IoT Edge Computing

SAP Leonardo

Defining IoT Edge Computing

Computing models evolve: from the centralized mainframe model of the '60s and '70s, to the distributed client-server model of the '80s and '90s, to the post-2000 centralized mobile-cloud model ubiquitous today. But what's next? And, more importantly, why? These answers are best explained by examining the rise of distributed intelligence, also known as the Internet of Things.

The Internet of Things (IoT) is the network of intelligent objects (examples include cars, containers, machines in production plants, construction tools, wearable devices, and much more). These "things" are connected to the Internet, sense the environment, exchange data, and ultimately interact with business systems to create business outcomes.

The core of an IoT solution is typically a central IT system for storing, processing, and analyzing IoT data. And much of this IoT data often can be located in the cloud, away from the core.

However, IoT endpoints (i.e., devices with sensors) frequently do not have communication capabilities to transmit all their sensor data in a secure, reliable, and cost-efficient manner to the core. Here are a few of the most common obstacles:

- sensors may only support low energy protocols to conserve battery power
- mobile devices leveraging cellular communication lack coverage in certain locations
- mobile communication links are often bandwidth constrained or expensive
- wide area connections can introduce too much latency for real-time decision making

Furthermore, certain local systems, for example self-driving vehicles, must autonomously make decisions in real-time and cannot wait for instructions sent from the cloud.

Edge processing can address these challenges. An edge processing unit is a physical device, typically referred to as an IoT gateway, also called a fog node. It connects to devices that are away from the core (often referred to as devices "at the edge") via communication protocols like Low-energy Bluetooth or ZigBee. At the same time, it also connects to the core directly using high-speed internet. Additionally, gateways provide security and lifecycle management at the edge, such that the edge is a sustainable and manageable compute unit. The hardware used for such gateways ranges from high-powered, rack-mounted servers to smaller devices with embedded ARM processors and anything in between.

IoT edge computing describes the capability of processing, storing, and analyzing sensor data as well as decision making at IoT gateways.

Analysts, for example IDC, indicate that 40 percent of IoT-created data will be subject to IoT edge computing and that this ratio of edge-to-core data and processing is growing annually.

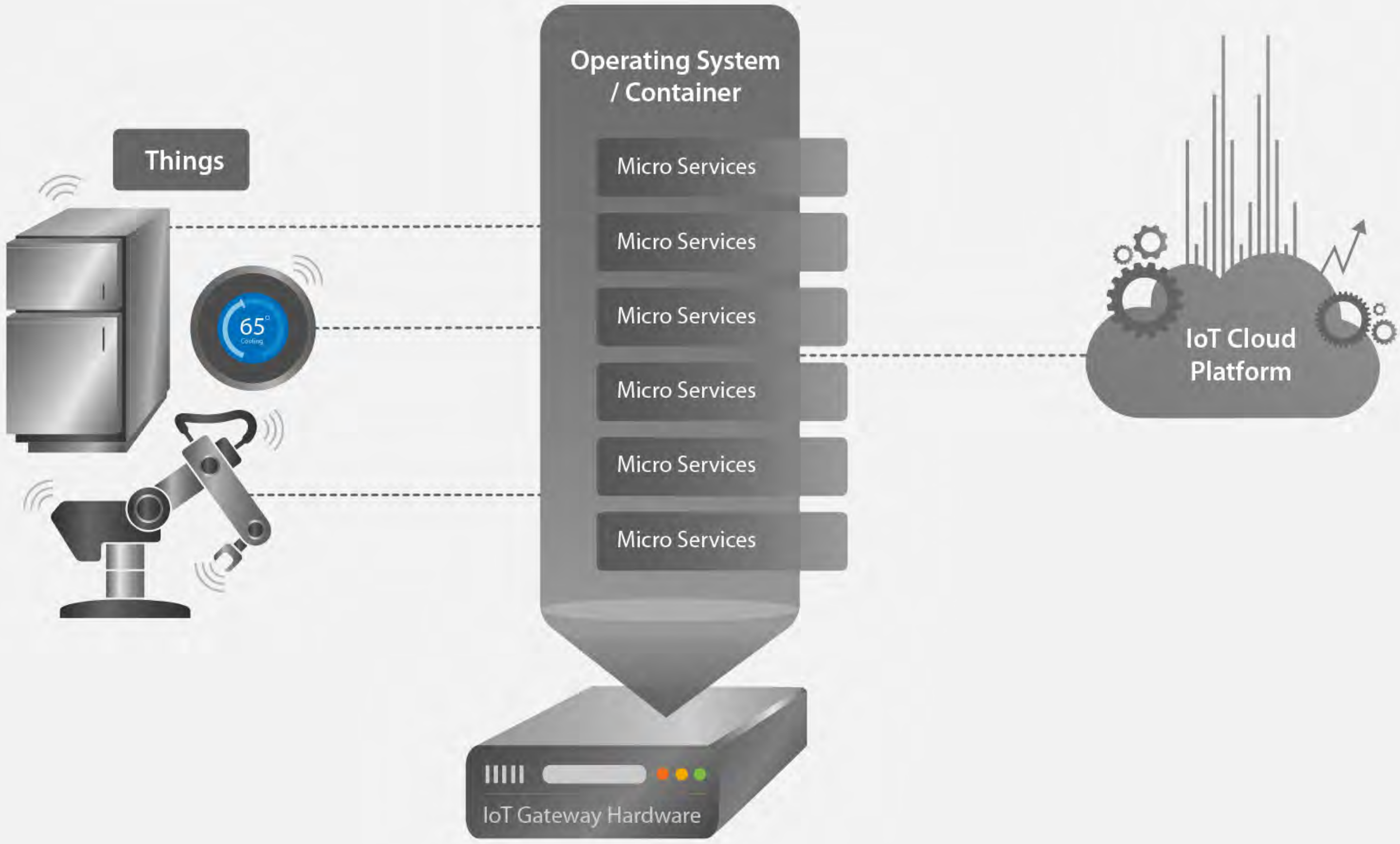

Figure 1: Edge Computing

Technology Trends

Most of the IoT gateway technology, that is, the technology which is the host for edge processing capabilities, runs on flavors of the Linux operating system while using different kinds of processor architectures. An industry wide trend is emerging to package edge computing capabilities into micro services and deploy them within containers on IoT gateways or fog nodes as illustrated in *Figure 1*. Containers provide security through isolation; they serve also as deployment units which simplify lifecycle management through less interdependency and complexity.

An exception to this Linux predominance is the manufacturing industry where various versions of the Windows operating system and Microsoft's .NET platform make up the majority of implementations.

Edge Computing Scenarios

Data Volume vs. Available Bandwidth

Devices and sensors can produce more data than is economically feasible to transmit to the cloud. To address this problem, analytical algorithms can be applied at the edge to process the incoming sensor data and only send higher level events to the core.

For example, tens or hundreds of cameras produce video streams at 25 frames per second. The transmission of video streams can be very costly. A video analysis service could be deployed at the edge which identifies people, objects (e.g. vehicles), and their properties (e.g. license plates and x-y coordinates). Only this higher-level information would then be sent to the core.

The video content would be stored locally at the edge for a certain duration and could be accessed by a human operator for further analysis as needed.

IoT solutions are often cost sensitive, and communication costs specifically represent a significant portion of ongoing expenses. Low Bandwidth Wide Area Protocol solutions, such as LoRA, Sigfox, and others, can reduce the communication cost. But these solutions come with the unwanted consequences associated with low bandwidth, such as reduced performance.

Thus, communication costs can be addressed more effectively by using analytical algorithms to process the incoming sensor data and only send alerts (another form of higher-level events) to the core.

Intermittent Connectivity

When devices and sensors are in locations with only intermittent connectivity they need local data processing and decision making in order to keep operating.

For example, off-shore oil rigs and container ships use satellite connectivity which can be easily interrupted. Similarly, cars and trucks using cellular data connections can drift in and out of coverage as they move around.

IoT edge computing can provide data buffering as well as rules or predictive algorithms which can allow for autonomous operation.

Immediate Response

Decisions based on sensor data often must be made in real-time if there is no time for a roundtrip to the core. For example, self-driving cars need to make decisions autonomously. Network latency likely would create severe safety issues.

Similar needs exist in process and discrete manufacturing industries where many parameters can influence the quality of the product. For example, sensor data is compared to a recipe through a multi-variant analysis. The Golden Batch, as it is known in process manufacturing, is created based on this analysis with adjustments to temperature, pressure, humidity, etc. made in real time.

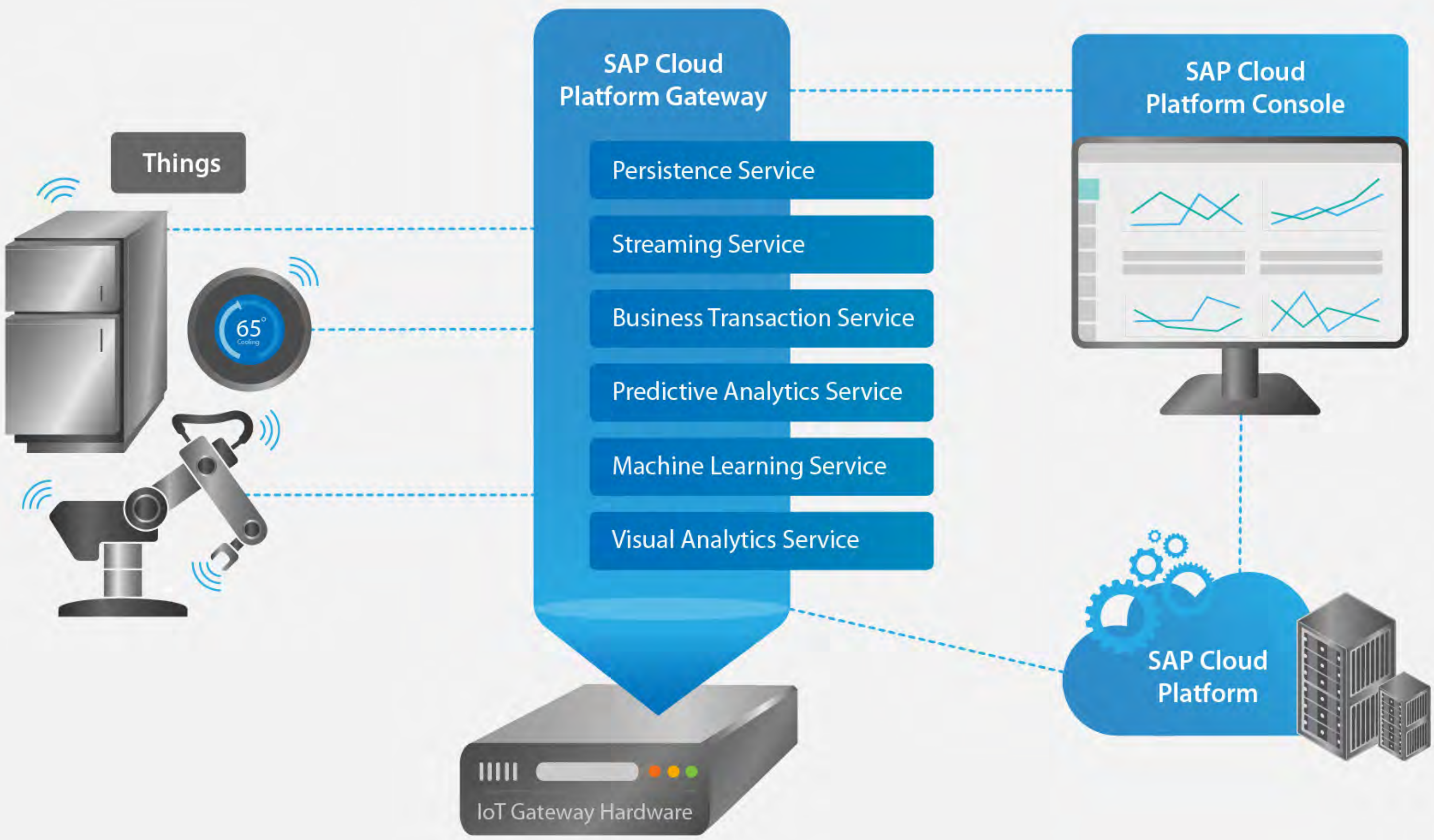

Figure 2: SAP Leonardo Edge Services on the SAP Cloud Platform Gateway

Integration of Edge and Core

In order to ensure data privacy and prohibit any data or system tampering, IoT edge computing solutions are expected to be securely integrated with the core. Edge solutions also need to be managed from a central point to minimize costs and optimize lifecycle management across a wide range of edge devices. Data management and processing can take place at the core or edge, whichever approach is optimal for the specific scenario.

SAP's IoT Edge Computing Solution

SAP Leonardo Edge Services provides edge computing as micro services which are optimized for either deployment on IoT gateways running Linux (as illustrated in Figure 2) or on Windows and .NET. These micro services can also be made available on other proprietary, open source or standards-driven emerging platforms, when they become relevant.

SAP is closely following and participating in efforts to standardize IoT edge computing including the Fog Consortium, Industrial Internet Consortium (IIC), and the Linux Foundations Fuse project. SAP also partners with leading IoT gateway manufacturers including Intel, Cisco, Dell, and HPE.

Services

SAP Leonardo Edge Services includes the following*:

Persistence Service – store IoT data on IoT gateways. IoT administrators can configure which data should be stored locally and set a data aging policy.

Streaming Service – analyze IoT data streams. IoT administrators can define conditions with adjustable time windows to identify patterns in the incoming IoT data as a basis for automated events. For example, certain conditions can initiate transactions and notify appropriate parties.

Business Transaction Service – execute business transactions at the edge to provide continuity for critical business functions even when the edge is disconnected from the core.

Predictive Analytics Service – use predictive models for analyzing the IoT data. The predictive algorithm is constantly "being trained" and improved in the core based on all available data. The resulting predictive model is then sent to the edge and applied there.

Machine Learning Service – apply SAP Clea's deep learning algorithms at the edge specifically for image and video analysis.

Visual Analytics Service – explore visually IoT data stored on IoT gateways. IoT data analysts can visually inspect the data collected at the edge. For example, after an alert has been sent to the core, an analyst can dig into the details which led to the alert.

Edge Platform

The primary means for the deployment of these edge services is the edge platform component of the SAP Cloud Platform, a software package that extends the SAP Cloud Platform to the edge and provides the following:

- support for a wide variety of IoT protocol adapters
- native integration with SAP Cloud Platform and SAP backend systems like SAP S/4HANA
- deployment and lifecycle management for edge services
- secure communication channels and isolation

As this edge platform software stack can be deployed on the physical gateway or in the cloud, functionality provided by the services can be made available at the edge or in the cloud, whichever is most suitable for a given business scenario.
This edge platform is implemented in Java and extends the standardized OSGI platform which allows for deployment on virtually any hardware and operating system.

*Planned funcitonality, subject to change

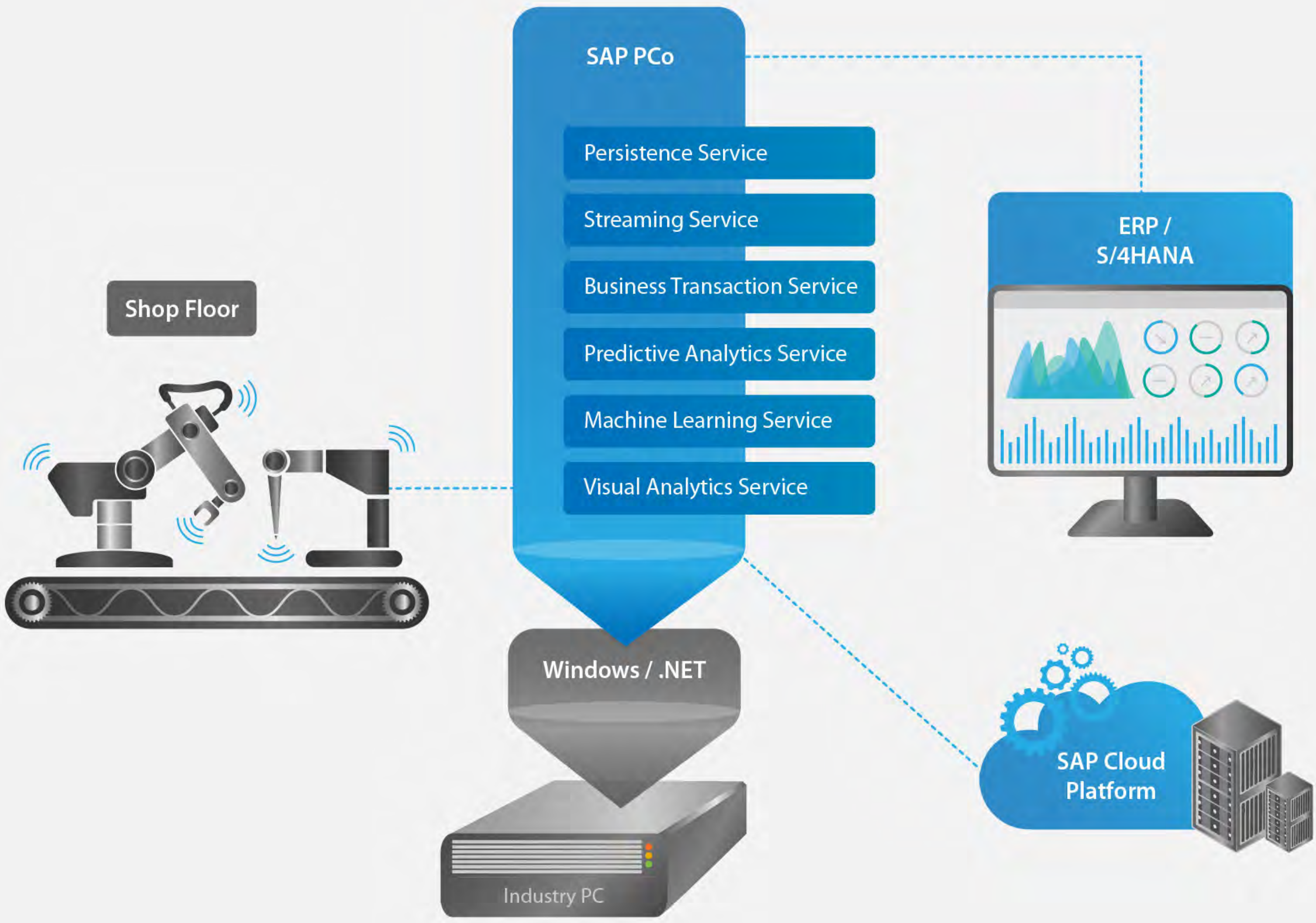

Figure 3: SAP Leonardo Edge Services for Manufacturing

Manufacturing

SAP Leonardo Edge Services can also be deployed on industry PCs running Windows and the .NET platform as shown in *Figure 3*. The services are tightly integrated with SAP Plant Connectivity (SAP PCo) and SAP Manufacturing Integration and Intelligence (SAP MII) as well as SAP backend systems, specifically ERP and S/4HANA.

Conclusion

IoT edge computing is playing an increasingly important role in IoT solutions. The industry trend is to deploy functionality as micro services and use container technology for lifecycle management and other benefits that come from isolation.
SAP Leonardo Edge Services represents the forefront of defining and providing relevant edge computing functionality such as persistence, stream processing, visual and predictive analytics, and other micro services for the edge. These services are designed for implementation on both existing and emerging edge platforms.

SAP Leonardo Edge Services implemented with the edge platform component of the SAP Cloud Platform together make up SAP Leonardo Edge, SAP's end-to-end solution for IoT edge computing. Services are also available for the manufacturing scenarios using the industry platform of Microsoft Windows and .NET combined with SAP PCo. The edge computing services are deeply integrated into the SAP cloud and enterprise systems.

SAP Leonardo Edge Services is unique in that it provides:

- a distributed programming model for the edge and the core which allows the solution to be placed where it is optimal for a specific scenario
- a lifecycle model for edge services, the edge platform, and the attached devices and sensors
- a deep integration with enterprise systems including the capability of bringing enterprise functionality to the edge

SAP Leonardo Edge Services empowers LIVE business, by connecting things with people and processes.

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