Market Guide for Edge Computing Solutions for Industrial IoT

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Initiatives: Cloud and Edge Infrastructure

Edge computing solutions in industrial settings are poised for rapid growth and innovation, driven by the need for real-time insights and localized action. I&O leaders must tread cautiously as vendors begin to collaborate and provide solutions based on temporary and opportunistic alliances.

Additional Perspectives

- Invest Implications: Market Guide for Edge Computing Solutions for Industrial IoT (19 August 2021)

Overview

Key Findings

- The need for real-time insights and localized action, regulatory requirements, network constraints, and volume and velocity of data generated from sensors and endpoints are forcing I&O leaders to deploy edge computing solutions in order to process data closer to the source of generation.
- Hardware OEMs, hyperscalers, analytics ISVs, OT vendors, telcos, colocation providers and vertical-specific emerging vendors are exploring partnerships to create end-to-end edge computing solutions.
- Most vendors are working toward providing “real-time analytics” and control at the edge; however, today, most use cases are focused on data aggregation and event filtering capabilities near the source of data generation.
- Industry- and use-case-specific device integration, device and application management, analytics, AI, visualization, edge hardware, and cloud integration are aspects of edge computing solutions that are currently undergoing rapid innovation.

Recommendations

I&O leaders responsible for cloud and edge infrastructure who are planning for a future data center infrastructure should:

- Reduce the need to send all data to the cloud and support local data processing and control by deploying edge computing solutions near the source of data generation at the edge.
- Jointly develop use cases, a roadmap and edge architecture by collaborating with data analytics teams and business units.
- Address computing requirements at the edge by deploying solutions that implement secure data processing in the device, gateway or edge server, or a combination of these.
- Deploy an edge computing solution that is modular, is scalable, is easy to manage and can accommodate additional use cases with minimum additional investments.

Strategic Planning Assumptions

By 2025, 30% of new industrial control systems will include analytics and AI-edge inference capabilities, up from less than 5% in 2021.

By 2023, at least 75% of “greenfield” IoT projects will use containers for application life cycle management at the edge, up from 30% in 2021.

By 2024, at least 50% of high-end industrial IoT gateways will offer an optional 5G module, up from less than 10% in 2021.

Market Definition

Edge computing solutions for industrial Internet of Things (IoT) facilitate data processing and access to IoT applications at or near the source of data generation, and serve as a decentralized extension of the cloud or the data center. Typical sources of data generation in the context of industrial IoT include sensors in industrial equipment, cameras and control devices such as programmable logic controllers (PLCs) and distributed control systems (DCSs).

Market Description

Key attributes of an edge computing solution in the context of industrial IoT include the ability to:

- Aggregate data generated from endpoint devices and normalize it in order to be ingested by analytics platforms.
- Process data, from simple tasks such as event filtering via a rule engine to complex use cases such as complex-event-stream processing or postprocess analytics near the source of data generation.
- Execute artificial intelligence (AI) inference models in combination with analytics.
- Take local actions based on incoming events and data.
- Provide visualization capabilities locally as well as remotely.
- Store data locally.
- Transmit and receive data to and from the cloud or any data center and operate autonomously in case of network disruption.

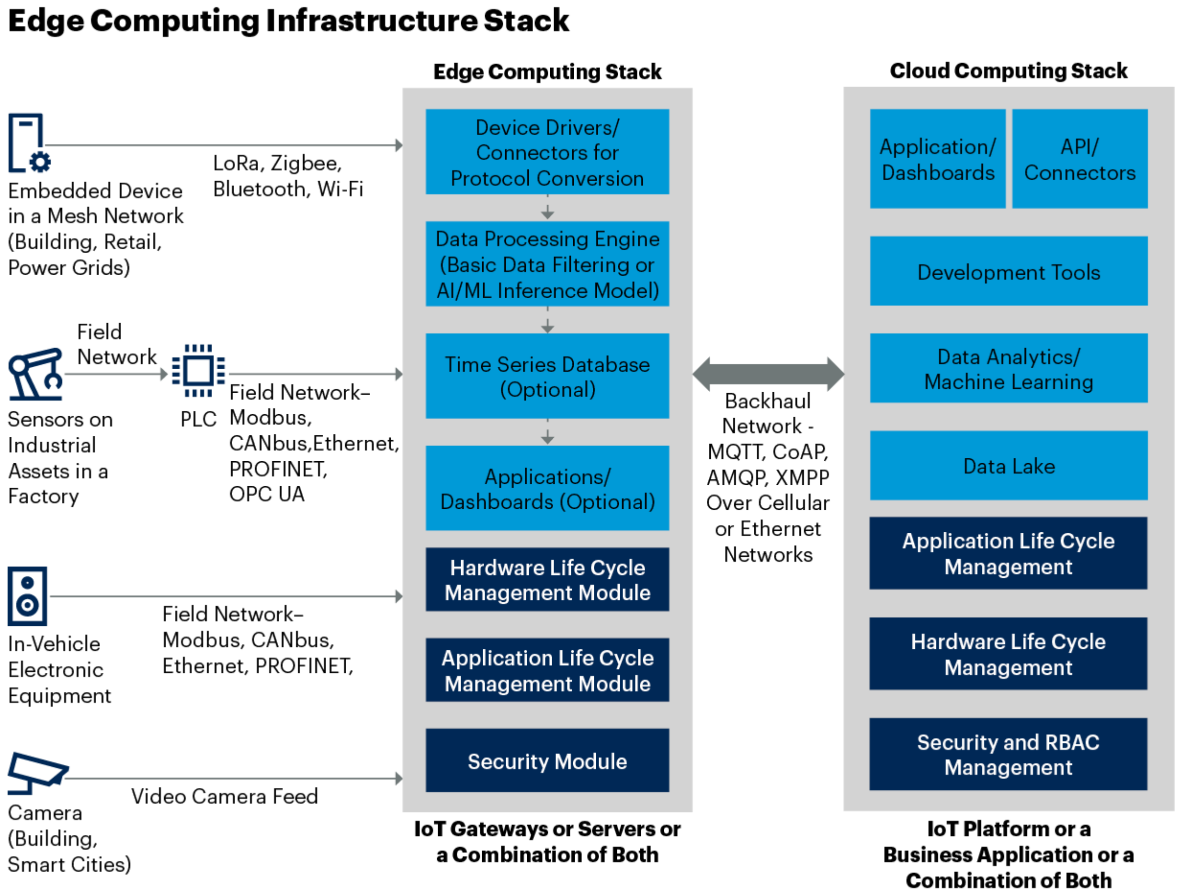
The attributes of an edge computing solution vary based on the use case and may not necessarily include all of the above. To address the above requirements, a typical edge computing infrastructure consists of the following components:

- **Data sources —** These typically include sensors in industrial equipment, data historians, cameras or PLCs/DCSs.
- **IO modules and industrial connectivity software —** IO modules interface with endpoints and convert the data generated from endpoints to digital outputs for further processing. IO modules are typically installed within PLCs, IoT gateways or edge servers. Industrial connectivity software provides the necessary device drivers to convert industrial protocols such as Modbus RTU to IoT-friendly formats such as MQTT or OPC/UA.
- **Data aggregation and processing hardware —** These typically include microcontrollers, IoT gateways, edge servers or edge server clusters. Selecting the right hardware type depends on compute power requirements.

- **Edge application life cycle management software —** These tools facilitate application development, packaging and delivery across the edge infrastructure. Lightweight applications or XML files containing specific execution logic can be containerized and delivered through IoT platforms to the endpoints. The edge infrastructure usually hosts an agent to orchestrate this activity.
- **Hardware life cycle management software —** These tools are usually provided along with the hardware and facilitate OS, device driver and security updates. They also monitor the health of the hardware infrastructure.
- **Data processing software —** After data is aggregated in the IoT gateway or edge server from several endpoints, the data processing software normalizes the data by labeling, filtering and adding metadata. The data is then usually sent through a complex event processing system for processing and publishing insights.
- **Data storage infrastructure —** In some cases, analyzed data may be required to be stored locally to enable offline analysis or due to bandwidth constraints. Such data can be stored in a time series database at the edge.
- **Edge colocation infrastructure —** Micro data centers are operated by service providers that provide an environment for hosting edge applications and analytics platforms near the source of data generation to address latency issues. These are positioned as interconnects between the edge and the cloud.

Figure 1 shows a typical edge computing stack and how it fits into an industrial IoT deployment.

Figure 1: Edge Computing Infrastructure Stack



Source: Gartner
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Gartner

Market Direction

The edge computing solution vendor landscape is rapidly evolving. Most vendors in the IoT market have recognized that edge computing is an integral part of an IoT solution. Not all data needs to be sent to the cloud or core data center — that would be cost-prohibitive, be bandwidth-intensive, have performance implications or would not be practical, as in the case of remote locations. Therefore, it is imperative to have data aggregation and processing capabilities deployed at the source of data generation as an aid to rapid decision making using near-real-time analytics. In some cases, data needs to be processed and stored at the edge location to meet regulatory requirements.

Gartner expects the industrial IoT landscape to go through a period of consolidation. Large OT vendors, industrial IoT platform vendors, and analytics and data center vendors are looking to fill gaps in their product portfolios by making strategic acquisitions to provide an end-to-end solution. Leading analytics vendors have already announced lightweight versions of their enterprise analytics platforms to address various edge use cases. Data center hardware OEM vendors view this as an opportunity to compensate for the revenue decline as a result of enterprises rapidly moving applications to the cloud. They are focused on providing custom hardware and system management software that address industrial IoT requirements, in addition to creating or acquiring analytics software.

Similarly, private cloud and virtualization independent software vendors (ISVs) are beginning to provide edge-optimized offerings. Hyperscale cloud providers are using edge computing products to extend their cloud-based IoT platforms. While hyperscalers are beginning to offer edge computing hardware appliances, they are also creating an ecosystem of hardware vendors to ensure their edge computing software stack is certified or validated to run on these hardware OEM products. Colocation providers are also offering edge colocation facilities and network interconnects that provide low-latency application access to enterprises.

System integrators will continue to play a key role in deploying and managing complex IoT projects for enterprises. They will need to ramp up from a skills standpoint to meet demands. System integrators are addressing this by creating IoT center of excellence (COE) groups within the organization, working with niche vendors and focusing on creating value by developing vertical-specific IoT solutions.

The following are some key trends that will shape the future of edge computing.

AI inference at the edge will facilitate localized insights and real-time actions.

While data from industrial systems from disparate sources can be aggregated and analyzed using an AI platform centrally, deploying machine learning inference models at the edge in conjunction with edge analytics will significantly improve the quality of data at the edge. This results in better real-time decision making by using locally available data that can be forwarded to the central AI training platform. Executing these inference models, specifically compute-intensive models such as convolutional neural networks (CNNs) and recurrent neural networks (RNNs) against incoming streams of text, video and speech data will require a relatively complex data processing architecture as the edge. See Enabling IoT Data Pipelines for Machine Learning Inference for more information.

New hardware form factors will address a broad range of edge computing requirements.

As a result of rapid innovation in processor and battery technologies, the market has witnessed the introduction of new types of edge devices with the ability to run analytics as well as AI inference models directly on the devices. Leading hardware vendors are focused on delivering edge computing hardware based on GPUs, vision processing units (VPUs), field-programmable gate arrays (FPGAs), application-specific processors and application-specific integrated circuits (ASICs). These are designed to execute complex, compute-intensive functions at the edge. Furthermore, there is an increased focus on improving power consumption efficiency, particularly in constrained systems such as gateways and embedded devices.

5G will accelerate distributed computing, but will only apply for some use cases.

The introduction of 5G cellular technology may influence I&O architects to reevaluate their edge computing architecture, specifically for use cases that are mobile in nature, such as autonomous vehicles, fleet management, transportation and logistics, and other use cases that integrate with IoT. 5G cellular technology facilitates gigabit-scale download and upload speeds. Thus, some enterprises may evaluate the possibility of sending all data generated to the cloud or core data center for near-real-time analytics. On the other hand, 5G may also accelerate the deployments of truly distributed computing architectures where information is exchanged and processed in near real time across multiple nodes that are geographically distributed. New software updates with the latest AI inference models can be pushed more frequently to the edge, significantly enhancing data quality and providing accurate localized insights. However, initially, 5G may be cost-prohibitive for large-scale IoT projects. Also, 5G may not be applicable for edge use cases in remote geographies that do not support 5G connectivity. In some cases, enterprises may consider leveraging mobile edge computing (MEC) from telecommunication providers rather than investing their own edge computing infrastructure near the endpoints.

Sensor fusion will refine data quality at the edge, but complicate edge computing architectures.

Sensor fusion is often used in personal devices such as smartphones and personal healthcare devices where data from GPS, gyroscopes and accelerometers is combined and analyzed in dedicated microcontroller units (MCUs) included in the device to provide specific, personalized insights to the user. Sensor fusion is also used in autonomous vehicles, where data from lidar, cameras, odometers, radars and other sensors is fused and refined via algorithms such as the Kalman filter to provide a comprehensive view of the environment. It is expected that sensor fusion concepts will influence the future shape of industrial edge computing architectures. The ability to combine multiple data types from different sensors, not only telemetry but also video and audio streams at the edge, helps refine data quality near the source of data generation. In other cases, it provides a complete view of the edge environment. However, fusing data from different and varied data sources is complex, because it would require that multiple data streams be ingested, normalized and processed. This will compel infrastructure architects and data architects to redesign their edge infrastructures.

Analytics and AI capabilities will move upstream into the control network.

Today, most IoT-analytics-related processes in industrial IoT projects are executed outside the industrial control network at the edge via gateways or industrial servers, on the OT platform, or both. This is because industrial automation vendors do not have advanced data analytics and AI-centric capabilities incorporated into industrial control systems such as PLCs and DCSs. Furthermore, they were not deemed as must-have capabilities thus far. However, we expect this to change gradually with the convergence of IT/OT and the shift toward Industry 4.0. Gartner anticipates deeper collaboration between industrial automation vendors and data analytics vendors, resulting in co-creation of intelligent industrial control systems. These will offer better asset control, asset life cycle management and possibly new revenue streams for the enterprise.

Containers will be viewed as a building block for large-scale “greenfield” IoT projects.

Gateways and edge servers deployed in the field may require application updates to add on new use cases or workflows. These systems often operate in bandwidth-constrained networks. Attributes such as modularity, portability, low overhead and isolation have made containers an attractive choice for greenfield IoT projects across vertical industries. Containers facilitate continuous application delivery and enable DevOps-based operations. Containers also ensure application components are updated with minimal change management overhead, thus reducing overall bandwidth requirements. They also provide an environment that facilitates isolation of specific processes.

Video analytics will accelerate edge computing deployments.

An escalating threat environment has resulted in government establishments and enterprises reevaluating their existing physical security infrastructure. Video analytics is increasingly viewed as a building block of modern surveillance infrastructure, owing to its ability to significantly improve situational awareness, ease operator fatigue and reduce time taken to analyze an incident. Video analytics can be extended to address use cases beyond physical security, for example, to monitor production in manufacturing or analyze customer behavior in a retail store. However, since video data consumes significant bandwidth, it must be processed at the edge — within the camera or a video analytics server at the edge. Early video analytics deployments use the later model, as the video analytics can coexist with existing camera infrastructure. The edge compute instances range from small-factor systems to multinode server clusters with hyperconverged software — based on use case.

Market Analysis

Based on the use case, edge computing can be implemented within the device itself, within the gateway or by deploying servers at the edge in order to address varying degrees of analytics and local decision-making requirements; or a combination of these. Table 1 represents the key attributes of various edge computing delivery models, based on the level of computing capability required.

Table 1: Levels of Edge Computing Based on Processing Type

(Enlarged table in Appendix)

Category	Computing Capabilities	Type of Analytics	Preferred Response Time to Event/Activity	System Capabilities	Location
Edge Devices (microcomputers, embedded systems)	Low	None or simple event processing	Microseconds to seconds	Forward/Filter and forward	Static or Dynamic
Gateways	Low to medium	Simple event processing, event stream processing (low velocity only)	N/A	Analyze	Static or Dynamic
Edge Servers	Medium	Event stream processing, complex-event processing, application hosting	Seconds to minutes	Analyze and control; Data persistence	Static or Dynamic
Micro Data Centers	High	Complex-event processing, batch processing, application hosting	Seconds to minutes to hours	Analyze and control; Data persistence	Static

Source: Gartner (August 2021)

Although most edge computing projects focus on data aggregation, normalization and basic processing, and mainly address one or two use cases, the edge computing infrastructure must be scalable and accommodate additional, complex use cases over a period of time. Table 2 represents the list of sample edge computing use cases by industry based on ease of deployment. I&O leaders must work with business units and data teams to understand the roadmap for use case rollout, work backward and arrive at a scalable infrastructure that can accommodate them.

Table 2: List of Edge Computing Use Cases Based on Ease of Deployment

(Enlarged table in Appendix)

Industry	Basic/Advanced Data Processing	Complex Event Processing	AI/Advanced Analytics
Oil and Gas	Predictive maintenance of oil well assets, pilferage detection on pipelines	Remote diagnostics	Flare stack monitoring using video analytics and telemetry data analysis, personnel safety
Manufacturing	Predictive maintenance of assets, energy management	Production monitoring, remote diagnostics and repair	Video analytics for personnel safety, Sensor fusion for production monitoring, augmented reality for accelerated learning
Transportation	Fleet management, people counting	Driver behavior analysis, engine diagnostics	Advanced driving assistance systems (ADAS) such as autonomous trucks in mining
Retail	Asset tracking, digital signage	Personalized advertising, footfall analysis	Computer vision for warehouse management, robotics for pallet management, smart mirrors
Power and Utilities	Asset tracking, predictive maintenance of equipment	Remote diagnostics and repair of equipment	Detection of transmission line damages through drone-based video analytics
Property Management	Predictive maintenance of assets, energy management, asset monitoring, fever detection	Footfall analysis for rental management	Contact tracing

Source: Gartner (August 2021)

Representative Vendors

The vendors listed in this Market Guide do not imply an exhaustive list. This section is intended to provide more understanding of the market and its offerings.

Market Introduction

Representative vendors that focus on edge hardware, edge data processing and analytics, industrial connectivity, edge application management, device life cycle management, and edge security are listed in Table 3.

Table 3: Representative List of Edge Computing Vendors Focused on Industrial IoT

(Enlarged table in Appendix)

Vendor	Key Products
ABB	Genix Edge
Advantech	Advantech Edge AI & Intelligent Solutions, UNO Series, EPC series.
AlefEdge	EdgeNet
Amazon Web Services (AWS)	AWS IoT Greengrass, AWS IoT Device Management, AWS Snowcone, AWS Snowball
Aspen Technology	Aspen Connect Family
AVEVA (OSIsoft)	Edge Data Store
Braincube	Edge Factory Box
Cisco	Cisco IoT Gateways, Cisco Edge Intelligence
Coral (Google)	Coral
Crosser	Crosser
DartPoints	Edge Interconnection
Dell Technologies	Dell Edge Gateways for IoT, Dell PowerEdge Servers
Detechtion Technologies	Enbase, Fieldlink
Eclipse Foundation (Opensource)	Eclipse ioFog
EdgeConneX	EdgeConneX
Efftronics	Point Machine Remote Condition Monitoring, Adaptive Traffic Control System
Emerson	PACEdge
Eurotech Group	Eurotech Multi-service IoT Edge Gateways, IoT Edge Management Platform
FogHorn	FogHorn Lightning Solutions
Hardis Group	Vision Insights
Hewlett Packard Enterprise (HPE)	HPE Edgeline systems
Hitachi Vantara	Lumada Edge Intelligence
Hivecell	Hivecell
Huawei	Intelligent EdgeFabric, AR502H Series Edge Computing IoT Gateways
Infiot	Infiot Thin, Infiot Wireless Edge
Inspur	EIS series, AI Station, Inspur Physical Infrastructure Manager (ISPIM)
LF Edge (Opensource)	EdgeX Foundry, Baetyl
Litmus	Litmus Edge, Litmus Edge Manager
Microsoft	Azure IoT Hub, Azure IoT Edge, Azure Data Box, Azure RTOS
Motherson	iDACS
Pratexo	Pratexo
PTC	ThingWorx, Kepware
Rockwell Automation	FactoryTalk Edge Gateway Software
SAP	SAP Edge Services
SECO	SYS-series gateways, EDGEHOG software platform
Software AG	Cumulocity IoT
Stratus	ztC Edge
Swim	SwimOS, Swim Continuum
Vapor IO	Kinetic Grid Platform
ZEDEDA	Zededa

Source: Gartner (August 2021)

Market Recommendations

- Deploy a device-to-gateway-to-cloud data center model when there are a large number of endpoints that are generating data in a specific geography and this data needs to be filtered before forwarding it to an advanced analytics platform.
- Deploy a device-to-gateway-to-edge-server-to-cloud option in environments with bandwidth challenges for use cases that need localized action and real-time insights at the edge.
- Consolidate traditional edge applications and IoT-centric edge applications on a single platform to simplify management.
- Use micro data centers for distributed environments such as offshore oil rigs and mining operations, particularly in use cases where it is not practical to set up a server room due to space, power and cooling challenges.
- Evaluate containers for greenfield IoT projects to simplify application life cycle management and device life cycle management.

Note 1
Representative Vendor Selection

Gartner estimates that there are at least 250 vendors in this market. The 40 listed here are representative of those that demonstrate capabilities that align with the vendor categories laid out in this report.

Document Revision History

Market Guide for Edge Computing Solutions for Industrial IoT - 23 September 2019

Market Guide for Edge Computing Solutions for Industrial IoT - 19 July 2018

Market Guide for Edge Computing Solutions for Industrial IoT - 9 May 2017

Recommended by the Author

Some documents may not be available as part of your current Gartner subscription.

2021 Strategic Roadmap for Edge Computing

How to Use Edge Computing to Modernize Your Retail Store Infrastructure

Market Guide for Industrial IoT Gateways

Emerging Technologies: Emergence Cycle of Video Analytics

Decide If You Should Use Containers for Your IoT Project

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Cisco	Cisco IoT Gateways, Cisco Edge Intelligence
Coral (Google)	Coral
Crosser	Crosser
DartPoints	Edge Interconnection
Dell Technologies	Dell Edge Gateways for IoT, Dell PowerEdge Servers
Detechtion Technologies	Enbase, Fieldlink
Eclipse Foundation (Opensource)	Eclipse ioFog
EdgeConneX	EdgeConneX

Efftronics	Point Machine Remote Condition Monitoring, Adaptive Traffic Control System
Emerson	PACEdge
Eurotech Group	Eurotech Multi-service IoT Edge Gateways, IoT Edge Management Platform
FogHorn	FogHorn Lightning Solutions
Hardis Group	Vision Insights
Hewlett Packard Enterprise (HPE)	HPE Edgeline systems
Hitachi Vantara	Lumada Edge Intelligence
Hivecell	Hivecell
Huawei	Intelligent EdgeFabric, AR502H Series Edge Computing IoT Gateways
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LF Edge (Opensource)	EdgeX Foundry, Baetyl
Litmus	Litmus Edge, Litmus Edge Manager
Microsoft	Azure IoT Hub, Azure IoT Edge, Azure Data Box, Azure RTOS
Motherson	iDACS
Pratexo	Pratexo
PTC	ThingWorx, Kepware
Rockwell Automation	FactoryTalk Edge Gateway Software

SAP	SAP Edge Services
SECO	SYS-series gateways, EDGEHOG software platform
Software AG	Cumulocity IoT
Stratus	ztC Edge
Swim	SwimOS, Swim Continuum
Vapor IO	Kinetic Grid Platform
ZEDEDA	Zededa

Source: Gartner (August 2021)