specialize in IT include VMware, Dell EMC, HPE, Red Hat, IBM, and SAP.

- **Create Cross-Functional Task Forces Internally**: Likewise, your own IT team needs to understand your own company's OT problems. IIoT solutions take joint project planning across IT and OT to succeed. OT shifts the focus onto business values and applications, while IT knows how to implement secure network infrastructure.
- **Stay as Open as Possible to New Solutions**: By integrating VMs under a hypervisor at the edge, CIOs do not limit themselves to any single type of solution in their gateways, but instead can integrate almost any new type of platform, edge analytics, and processing.
- **Embrace Distributed Computing**: Distributed computing empowers end users to process data wherever makes the most sense for their use cases. Centralized management provides a solution for finding long-term trends and strategic planning, but edge computing provides actionable analytics in near real time, resulting in faster return on investment (ROI).

Balancing consolidated and distributed computing

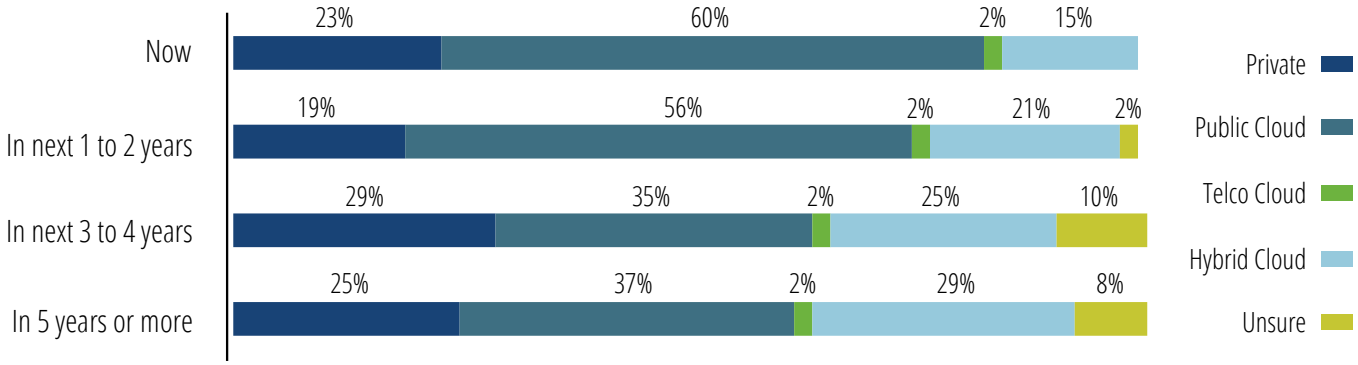
As stated above, both consolidated computing in the cloud and distributed computing at the edge have roles to play in the IIoT. This section examines the current *status-quo* and the drivers that will force a more optimized balance.

CURRENT SITUATION

Many IIoT implementations currently conduct a minimal amount of processing and analytics at the edge, relying instead on the public cloud. This results in higher bandwidth and storage costs, higher latencies, and performance constraints. It centralizes more operations, but also makes them less agile, reducing the benefits of applications like predictive analytics because it takes longer to respond.

Recently, companies like VMware and Eurotech have drawn the focus back to a more distributed computing model through powerful edge gateways and hyper-convergence at the edge. This approach results in less expensive communications and storage with software-defined systems at the edge processing data in near real time. As seen in Chart 1, according to an industry survey conducted by ABI Research, this type of hybrid cloud computing will gradually increase in popularity relative to other cloud models over the next several years.

Chart 1. Dominant Cloud Model



Source: ABI Research

DRIVERS OF CHANGE

Many factors increase the demand for edge computing and hyper-convergence. These drivers act as catalysts for adoption across industries and geographies.

- **Increase in the Vs of Big Data**: All the Vs of big data (volume, variety, velocity, veracity, variability, etc.) have and will continue to increase. Again, cloud computing can find long-term trends in these data and consolidate insights for strategic planning, but edge computing can process and analyze streams of data in near real time. This reduces the amount of data that the user needs to ship to the cloud. Hyper-convergence at the edge empowers them to manage different apps and types of data, again in near real time.
- **Constantly Evolving Ecosystems and Solutions**: The IIoT ecosystem changes constantly. Hundreds of companies have built pieces of software that they call "platforms." Perhaps the "platforms" that best suit that word fill the role of an application enablement platform (AEP). AEPs provide a solution for importing data, but they often require partners, such as Eurotech, to provide gateways and edge server systems. These gateways must connect to devices from any number of original equipment manufacturers (OEMs) in any number of industries. They also must run all the existing and new types of edge processing software, as well as different OSs. Hyper-convergence virtualizes any industrial PCs that monitor the devices and consolidate or converge the new VMs on the hypervisor. A hyper-convergence offering that combines optimized and validated hardware and software, such as an edge system with a hypervisor, offers obvious value.
- **Heterogenous and Fragmented Stacks**: No company has yet built its IoT stack in the exact same way as any other, and no company will design its balance between consolidated and distributed computing the same as any other. Ultimately, each enterprise must find the optimal balance that suits its cost structure and systems architecture; however, to achieve operational excellence, organizations must stay flexible and simplify their IT architecture. Looking at data centers, IT departments simplified heterogenous and fragmented stacks with hypervisors, and they should do

the same at the edge. Virtualization or hyper-convergence at the edge improves operational efficiency by allowing flexible infrastructure management with software-defined gateways and devices linked to the rest of the IIoT system.

- **Open Potential for Innovation**: Flexible infrastructure management empowers end users to keep their systems open to new and innovative applications. Giving end users access to new applications will increase the exchange of ideas. New ideas lead to new products for new customers and, therefore, growth.

Impact of hyper-convergence and use cases

CAPABILITIES

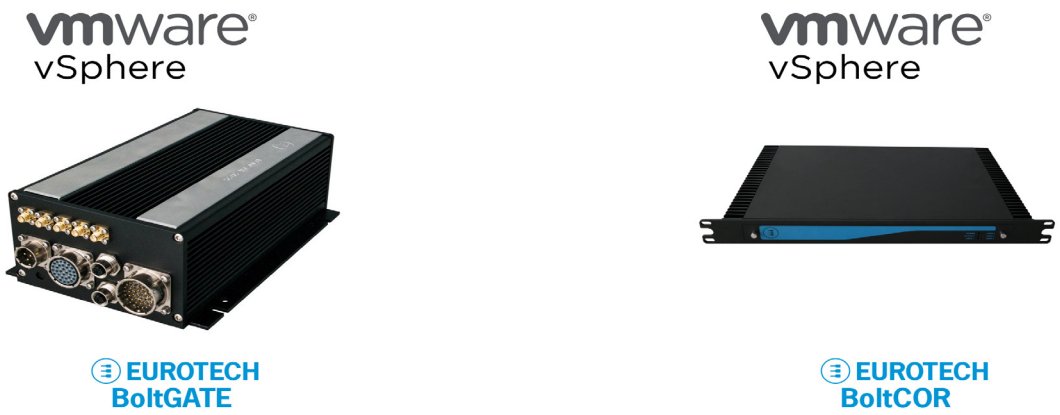
- **Virtualizing OT Systems**: Historically, a disconnect has existed between IT and OT in most organizations. IT and OT both innovated and added capabilities, but this was done with divergent paths and designed in proprietary ways. OT communicates through many diverse proprietary protocols. Hyper-converged edge systems will virtualize the edge control systems from multiple industrial automation equipment suppliers under one hypervisor and stay secure against malicious attacks.
- **Integrating Previously Siloed Applications**: Older telemetry models have hardly any standards, especially in the commercial transport industry. Now, enterprises need to integrate these telemetry applications with newer IIoT solutions on-premises to get a complete view of their operations in near real time. High-quality virtualized or hyper-converged edge systems, such as Eurotech's, can present a single administrative platform for all applications and solutions based on open and/or industry standards.

  Additionally, in terms of hardware, having individual "siloed" pieces of hardware for each application running a "siloed" OS results in many different types of hardware with different ruggedization, different manufacturers, and different OSs for each application. These differences make it much more expensive to repair, maintain, and replace the hardware in the field, especially in geographically dispersed or mobile environments. Standardizing the hardware lowers the total cost of ownership (TCO).
- **Analytics and IIoT Platforms in the Software-Defined Edge**: This software-defined administrative platform empowers end users to run any analytics or platforms that they like at the edge. This means implementing tools such as predictive maintenance, digital twins, IoT-based AR applications, computer vision, and AI for quality control, all at the edge over a virtualized network. These types of cutting-edge technologies provide actionable insights to technicians on-premises that can help reduce down-time and improve repair processes.
- **Integrated, Managed IT/IP Infrastructure**: Hyper-convergence at the edge brings OT data and device/asset application management into the virtualized IT world through application-optimized hardware and IoT gateways with hypervisor software and network virtualization. Network virtualization creates entire networks in the software and embeds them in the hypervisor. This drives effective and seamless integration and management capabilities for CIOs at every level of their system's architecture. Extending IT management stacks to the edge will simplify infrastructure management because it empowers IT departments to synchronize and manage edge systems with the same tools they use in the data center.

EXAMPLE: VIRTUALIZED OR HYPER-CONVERGED EDGE SYSTEMS

Eurotech and VMware have partnered to offer a combined IIoT hardware and software value proposition composed of Eurotech's application optimized hardware platforms and IoT gateways with VMware vSphere and NSX. They have already started to realize these hyper-converged systems on Eurotech's BoltCOR and BoltGATE edge hardware platforms, which are suitable for many demanding applications, including rolling stock/rail. vSphere brings the hypervisor to the edge hardware. As seen in Figure 2 below, Eurotech builds these pieces of hardware specifically for edge applications, and they do not share much resemblance to traditional data center servers.

Figure 2. Eurotech hyper-converged edge systems

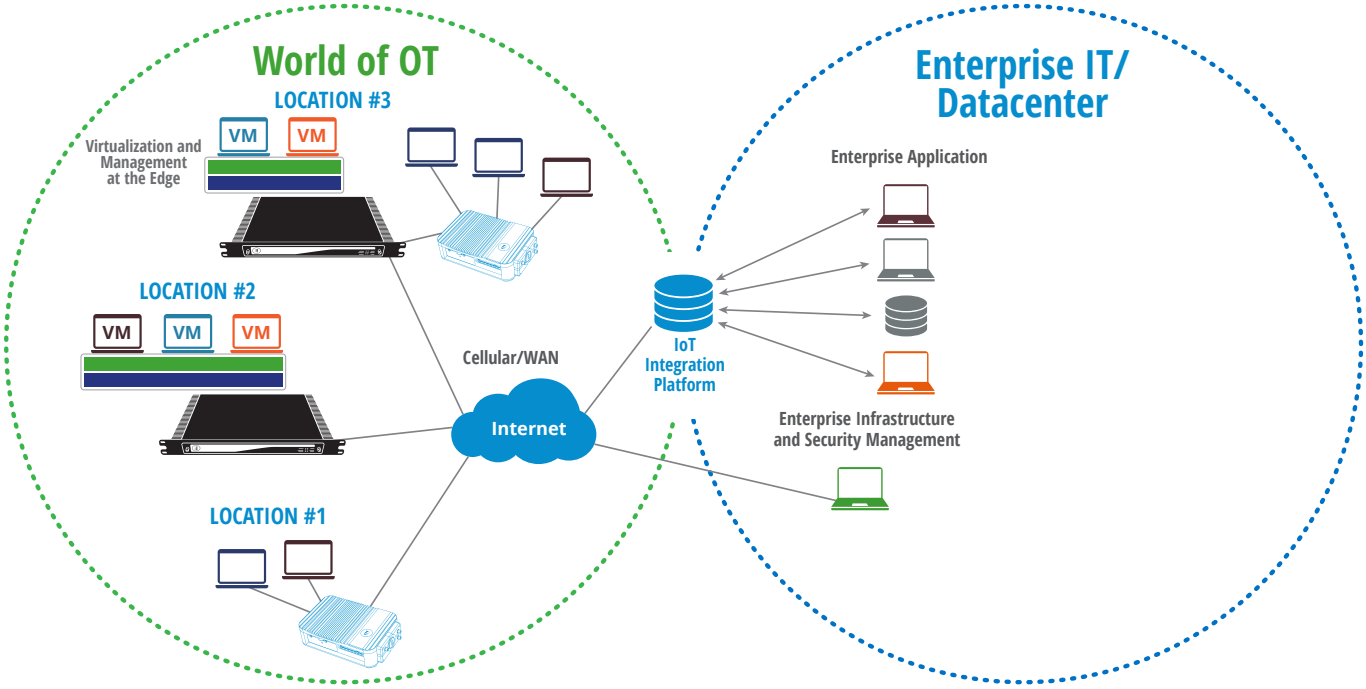


Source: Eurotech

NSX provides network virtualization and security, extending security between facilities and data centers. This security includes the ability to deliver micro-segmentation anywhere. Micro-segmentation means it reduces the attack surface through distributed stateful firewalling at the gateway level. It empowers end users to create and provision a centralized security policy of the distributed services, but the application level gateways can still have their own security perimeters.

The hyper-converged systems can also come with the Pulse IoT Center or Eurotech's Everyware Software Framework (ESF) and Everyware Cloud IoT Integration Platform pre-integrated on the gateways as VMs. The Pulse IoT Center brings in additional features for system health monitoring, security, and management features throughout the IoT architecture. ESF represents an open, Java-based IoT architecture stack that can integrate the edge system with on-premise, private, or public clouds for OT data and extended device and embedded application life cycle management. Figure 3 below shows how the ESF, the Everyware Cloud IoT Integration Platform, and the hyper-converged edge system might fit into the overall IT architecture.

Figure 3. Hyper-converged edge systems and the IT/OT architecture



Source: Eurotech

The hyper-converged edge systems will provide computing and data management for a wide range of applications close to the data sources. The two companies will target the rail industry, as well as the manufacturing and retail sectors. Currently, these use cases have siloed applications operated from a specialized PC. Hyper-convergence takes the best practices from an IT perspective and pushes them to the edge by virtualizing these PCs and running them over edge systems.

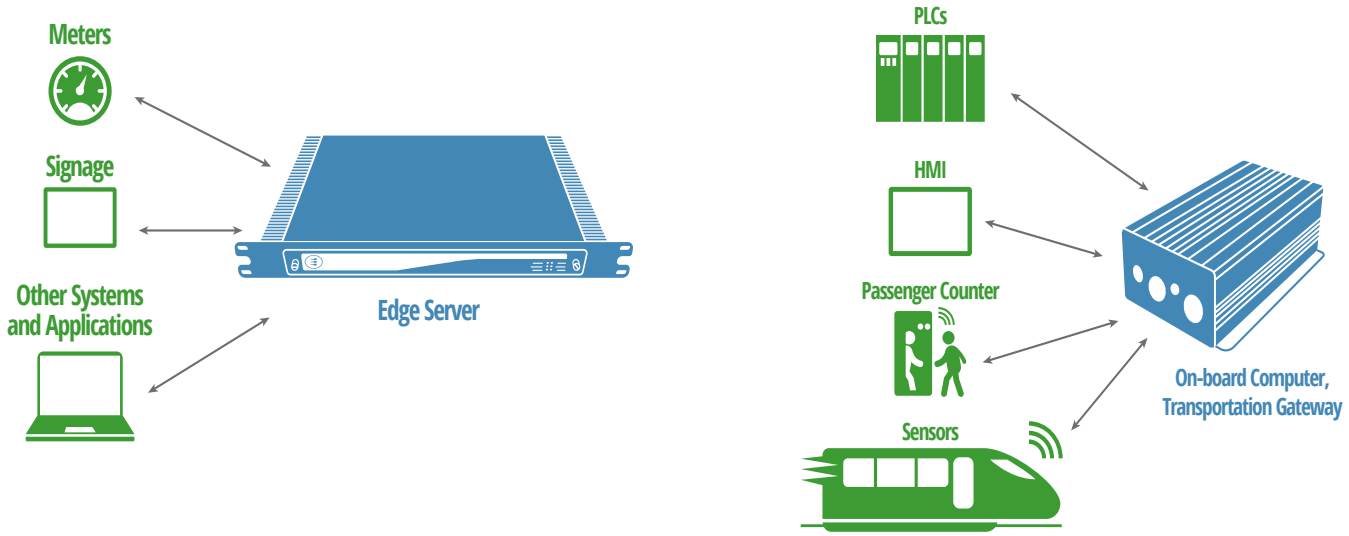
USE CASE: SMART RAIL

Railways generally have their own dedicated telecommunications networks that deliver voice and data bandwidth for signaling, electrification control, employee communications, CCTV, station information, security, and maintenance teams. These networks consist of fiber-optic and copper cables, as well as radio and GSM-R basestations and antenna systems. Many of the most valuable IoT applications will rely on this extensive telecommunications infrastructure to some extent, but more importantly, they need multi-tenant computing on-board the trains and in the stations. The Positive Train Control (PTC) regulation in the United States and the European Rail Traffic Management System (ERTMS) both have requirements that will also drive adoption of more on-board computing.

A virtualized or hyper-converged edge system will handle control, cargo and cold chain monitoring, predictive maintenance, people counting, security, and surveillance, or any number of other applications, as seen in Figure 4 below. These applications can feed data to the gateways, which will run customized apps and

VMs to suit the needs of the train operators and their passengers. The gateways can then send actionable insights to employees, alerts to passenger information systems, updates about delivery times for cargo shipments, or reports to the cloud through the railway infrastructure. NSX micro-segmentation can keep these apps from talking to each other and prevent malicious attacks from spreading. If the app keeps all the data on the train or in a station, then all computing, insights, and alerts should be processed and sent at very low latencies.

Figure 4. Smart Rail use cases



Source: Eurotech

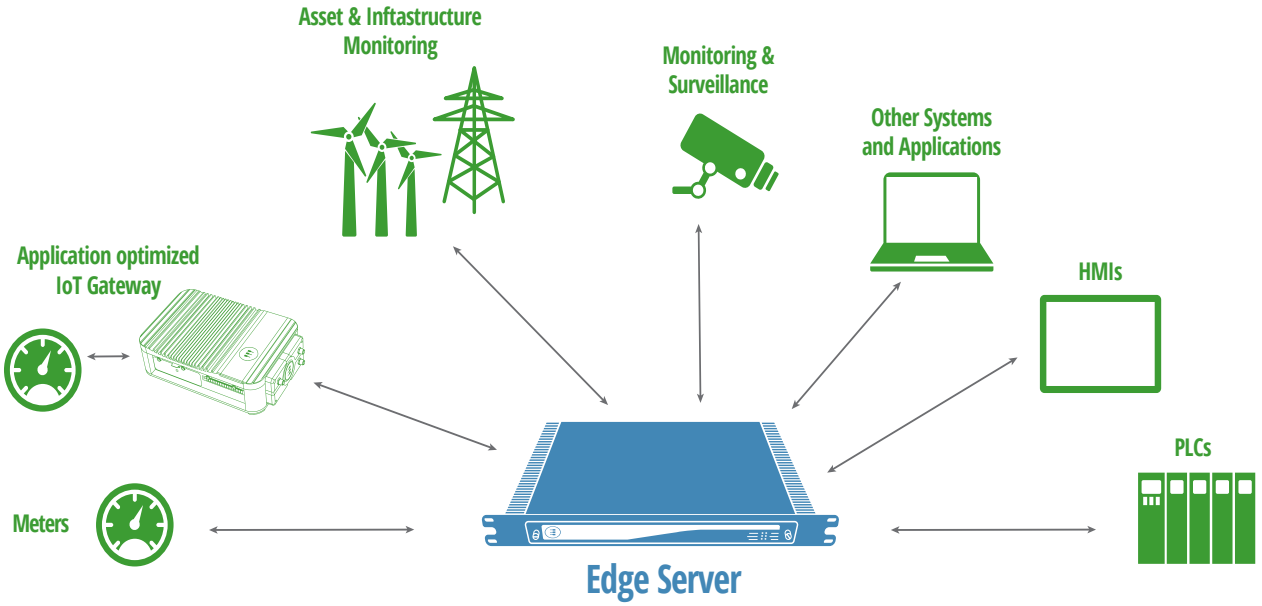
USE CASE: SMART MANUFACTURING AND SMART ENERGY

Like many other sectors, the manufacturing and energy sectors have seen and continue to see a massive explosion in the numbers of sensors, sensor types, data, data types, and IIoT applications. Some manufacturing firms have adopted cloud platforms to orchestrate all of these data and run applications, but in general, these types of companies tend to lean quite conservatively when it comes to privacy, security, and data management. As such, most prefer to keep as much data on-premises as possible. Between their conservative tendencies and the explosion of data, hyper-converged edge servers and application-optimized IoT gateways can fill an important demand. Specifically, hyper-converged edge servers could virtualize the edge control systems from multiple industrial automation equipment suppliers under one hypervisor and stay secure against malicious attacks with NSX. Already, suppliers like GE, Schneider Electric, Siemens, and others have started to virtualize some of their systems.

Within the energy sector specifically, the IIoT can help grids manage demand-side response. More renewable energy results in a demand for more flexible grids and power loads. Hyper-converged edge systems can help better balance supply and demand of energy to keep the grid stable at peak times and measure the key performance indicators (KPIs) of when, where, and why power loads shift.

Many energy companies operate in remote locations and have many such highly specialized applications, but no data center on-site. Therefore, they need to make the most of whatever computing power they can get in these locations. As seen in Figure 5 below, hyper-converged edge servers and application-optimized IoT gateways can handle these highly specialized applications, including load profiling, grid loss, metering, asset and infrastructure monitoring, energy trading solutions, outage analysis, distributed network management, event tracking and trending, security/surveillance, and demand-side response.

Figure 5. Smart Manufacturing and Smart Energe use cases



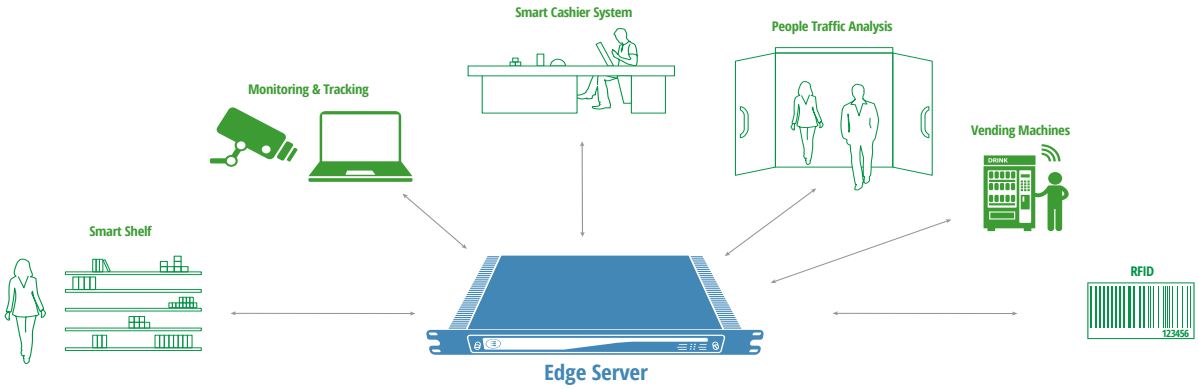
Source: Eurotech

USE CASE: RETAIL

Operating on razor-thin margins, retailers must consider every opportunity to cut costs and improve efficiency. The IIoT presents an almost unlimited number of applications that can help accomplish these goals. Unfortunately, the IIoT comes with its own costs in the forms of bandwidth and data storage.

Retailers need to run these applications at the edge to minimize costs and maximize efficiency, and hyper-converged edge servers empower them to do this. As seen Figure 6 below, a hyper-converged edge server could run VMs for a wide variety of retail applications, including cold chain monitoring/compliance, smart shelves, POS systems, information kiosks, people counting, scanning and weight control, smart carts, line management, anti-theft security/surveillance, and integrated logistics/supply chain. Retail also stands to gain from micro-segmentation and other NSX features because they can keep these apps from talking to each other, preventing malicious attacks from spreading.

Figure 6. Retail use cases



Source: Eurotech

Industry overview

ECOSYSTEM

The IIoT has some horizontal players, but the ecosystems of important companies vary for each vertical end market. For instance, across every IIoT end market, CIOs of end users need to develop relationships with sensor suppliers, edge processing and data management specialists, AEP providers, cloud infrastructure service providers, communication service providers (CSPs), platform virtualization specialists, and app developers. Although these types of companies might have horizontal offerings, the leading companies may differ in each vertical. A few companies, including Eurotech and VMware, offer leading products in multiple end markets.

Vertically, each end market has its own industry alliances, partner networks, trade organizations, and Tier One suppliers that also need to work with the IIoT specialists. For instance, smart manufacturing has the Alliance of Industrial Internet (AII), the Industrial Internet Consortium (IIC), different industry associations in every country, and all the industrial automation suppliers. Rail has the train manufacturers and awkward region-specific regulators (NAR, EU, *etc.*), and retail has incredibly complex supply chains. Chief digital officers or chief analytics officers of end users must coordinate the relationship-building process between their existing stakeholders and newer IIoT stakeholders to facilitate the IT-OT integration process both internally and externally. They all must work together.

BUSINESS OPPORTUNITIES FOR VENDORS AND END USERS

Once end users get virtualized or hyper-converged edge systems up and running, they can build an almost unlimited variety of VMs and applications on top. Computing at the edge requires a certain amount of programming, algorithms, and analysis to obtain actionable insights out of it, but hyper-converged systems create opportunities for platforms, full legacy systems, and vendors with micro-services to deploy their offerings on the same piece of hardware. End users can pick and choose almost any micro-service or app that has a real business benefit and run them all over the hyper-converged system. Applications that must process massive

amounts of data or depend on low-latency processing and communication, such as augmented reality (AR), automation/autonomy, or predictive maintenance of high-value assets, stand the most to gain from edge computing.

Given all the expanded edge computing capabilities made possible by hyper-converged systems, end users must keep business goals and outcomes as the driver for all IIoT implementation decisions. Most manufacturers, when meeting with an IIoT supplier for the first time, go into the meeting with no plan beyond "I've got to get a piece of this IoT stuff," or (only slightly better) "We need some predictive analytics." Rather than asking for a solution without a problem, they should look at where their operations have failed in the past. If they repeatedly experienced downtime on a production line due to unexpected breakdowns and repairs, they should ask the IIoT supplier if it can help find the cause of the breakdowns and extend the useful life of their equipment. If manufacturers have a quality control problem, they can ask the IIoT supplier if it can help catch and reduce defects earlier in the process. A virtualized or hyper-converged edge system enables them to easily implement applications that solve these problems.

Conclusion

The hyper-converged edge use cases outlined in this paper, together with advances in other technologies, such as digital twins, AR, machine learning, and AI, will increase efficiency, reduce maintenance costs and down-time of high-value assets, reduce costs for inventory and logistics, simplify IT architecture, and open potential for innovation. Edge servers and gateways need to run multiple VMs to maximize their own utility and to integrate previously siloed applications. Rail, retail, smart manufacturing, and smart energy all stand to benefit from reduced bandwidth and storage costs, as well as lower latencies for all of the new IIoT apps. Virtualized or hyper-converged edge systems will contribute to the economies of scale for IIoT deployments. End users need to prepare to take advantage of new IIoT apps that solve their business problems and virtualized or hyper-converged edge systems empower them to do so.

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