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# Edge computing for IoT

## A guide on how edge computing complements the cloud in IoT

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# Introduction

The Internet of Things (IoT) is having a significant role in the digital transformation of organizations and industries. The growing number of sensors and smart devices generating terabytes of data, and the need for quick and reliable processing of this data has motivated a common IoT architecture of edge devices communicating with IoT cloud platforms.

The importance and benefits of cloud computing, such as high computational processing and storage, are well understood in the industry. Edge computing is rising in prominence enabling quick, secure, and local processing on gateways located near the devices.

This white paper will explore the benefits of edge computing. It will take a look at the key features that a software solution requires in order to build a bridge between edge devices and cloud computing platforms.

For the last several years, enterprises have focused on cloud computing, and have been developing strategies to “move to the cloud” or at least “expand into the cloud.” It’s been a one-way, straight highway. There’s a sharp left turn coming ahead, where we need to expand our thinking beyond centralization and cloud, and toward location and distributed processing for low-latency and real-time processing.

Gartner

## Why edge computing?

For IoT use cases, connecting thousands or even millions of devices directly to the cloud is often not feasible due to costs, privacy, and network issues. Edge computing facilitates data processing at the edge of a network, close to the edge devices, and thus avoids the issues of sending all the data directly to the cloud.

In particular, edge computing addresses many of the technical challenges experienced by large-scale IoT applications:

### Network latency

Network latency is a significant issue for safety critical systems, like a self driving car or a factory control system. The difference between a response time of 100ms and 1ms can be life threatening. Edge computing allows for reduced latency due to local processing of key compute decisions.

### Data privacy and security

Reducing the attack vector of an IoT application is a way to create a more secure system. Edge computing reduces the number of devices connected to the internet and local data filtering reduces the amount sensitive data being transmitted.

### Network load reduction

By processing data locally, edge computing can significantly reduce network bandwidth requirements. This is particularly important in cases where bottlenecks might occur due to unreliable and constrained network connectivity.

### Computational efficiency

It is often more efficient to perform data processing and analytics on smaller data sets and with longer inter-arrival time. For example, more efficient analysis can be performed on a smaller data set (such as smaller geo-specific areas) and data that is arriving with a longer time interval (in the order of seconds instead of milliseconds).

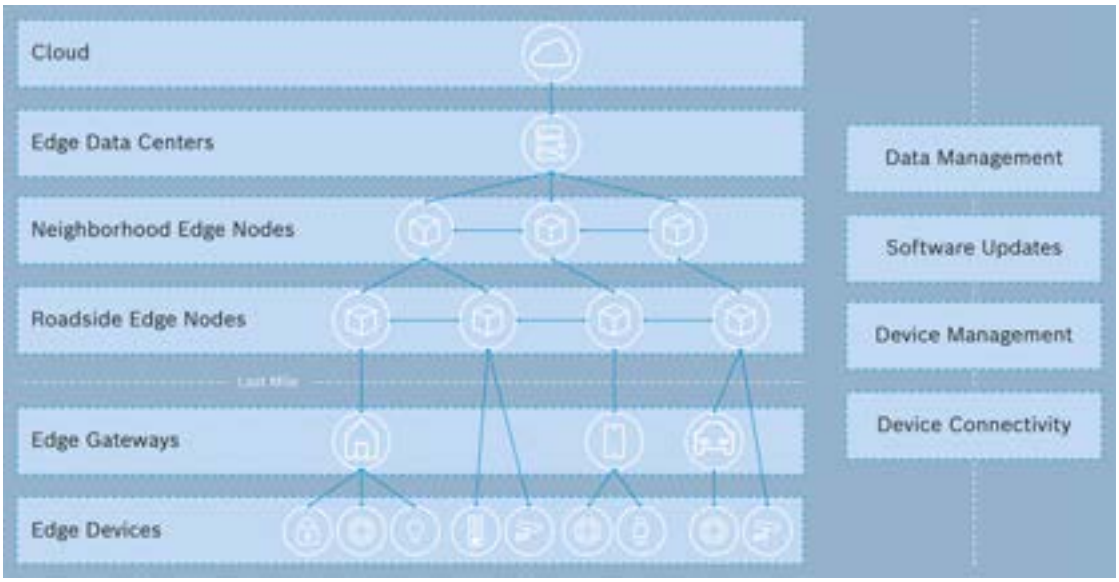
### Reduced cloud costs

Local storage and processing not only reduces network load, it also avoids sending unnecessary data to the cloud, consequently decreasing the costs associated with cloud storage and processing.

### Autonomy

For certain use cases, it is critical that the local application can continue to run in disconnected mode. Edge computing allows for local execution so a system can continue to run autonomously even if there is no network connectivity.

## Which edge are we talking about?




Edge computing solutions can consist of several layers connecting edge devices to edge gateways, edge nodes, data centers and the cloud to support different IoT use cases.

Edge is not equal edge. It is more like different types of edge devices, such as small microcontrollers, powerful microcontrollers, gateways, powerful edge nodes, and the cloud, that have to work together. The deployment of IoT devices therefore needs to take care of the connecting of complex assets and these different edge platforms comprising sensors, gateways, and actuators. For small microcontrollers, it is important to find lightweight components that can be installed on them to connect devices that were previously unconnected. Once there is connectivity from device to device or via gateway to the cloud, the next step is to find a solution that takes care of software management topics such as keeping the software on devices up to date.

Regarding data management there are several factors to consider. Data processed at the edge using local compute power allows the making of decisions in real time while also reducing cloud costs. Security topics are another good reason to store and process data decentralized at the edge.

# Edge computing use cases

Edge computing is applicable to a wide range of industries and use cases. The following use cases provide some additional insight to how edge computing can solve some of the challenges of IoT deployments:

## Industrial IoT

There are many Industrial IoT use cases which require quick response times enabled by edge computing:

- For safety critical systems, a sub-second response time is required to avoid physical injury and machine damage. For instance, when a human enters a restricted area in a factory, machines need to stop immediately. In this case, the ability to make fast, deterministic decisions at the edge is critical for human safety and machine preservation in industrial IoT applications.

- For predictive maintenance and condition monitoring applications, data processing can be performed locally on an edge device reducing the amount of sensitive data sent outside a factory and improving the overall privacy and security of the application.

When you start moving real-world machinery around instead of just bits, it's no longer good enough to provide 99.99% reliability or millisecond latency. When challenges in the digital world meet the physical world they are magnified; real people's lives or production processes are on the line, with real-world consequences.

Stacey on IoT

## Retail

Supermarkets and retail stores can benefit from IoT applications to improve the efficiency of their buildings and customer experience. Some examples how edge computing helps retailers:

- Due to legal regulations, the temperature and humidity levels of cooling systems must be monitored and logged to prove the food has been safely stored. This case is known as hazard analysis and critical control points (HACCP). Usually, the systems are manually checked once per day, which takes up a lot of time. In addition, the stores are closed Sundays and public holidays, so if a cooling system breaks, no one will notice and the result would be spoiled food that needs to be discarded.

- An edge computing solution enables local monitoring of temperature, humidity, and air pressure without the need to involve the cloud. Thus, cloud costs can be reduced and any change in conditions can locally trigger notifications, and consequently corrective actions can be taken before any food is spoiled.

## Automotive

Edge computing is well suited for automotive and other mobility use cases like autonomous driving, and remote monitoring and diagnostics of automobiles. In particular, an edge gateway can run on a vehicle's telemetry control unit to enable the following functionalities:

- Communication: Edge software can act as the communication client to enable the exchange of control information for device management and telemetry data.
- Applications: Edge software can run user applications on the automobile, such as emergency call service (eCall) that provides precise location in case of accidents. Another example is a diagnostics application that collects logging information coming from different components within the vehicle to identify problems.
- Updates: Edge software can be used to coordinate software updates of the vehicle's electronic control units, head units, or navigation map material.

**Busch-Jaeger home controllers**
Edge computing and backend software make home automation robustand resilient, yet flexible and easy to use.

**Hager: The role of standards in home energy management**
Hager uses edge computing to smoothen the process of electric vehicle charging.

# Things to consider when selecting edge computing solutions

An edge computing solution typically sits between the IoT devices, the gateways to connect the devices, and the IoT cloud platform. The main features of an edge solution focus on connecting the devices, locally processing and managing the data, and moving data to the cloud platform for further data analytics and integration with backend services.

To deliver on the benefits of edge computing, there are a core set of features that should be considered when selecting an edge solution:

### Support for different edge platforms

The variety of available edge devices is changing rapidly. Future-proof edge solutions employ lightweight native components to run on a choice of platforms from small microcontrollers to powerful edge nodes.

### Support for device protocols

There is a wide variety of communication protocols used to connect sensors and actuators. To facilitate connectivity of these devices, an edge gateway should support prominent IoT protocols such as Z-Wave, ZigBee, KNX, DECT ULE, Bluetooth LE, EEBus SPINE, EEBus SHIP, HomeConnect, Modbus, UPnP, SNMP, PROFINET, wMBus, ONVIF, EnOcean, BACnet, OPC UA, LoRa, IP cameras and Siemens S7.

### Rule engine

A simple rule engine should be available for the automatic execution of predefined business rules, local monitoring, and control of various aspects on the edge. Rules typically have the following form:

- ON - something happens (window state changed)
- IF - conditions are satisfied (window.state == open state)
- THEN - do the task (light.state = off)

## Device abstraction and digital twin

To make it easier to create applications for an edge solution, a device abstraction layer should offer a unified interface for devices, regardless of the device type or connectivity protocol. The abstraction should support implementing applications without the need to know details of a specific protocol. A digital twin, controlled from the cloud, should be able to access the same device abstraction layer to monitor and control the devices in a consistent manner.

## Local persistence storage

Edge solutions should allow for local storage of data on the gateway without requiring connectivity with the cloud. Different options for storage might include relational database, normalized telemetry data from edge resources and devices, and the ability to add your own storage types.

## Cloud connectivity out of the box

To simplify creating edge solutions, cloud connectivity should be available out of the box. Lightweight components that can run on even the smallest microcontrollers should enable the devices with IoT essentials such as cloud connectivity, local messaging, software management, and container management and integration with the cloud services platform.

## Autonomous operation while disconnected

Edge solutions should be able to function without connectivity to the cloud and possess robust capabilities to handle cloud connection interruptions and ensure consistency and autonomous operation.
The edge solution must manage cloud connectivity status, publish notifications on cloud connectivity changes, buffer messages during connection loss, manage connection retries, and synchronize messages on successful reconnection. This way, the IoT applications at the edge stay up and running even if the connection to the cloud is interrupted, unreliable, or lost.

## Security and privacy

Key security and privacy features of an edge solution should include:

- The ability to configure the permissions of components and applications based on location, signer, and other custom conditions.
- Management and configuration of security policies for controlling access to various gateway resources in an easy way.
- Support for secure communication to the gateway runtime through TLS and data encryption.
- Certificate management including revocation and update of certificates.
- Integration with 3rd party key management services, public key infrastructures, and hardware security modules.

### Availability and reliability

Edge computing solutions should be able to constantly monitor the health of the gateway runtime, detect faults, and execute actions like reboot, restart, or initiate a factory reset. Additionally it should be possible to backup important user data on a periodic basis or with an explicit request.

### Remote management and update

It should be possible to remotely manage edge computing devices to start, stop, configure the device, and remotely install new software and hotfixes.

Local applications

It should be possible to develop local applications that are installed and executed at the edge.

### Analytics and machine learning

An edge computing solution should make it possible to apply different machine learning algorithms at the edge. Advanced capabilities might include the ability to combine local solutions on the edge with algorithms and services on the cloud.

### Integration of custom applications

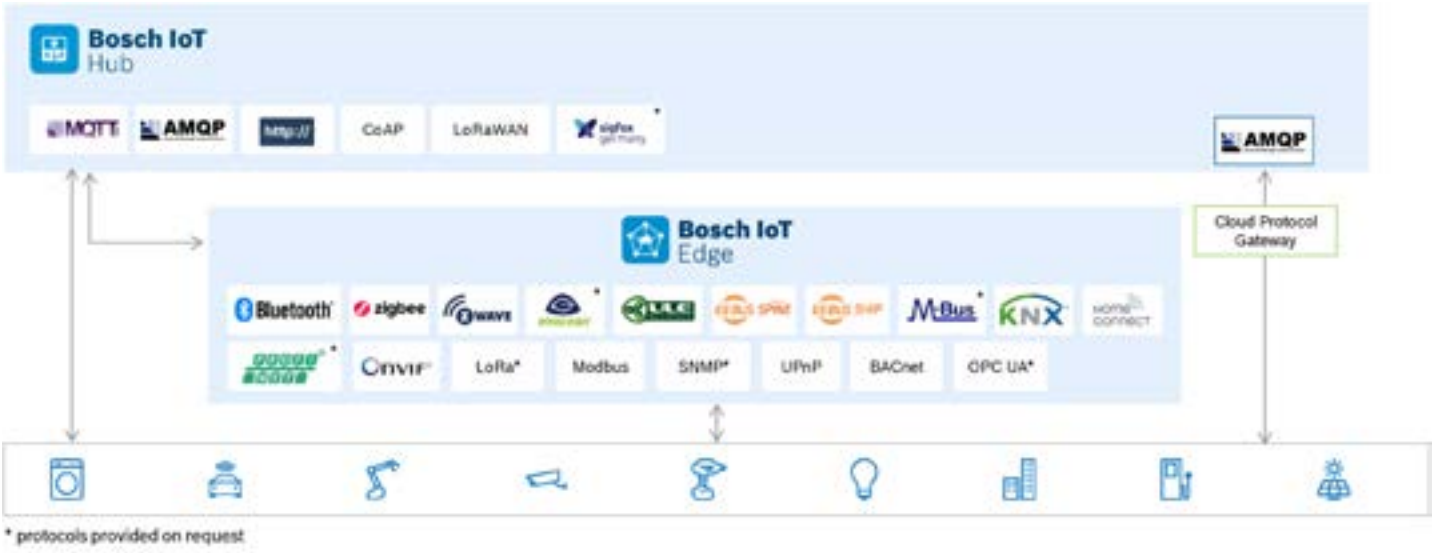
Custom applications or advanced edge services should be deployable at the edge as standard OCI containers. Containers allow creation of scalable applications using most fit-for-purpose technology and language, reuse of cloud applications without rewriting code, or seamless access to IoT device data and edge services.

# Bosch.IO's offering for edge and cloud computing

With its different services in the Bosch IoT Suite, Bosch.IO offers its customers both edge and cloud computing. While the Bosch IoT Edge is mainly covering the edge computing aspects, the remaining Bosch IoT Suite services are running on the cloud, and thus addressing cloud computing.

The Bosch IoT Suite connects devices in two different ways:

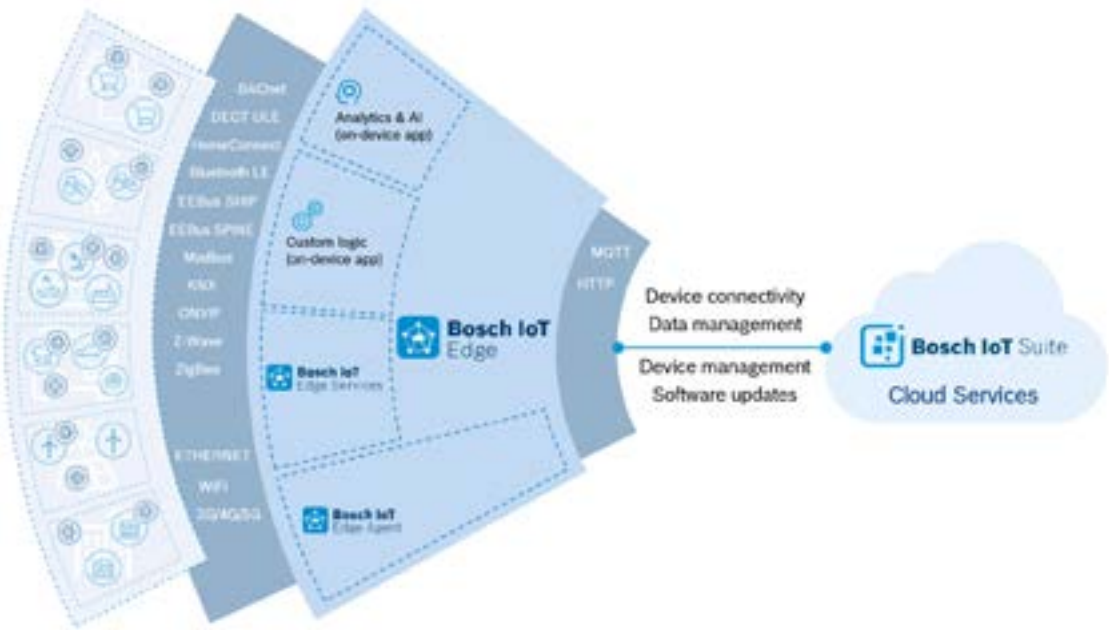
- Either directly to the cloud by using the Bosch IoT Hub or
- Indirectly via gateways to benefit from the above-mentioned edge computing features.



## Bosch IoT Suite: Edge computing with Bosch IoT Edge

Bosch IoT Edge is an integrated set of tools and services that work together to connect diverse IoT devices locally and to the cloud, set communication between devices, and develop scalable IoT applications that bring IoT device data processing and services where they can best optimize outcomes.
Bosch IoT Edge makes it possible to deploy cloud or custom logic on the device so enterprises can get more value out of diverse edge assets, process and act on IoT data right on the device and manage devices from the cloud. Device manufacturers can tap new revenue streams with connected products and ensure the agile development of hardware and software.
Using Bosch IoT Edge, technology teams benefit from configurable and reusable building blocks that ensure the availability of platforms, require a minimum of integration work, and enable scalable applications.

**Lightweight** – run on a wide range of platforms from small microcontrollers to powerful edge nodes to scale hardware and connect diverse devices with varying specifications and capabilities
**Containerized** – develop applications using fit-for-purpose languages, scale applications selectively, re-use cloud applications without re-writing code, and access advanced edge functions
**Fully integrated** – connect to Bosch IoT Suite and use digital twins, manage data and devices from the cloud with minimal customization, prototype quickly



### Bosch IoT Suite: cloud computing with its cloud services

The Bosch IoT Suite is Bosch's comprehensive toolbox as a cloud-based Platform-as-a-Service (PaaS). The Bosch IoT Suite consists of various cloud-enabled services and software packages that enable the fast, easy, and secure development of sustainable applications in the IoT.

# Conclusion

Edge and cloud computing are complementary approaches to solve some of the more challenging use cases in IoT. This is why Bosch.IO provides solutions for both edge and cloud. Thanks to this combined approach, Bosch customers can rely upon integrated solutions from devices (sensor, actuators, edge) to cloud (device management, data storage, analytics).

Do you have particular interest in edge computing for your IoT project? Have a look at the technical features of the Bosch IoT Edge, take a deep dive in our user documentation or subscribe to a free trial.

Your project requires both edge and cloud computing and you are looking for a custom tailored solution? Get in touch with our team in order to get started.

# Bosch in the Internet of Things

We believe that connectivity is more than just technology – it's part of our lives. It improves mobility, shapes the cities of the future, and makes homes smarter, industry connected, and healthcare more efficient. In every sphere, Bosch is working towards a connected world.

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