Capture the Value of the IoT by Integrating the Physical and Digital Worlds
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Quick Facts

Summary
The SAP® Leonardo digital innovation system harnesses Internet of Things (IoT) technologies to help you create “digital twins” of physical assets, apply smart device management to read data from the assets into the twins, and feed the data to analytics software. Companion microservices help automate data storage, manage access, and organize data around a thing model. You can fold IoT capabilities into existing applications and build new ones using application templates and a wealth of APIs. And you can maximize business value by integrating IoT-enabled applications directly with your core processes.

Solution
- Central device management with quick onboarding of devices with comprehensive functionality
- Support for leading IoT protocols to connect devices from diverse vendors
- Creation of a digital twin for each physical asset
- Reliable microservices and reusable business semantics to integrate new features into applications
- Wizards and storyboards for visibility and consistency during development
- Attractive user interface to deliver analytics and provide role-based user access to data

Objectives
- Onboard large numbers of devices from multiple vendors
- Keep device-to-application connections secure
- Integrate IoT functionality smoothly into applications
- Fold new applications tightly into core processes
- Keep IoT applications scalable and consistent across the business
- Deliver new insights to business users through IoT features

Benefits
- Integrate your physical and digital worlds
- Invent new business models combining IoT and business data
- Choose the cloud infrastructure you prefer
- Build IoT applications quickly, consistently, and scalably
- Capitalize on reusable IoT components from SAP and partners
- Offer developers open-source tools and community forums

Learn more
For more on SAP Leonardo IoT Foundation, visit us here.
Figure 1 illustrates the comprehensive SAP solution for collecting, managing, and integrating IoT data. In the cloud-based SAP Leonardo IoT Foundation, the SAP Cloud Platform IoT service delivers technical services, and the SAP IoT Application Enablement toolkit delivers data management and business services. Among the technical services, a comprehensive library of IoT protocol adapters helps you interact with devices from various vendors. Business services enable you to give each device a “digital twin” through which you can consume IoT input. SAP Leonardo IoT Edge complements SAP Leonardo IoT Foundation by providing packaged services to help you process data at the edge of your network to reduce costs and increase agility.

Your development organization can use the digital twins to maintain scale and enforce consistency when programming and integrating IoT applications in SAP Web IDE. Flexible, reusable IoT application services keep development operations simple so your business realizes value quickly and affordably. Automated access to dynamic Big Data storage lets you manage transaction and application volume efficiently. And you can take advantage of the latest IoT capabilities by folding IoT data into SAP and non-SAP applications through the SAP Cloud Platform Integration service. The SAP Fiori® user experience delivers insights from the IoT data to your decision makers in an attractive, intuitive format.

MANAGE DEVICES EFFICIENTLY
SAP Leonardo IoT Foundation lets you conveniently onboard large numbers of various devices. You can centrally manage all phases of the device lifecycle in the cloud.

Perform Mass Onboarding
You can efficiently onboard masses of devices at once using OData-based APIs that automatically detect and enrich device data models. You can also group devices with the same metadata and manage them together.

Safeguard Communication Between Devices and the Platform
Digital certificates help keep communication secure between devices and SAP Cloud Platform. SAP hosts a certification authority for the SAP Cloud Platform IoT service in our data center, through which we assign a digital certificate to each new device you create.
Capture the Value of the IoT by Integrating the Physical and Digital Worlds

Figure 1: Architecture for SAP Leonardo Internet of Things

- **Hardware gateway**
  - SAP Leonardo IoT
  - SAP Leonardo IoT Edge
  - SAP Edge Services
  - Sensor-embedded things

- **SAP Cloud Platform**
  - SAP Web IDE
  - Portal SAP Fiori® launchpad

- **Cloud Foundry Environment**
  - SAP Cloud Platform Internet of Things (core)
  - SAP IoT Application Enablement toolkit
  - Data ingestion pipeline

- **SAP Leonardo IoT Bridge digital operations center**
  - Connected products
  - Connected assets
  - Connected fleet
  - Your IoT applications
  - Connected infrastructure
  - Connected markets
  - Connected people

- **SAP Cloud Platform Integration service**
  - SAP S/4HANA®
  - SAP Hybris
  - SAP Ariba
  - SAP and non-SAP applications
  - and more...

- **Your IoT data**
  - Cold, warm, and aggregate store
  - SAP HANA® database

*Belongs to the SAP Cloud Platform Internet of Things service
Monitor and Manage Remotely
Administrators can monitor device operation centrally in the cloud using the cockpit in SAP Cloud Platform IoT. The cockpit provides dashboards for technical staff, displaying such information as alarms, KPIs, and historical and current time-series data.

Enjoy Rich Support for IoT Protocols
SAP Cloud Platform IoT includes a library of technical protocol adapters for connecting with devices from various vendors. The current list of IoT connectors includes such open-source protocols as OPC Unified Architecture (OPC UA), Modbus, Constrained Application Protocol (CoAP), Simple Network Management Protocol (SNMP), MQTT, and REST, along with vendor-specific protocols such as Sigfox from Sigfox S.A. – and the list is still growing. You can use the core services of SAP Cloud Platform to connect non-IP devices through gateway edge components. An IoT protocol normalization mechanism abstracts protocol and vendor specifics to help you manage all devices according to a uniform procedure. And a software development kit for SAP Cloud Platform IoT lets you build new IoT connectors using the Java development environment Eclipse, from the Eclipse Foundation.

Distribute Data Load Efficiently
Gateway software, which typically runs on a machine with a small hardware footprint, lets you connect with groups of devices, which you can manage and monitor remotely in your cloud. Data moves from the devices through the gateways toward the cloud, and administrators can use the IoT cockpit to send commands or firmware updates through the gateway to a single device, a set of devices, or all devices. You can reduce costs and increase agility by storing or processing IoT data on these gateways at the edge of your network. The gateway software includes interceptor technology for injecting custom logic. With this feature, you can bring innovative technologies such as machine learning or data streaming to the edge of your network, where you can integrate it cost-effectively into your existing systems.

To help ensure smooth operation and reliable connectivity of gateway software with the core of SAP Cloud Platform IoT, SAP offers a certification program for gateway hardware vendors.

Rely on Strong Central Core Services in the Cloud
The core services of SAP Cloud Platform IoT are based on an elastically scaling infrastructure that facilitates central functions such as message management, resource and access control, and security. They are the backbone of the entire system, bringing together all IoT functional components. Administrators manage the core services using the IoT cockpit, which includes the dashboards for real-time viewing of KPIs, notifications, and time-series data.

The SAP Cloud Platform IoT service delivers technical services, and the SAP IoT Application Enablement toolkit delivers business services.
Build Stunning Applications to Support Innovation

Managing and connecting existing physical devices is only a first step in exploiting the full innovation potential of the IoT. SAP Leonardo IoT also helps you build new applications to reap full benefit from this groundbreaking technology.

DEVELOP THING MODELS
In SAP Leonardo IoT Foundation, a semantic and hierarchical model lets you create a digital representation for each physical object or “thing,” such as a specific machine. You can reuse components of a machine description, such as groups of sensors, to model additional thing types. And a particularly useful feature lets you freely define the properties associated with a thing type, as well as the semantics of a time series to be captured. The thing registry stores all things that have been created, and each thing is an instance of a specific thing type.

Manage Business Partners
Business partner management functionality lets you define employees, customers, or collaborating companies as business partners and grant them role-specific access to data. A thing authorization model provides the services that let you define object groups and roles, assign roles to user groups, and authorize role-based access to specific object groups – even restricted to the value of a certain property.

Synchronize the Physical and Digital Worlds with the Thing Shadow
An entity called the thing shadow helps you keep the physical and digital worlds synchronized. It contains the latest set of data that has been stored for a specific thing and thus represents the current state of the thing. Working in one direction, a remote device can update the thing shadow in its instance of the thing model, allowing a user to view the last reported state of the device. In the other direction, the user can then update the thing shadow of the device in its instance of the thing model to direct the remote device to synchronize with the new target state.

Manage Events
You can implement event creation and handling as part of your application, harnessing an event management function in SAP Leonardo IoT Foundation to monitor and control changes in the status of a thing. Then, if sensor readings exceed a specified threshold, for example, your IoT application can show a record of threshold violations over time.

Your development organization can use digital twins of your assets to maintain scale and enforce consistency when programming IoT applications.
BUILD APPLICATIONS IN AN IOT-READY DEVELOPMENT ENVIRONMENT

Application development templates are available through the SAP Cloud Platform Web IDE service. With these templates, you can create powerful applications by selecting user interface (UI) patterns – such as maps, lists of things, or thing information cards – and connecting them with data sources using SAP IoT Application Enablement to generate code. You can then enhance or modify the code to fit your use case. Useful features include:

• A wizard for creating applications running on SAP Cloud Platform
• Definable page layouts with horizontal and vertical sections
• Free-style page layouts in which you eliminate coding altogether and focus on design
• A storyboard perspective for quick prototyping with complete visibility
• A rich selection of reusable UI controls, including geo maps, thing lists, thing pages, sensor charts, gauge charts, event lists, and sensor images
• Drag-and-drop functionality for reusable UI controls
• Advanced features for modeling analytical content based on aggregated time-series data
• Convenient data binding to back-end services
• Simple-to-configure controls for interaction with events and actions
• Live connection to data, including live preview
• Java and JavaScript support for server-side business logic
• OData support

You can onboard masses of devices at once using OData-based APIs that automatically detect and enrich device data models.
Add Value by Integrating IoT Applications with Existing Business Scenarios

The IoT is a totally new paradigm for generating and handling data. But it complements rather than replaces traditional processing in the world of business, enhancing rather than upending current business scenarios and the IT infrastructure that underlies them. You can smoothly connect the data generated through the IoT to legacy infrastructures and applications. In fact, your IoT applications deliver their optimal value through defined and reliable interfaces and seamless back-end integration.

**ACT ON IOT DATA BY CONNECTING TO BUSINESS PROCESSES**

With SAP Cloud Platform Integration, you can connect new applications to your SAP Hybris® Cloud for Customer solution, a software-as-a-service (SaaS) offering for sales and after-sales functionality, to trigger service requests before machine performance degrades. Or you can connect them to your SAP Ariba® solutions to generate orders for spare parts and integrate the procurement process directly with functions for invoice and payment processing in SAP S/4HANA®.

**SUPPORT BUSINESS DECISIONS WITH INSIGHT GROUNDED IN DATA**

You can generate and deliver business insights from IoT applications by integrating with the SAP Smart Business cockpit or by using the analytical OData service to facilitate consumption by such analytical tools as Microsoft Excel. Either method lets you track important key performance indicators in shared interactive dashboards, so that all stakeholders can explore your company’s business drivers and make sound decisions backed by solid data.

We plan to add an integration feature to the SAP Analytics Cloud solution that will let you access data from your machines and blend it with data from existing applications and other cloud-hosted sources. The goal is to help you create visualizations from insights discovered in this collected data and apply predictive analytics functions to uncover developing trends and reveal hidden influences. Then machine learning functionality can further increase the visibility of key variables affecting your operational performance.

**REALIZE NEW VALUE WITH A ROBUST IOT ARCHITECTURE**

With SAP Leonardo IoT Foundation, you can exploit the IoT to sharpen your competitive edge and bring innovations to value faster. You gain a top-notch IoT backbone, full integration of IoT insights with business processes, and an open ecosystem to boost your continued growth and diversification. For input, SAP Leonardo IoT Foundation integrates natively with SAP Leonardo IoT Edge, which delivers persistence services, streaming analytics, and core functions for computing at the outer reaches of the cloud. To relay output, SAP Leonardo IoT Foundation connects with SAP Leonardo IoT Bridge, a digital operations center that combines IoT data with business processes.
We designed this architecture specifically to help you jump-start digital transformation projects and activate and scale applications that take advantage of IoT technology. SAP Leonardo IoT Foundation, shown in Figure 2 in context with other SAP Leonardo–based offerings for the IoT, helps your business realize value quickly and efficiently by:

• Connecting with any device and managing large numbers of devices
• Collecting data from connected devices and delivering it to applications across your business
• Reducing the cost and time it takes to develop IoT applications
• Implementing IoT use cases that can increase revenue or customer engagement
• Harnessing automated, dynamic data tiering in infrastructures that manage Big Data
• Integrating new functionality tightly with core business processes using SAP Cloud Platform Integration
• Extending existing SAP applications with additional IoT capabilities that emerge in the future

Figure 2: How SAP Leonardo IoT Foundation Fits with Other SAP Offerings for the IoT
You can count on SAP Leonardo IoT Foundation to help future-proof your business by making the most of the latest IoT capabilities and continually improving your ability to respond profitably to today’s fast-moving marketplace.

**FIND OUT MORE**
For more information on innovating with SAP Leonardo to capitalize on IoT technologies, visit us online [here](#). And visit us [here](#) to check the SAP Cloud Platform product road map for planned support of other cloud infrastructures.

You can track key performance indicators in shared interactive dashboards, so that all stakeholders can make sound decisions backed by solid data.