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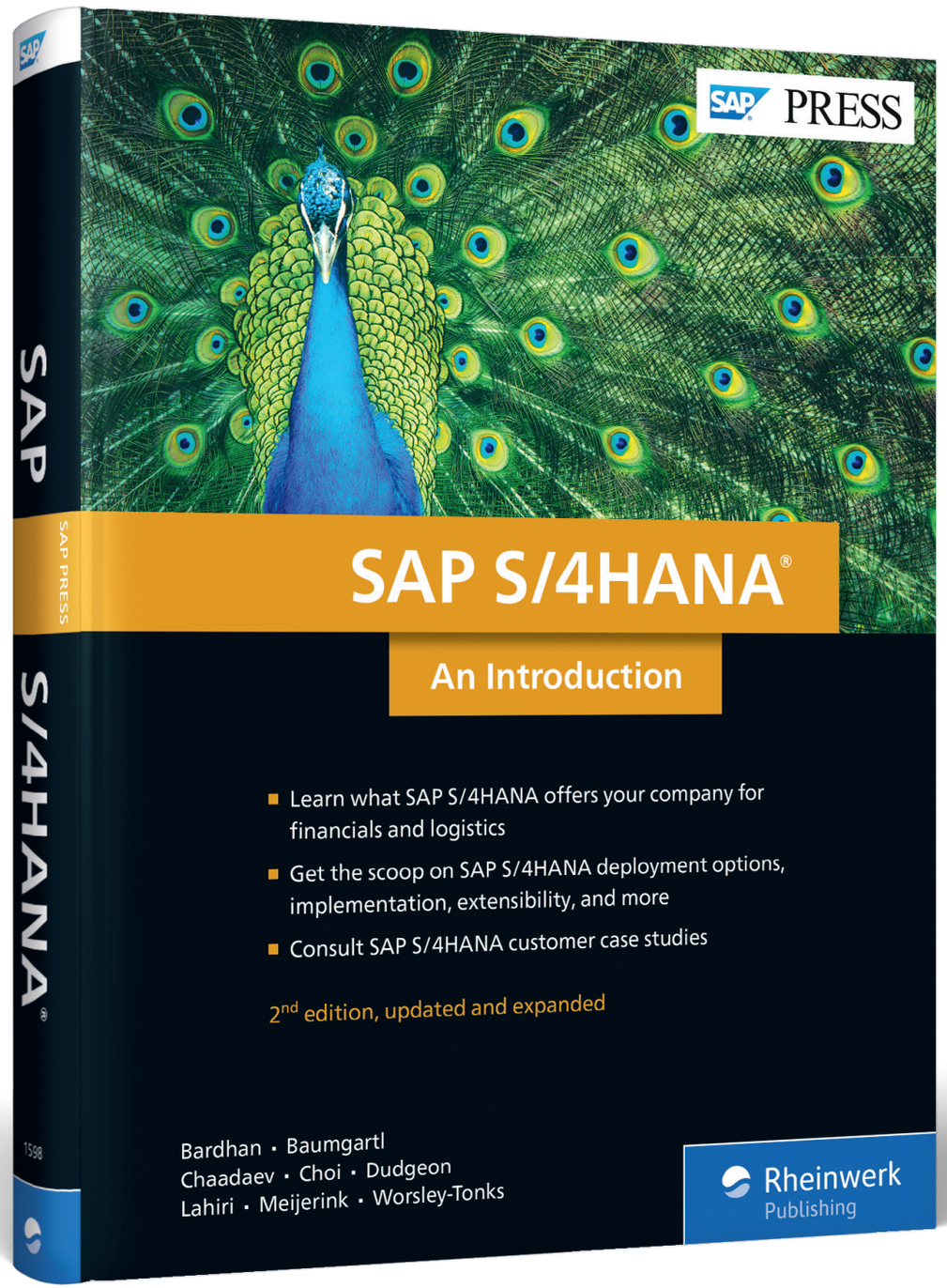

Reading Sample

This sample chapter discusses SAP's extension strategy for SAP S/4HANA, with coverage of both in-app extensibility and side-by-side extensibility. It also discusses SAP Cloud Platform, IoT, and SAP Leonardo's machine learning capabilities in terms of extensions.

"Extending SAP S/4HANA"

Contents

Index

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Chapter 12
Extending SAP S/4HANA

This chapter provides an overview of SAP's extension approaches, a cloud-first extension strategy, and SAP Cloud Platform capabilities. We also discuss leveraging emerging technologies for future SAP solutions.

Customization underpins our world. Everyone has different techniques and preferences, and businesses are no different. The very first IT systems were specifically tailored to how businesses operated, at a high cost and risk. Later came out-of-the-box products to increase success and decrease costs and risk by using best practices to encourage businesses to adopt the standard processes and use customization for unique business processes.

Software as a service (SaaS) encourages best practices even more, providing robust functionality with less customization, which businesses are willing to sacrifice for agility, faster deployments, regular feature updates, and reduced costs. However, the inescapable truth is that customization can't be removed fully from the technology that supports businesses. Because each business is different, there will always be some custom application code and software parameters configuration. Best practices may enable businesses to upgrade functionality with less prep time, effort, and risk, which is good for software companies that want happy clients, but businesses require technology to enable their uniqueness, too.

The answer to this dilemma lies in a computing concept that's both logical and old; separate the application from the customization by creating extensions.

In the past, the customization and extension of SAP functionality focused mainly on ABAP application development as part of the SAP ERP solution. Later, Java application development was added with the introduction of SAP NetWeaver and service-oriented architecture to create a composition environment. Building in the runtime environments of SAP NetWeaver AS ABAP or SAP NetWeaver AS Java were the two methods to enhance the SAP ERP core.

With the move to cloud-based "X as a service" solutions, there's a need for strong governance to maintain the solution and therefore restrict options to extend or customize

SAP S/4HANA. The same is true for other cloud-based line of business (LOB) solutions, such as SAP SuccessFactors, SAP Hybris Cloud for Customer, SAP Ariba, SAP Fieldglass, and Concur.

SAP's approach for SAP S/4HANA is to keep a stable solution running the business and to use extensions to provide custom functionality without implications for maintenance. The previous methods and tools are still available for SAP S/4HANA, but the recommendation is to adopt the approach and tools available for SAP S/4HANA Cloud to prepare for the future and to leverage their benefits.

Separating all custom development into extensions is a fundamental business architecture and technology architecture decision with an impact on SAP S/4HANA design and implementation, and which will have an impact for the next decade or more.

In the following sections, we'll detail the various extension approaches.

12.1 Extensions for SAP

In the following subsections, we'll begin with an overview of the two extensibility approaches available for SAP S/4HANA, then we'll jump in to their specifics.

12.1.1 Overview

SAP has defined two approaches for going forward: in-app extensibility and side-by-side extensibility. These two approaches are illustrated in Figure 12.1.

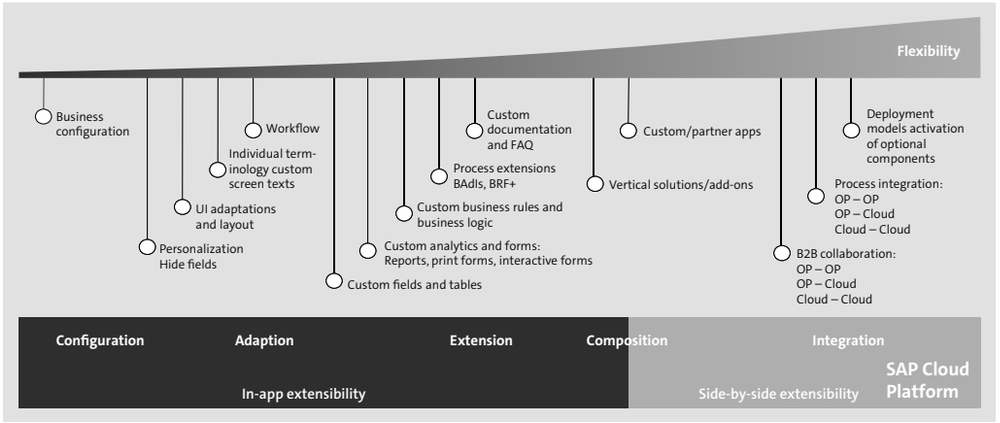


Figure 12.1 Overview of In-App Extensibility and Side-by-Side Extensibility Approaches

In the *in-app extensibility* approach, customization occurs in the SAP application. This approach uses the same methods and tools as in past SAP ERP releases to create capabilities built into SAP S/4HANA across data (SAP HANA database) and application (ABAP) layers. These have been classified into two subtypes:

- Key user in-app extensibility, in which a key user (e.g., a super user or functional consultant) performs configuration changes via SAP Fiori–based tools to customize the SAP S/4HANA ABAP backend and SAPUI5/JavaScript SAP Fiori frontend. As a key feature of SAP S/4HANA using SaaS principles, this option is available for all SAP S/4HANA editions.
- Classic in-app extensibility, in which developers have full access to the SAP S/4HANA ABAP backend, SAP HANA database backend, and SAPUI5/JavaScript SAP Fiori frontend. This is a continuation of the customization available in previous SAP ERP suites and is only available for on-premise SAP S/4HANA.

In the *side-by-side extensibility* approach, customization occurs on an adjacent application layer. This approach uses the latest development advantages from cloud technologies and tools to create capabilities on an adjacent application layer with decoupled feature update timelines for parallel delivery. Using side-by-side extensions is the next method to provide the business with a value-add for SAP products.

An overview of the differences between the two extensibility approaches and their use is provided in Figure 12.2.

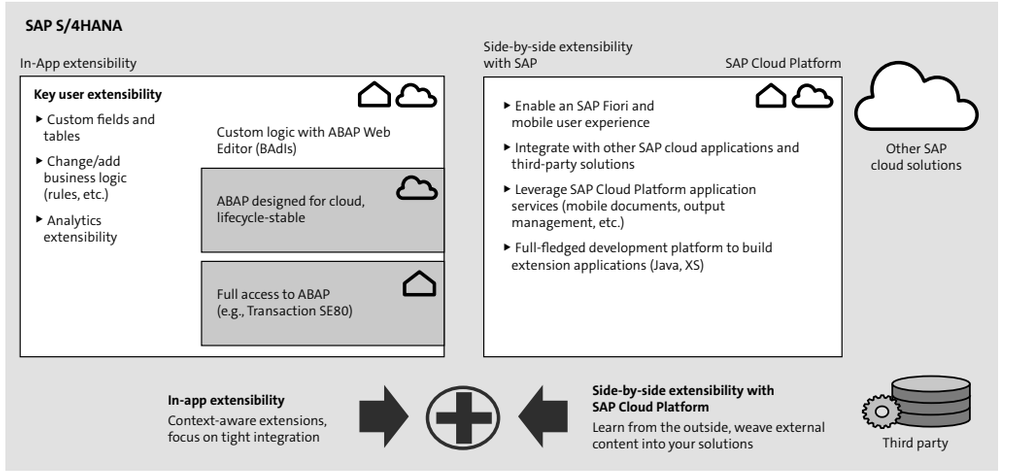


Figure 12.2 Comparison of In-App Extensibility and Side-by-Side Extensibility Approaches

The extensibility approaches available are different from what you may have experienced with SAP, as shown in Figure 12.3, which depicts extensibility approaches for SAP S/4HANA compared to SAP Business Suite (SAP ERP 6.0).

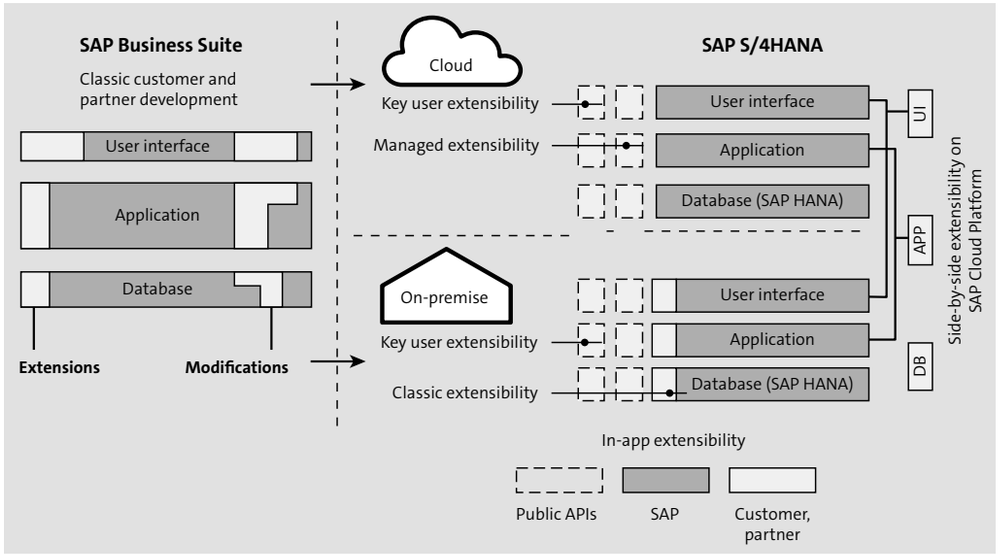


Figure 12.3 Extensibility Approaches for SAP Business Suite versus SAP S/4HANA

The key consideration when comparing in-app extensibility, which is very similar to the approach that's been used for many years, and the cloud computing–based side-by-side extensibility approach is the technologies introduced and therefore the impact on skills availability, best practices, and methodologies. The new approach considerations are discussed in Section 12.1.3.

Figure 12.4 summarizes the key technologies from both approaches for customization, and the following sections will discuss the approaches and their implications in detail.

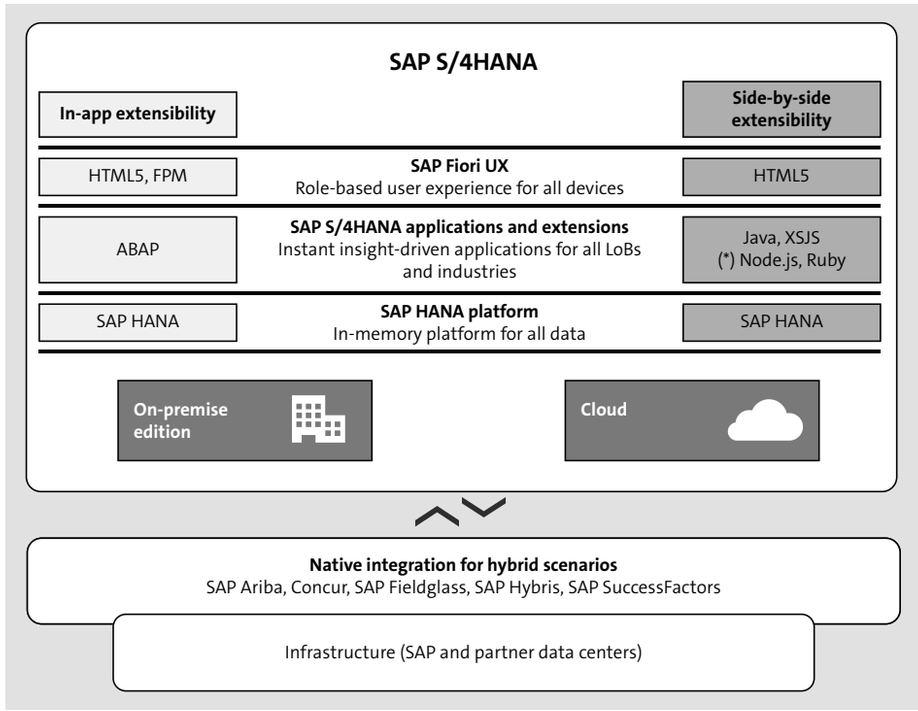


Figure 12.4 Possible Technologies to Adopt or Extend Business Applications

12.1.2 In-App Extensibility

In the in-app extensibility approach, customization occurs in the SAP application. The following subsections briefly describe the additional knowledge required for SAP S/4HANA, as this approach uses the same methods and tools from past SAP ERP releases.

Key User In-App Extensibility

This approach provides SAP Fiori–based tools to customize SAP S/4HANA and is designed for smaller changes made directly to the application (SAP S/4HANA) or data (SAP HANA database) layer.

The approach is named the *key user* approach because it relies on a super user or functional consultant who has been empowered to perform these customization changes as part of the design. It's a key provision of SAP S/4HANA and critical for the

public cloud edition; this feature has been adapted from the principles of other SaaS offerings in the marketplace.

The tools used for key user in-app extensibility in SAP S/4HANA are as follows:

- UI Adaptation Mode
- Custom Analytical Queries app
- Custom Catalog Extensions app
- Custom CDS View app
- Custom Communication Scenarios app
- Custom Fields and Logic app
- Custom Business Objects app
- Adobe Forms Designer and the Maintain Form Template app
- KPI Design app
- Manage Software Collection app
- Cloud ABAP Web Editor (high restrictions)

These SAP Fiori-based tools empower key users with the following tools and advantages:

- UI tools to customize the application simply and within restrictions
- Stable lifecycle due to restricted customizations removing regression impact after product upgrades
- Support for both on-premise and cloud deployment options

An example of a smaller change performed on an SAP Fiori app—the SAP S/4HANA Custom Fields and Logic app—is shown in Figure 12.5.

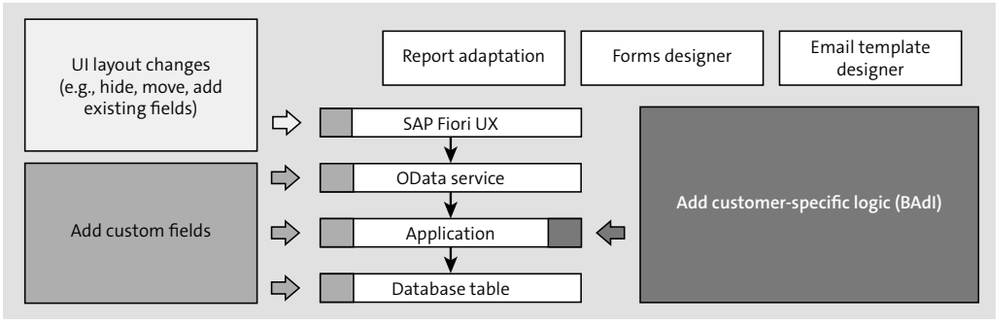


Figure 12.5 Key User Extensibility Example

Classic In-App Extensibility

This approach provides preexisting tools for full access to customize all layers; examples of these tools include the ABAP Workbench, ABAP Development Tools (ADT) for Eclipse, and SAP HANA Studio, based on Eclipse.

This approach is called the *classic* approach because it follows the same principles used in previous SAP ERP suites. The provision is only available in on-premise SAP S/4HANA, and we recommend that this approach only be used with the whitelisted APIs for SAP S/4HANA to ensure greater governance and reduced requirements for regression testing during product upgrades.

Whitelisted APIs for SAP S/4HANA In-App and Side-by-Side Extensions

In-app extensions and side-by-side extensions can use the SAP-managed (and thereby regression-controlled) public model APIs for SAP S/4HANA. These APIs are designed for SAP S/4HANA Cloud but are available for on-premise SAP S/4HANA as well.

The whitelisted APIs provide a wide variety of functionality, which provides greater governance of changes to the SAP S/4HANA application itself.

For SAP S/4HANA Cloud, this is the only method for in-app extensions and side-by-side extensions; it ensures stable lifecycle management and enables regular product upgrades on the public cloud.

The following types of APIs are available for in-app extensions:

- ABAP classes
- BAdIs for implementable code breakouts of business logic changes
- BAPIs and other function modules
- CDS views

Previously, SAP also defined *managed in-app extensibility* using the whitelisted APIs. This was a paid service for the enterprise edition of S/4HANA Cloud and has since been removed from documentation.

12.1.3 Side-by-Side Extensibility

In the side-by-side extensibility approach, customization occurs on an adjacent application layer. This approach is available for on-premise and cloud editions, using the latest development advantages from cloud technologies and tools to create extensions with development and update timelines decoupled from the SAP applications.

Therefore, side-by-side extensions can be built more quickly and released more frequently without impacting SAP S/4HANA, and these extensions provide the business with value-adds for SAP and early value realization.

This approach often uses PaaS provisions, such as SAP Cloud Platform, which is detailed in Section 12.2.

The purpose of the side-by-side extension is to ensure the stability of the core solution while extending the solution. It's the default option for SAP S/4HANA extension development and can provide the following, for example:

- Unique business processes (e.g., industry solution extensions)
- Specific front-office functionality for business-to-business (B2B)
- Specific front-office functionality for business-to-consumer (B2C)
- Specific back-office functionality
- Integrated custom or partner solutions for SAP S/4HANA
- Integrated open-source developments
- Integrated emerging technology services and solutions
- Integration with social networks
- Event streaming and triggering from IoT devices

Product upgrades and feature updates are the main benefits of this side-by-side extensibility approach; separate lifecycle management enables a stable SAP S/4HANA and stability in other SAP applications for LOBs to provide for business transactions and provide separate customization.

For example, SAP applications such as SAP S/4HANA or SAP Ariba can be upgraded separately from adjacent applications (e.g., a customized SAP Fiori-designed SAPUI5 application for a calendar view of deliveries). Therefore, business operations will continue to meet best practices, and the extensions will enable agility in the business to adapt rapidly to new requirements, market changes, and new technologies.

The side-by-side extensions are usually SAP Fiori-designed, SAPUI5-based server-side applications and are primarily run on a PaaS model; the PaaS offerings can be from different cloud providers and use different services. Businesses are increasingly adopting PaaS as a strategy for agile application development, with PaaS providing centralized and usage-based application hosting that's scalable and highly technology flexible. The hybrid cloud model, using best-of-breed services, solutions, applications, and "as a service" applications, has wide-ranging architectural implications for the technology landscape.

Critically, the side-by-side extensions should always be delivered through agile application development. When building within a cloud environment, it's necessary to leverage the best-in-class tools available for automating build, test, and release, as well as open-source frameworks for building the applications; this comes with risks, as we'll discuss in the following subsections. This approach requires agile methodologies to be used in delivery and a DevOps culture to be instilled in the business and developers.

The various scenarios for side-by-side extensions are as follows and are shown in Figure 12.6:

- Scenario S1 is an extension of the frontend server with a custom UI consuming existing OData services.
- Scenario S2 demonstrates the possibility of extending the existing UI via SAP Cloud Platform by calling an existing OData service.
- Scenario S3 has no change in SAP S/4HANA while you build a new data structure, business logic, and OData service with a new UI to develop a complete new solution that extends SAP S/4HANA.
- Scenario S4 shows data replication for analytics on SAP Cloud Platform.
- Scenario S5 is based on a new SAP S/4HANA OData service that is being consumed by a new custom UI on SAP Cloud Platform.
- Scenario S6 shows that SAP S/4HANA is consuming an SAP Cloud Platform service.

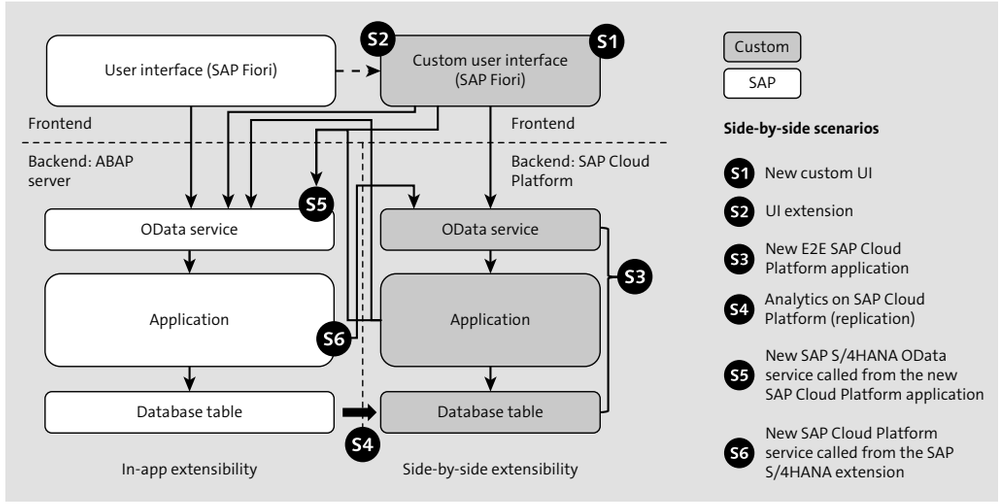


Figure 12.6 Side-by-Side Extension Scenarios

To complete the picture, Table 12.1 provides an overview of the programming models, development tools, and SAP S/4HANA APIs available for the different extensibility options.

Extension Type		On-Premise or Cloud	Programming Model	Development Tools	SAP S/4HANA APIs
Side-by-side extensibility with SAP Cloud Platform		Both	■ SAP Fiori ■ Other web techniques ■ Java ■ JavaScript ■ SAP HANA	■ SAP Web IDE ■ Related IDEs ■ Eclipse ■ SAP HANA Studio	■ Remote APIs: web services (OData) ■ SAP S/4HANA Cloud: only public remote APIs
In-app extensibility	Key user	Both	■ SAP Fiori flexibility ■ Custom fields, logic, reports, and so on ■ SAP HANA new/extended CDS views	■ SAP Fiori UX adaption mode ■ SAP Fiori key user tools	■ Public local APIs: CDS views, ABAP class APIs, etc. (restricted key user scope)
	Managed	Both	■ SAP Fiori ■ ABAP web techniques (restricted) ■ ABAP (restricted) ■ SAP HANA	■ SAP Web IDE ■ Eclipse ■ ABAP Workbench	■ Public local APIs: CDS views, ABAP class APIs, etc. (restricted scope)
	Classic	On-premise only	■ SAP Fiori ■ Other ABAP UI techniques ■ ABAP ■ SAP HANA	■ SAP Web IDE ■ Eclipse ■ ABAP Workbench	■ Recommended: public local APIs: CDS views, ABAP class APIs, etc. ■ No technical restrictions

Table 12.1 Programming Models, Tools, and APIs for SAP S/4HANA Extensions

The side-by-side extensibility approach is recommended for most cases going forward. This approach provides the following benefits:

- Adjacent application layer hosting extensions creates a decoupled feature update timeline for SAP applications and enables parallel lifecycles of application development; reduced or no reliance on deployment windows and cutovers.
- Uses the latest development advantages from cloud technologies and toolsets, including a move to continuous integration, delivery, or deployment.
- Far wider choice and flexibility when selecting the right programming languages, frameworks, and run times from open-source options that are the best of breed for the intended use case; in addition, enables faster leverage of emerging technologies as new services are released from cloud providers.
- Retains SAP S/4HANA and other SAP applications running near best practices, with significantly reduced regression impact, enabling faster innovation cycles from SAP product updates.
- Cost efficiencies from cloud providers when running extensions using microservices (or, soon, serverless) runtime architecture.

However, when compared to development of in-app extensions, the development of side-by-side extensions requires a lot of initial effort, including cultural changes (which will be challenging for SAP ERP process-embedded developers and IT operations), such as the following:

- Redesign of architecture to encompass microservices (or, soon, serverless) options.
- New interfaces.
- New development processes and best practices to be instilled, including a path to production changes (such as continuous integration, delivery, or deployment). For example, there's a significant adjustment for build management, moving away from cherry-picking transports that move object version updates to environments and toward continuous code delivery environment updates based on updates to GitHub source control that trigger task runners.
- New project deliveries and prioritizations (i.e., agile methodologies) with associated mentality changes (developers work with key/end users).
- New developer and operations teams instilled with new way of working (developers work with operations and automate what they can to reduce burden/workload overall—as with DevOps).

12.2 SAP Cloud Platform

SAP Cloud Platform, the rebranding of SAP HANA Cloud Platform, is a PaaS offering that provides various solutions and services to leverage in application development. As shown in Figure 12.7, SAP Cloud Platform is to be the glue between SAP applications on-premise, application in the SaaS model, and all extensions.

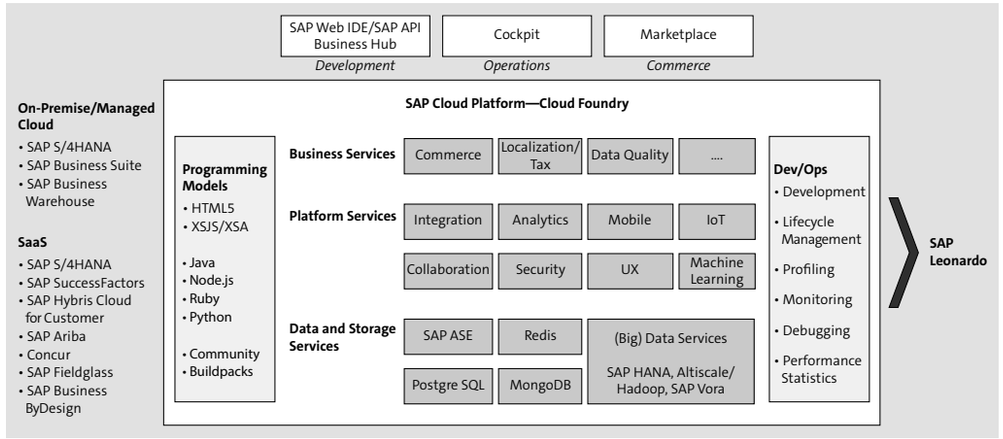


Figure 12.7 SAP Cloud Platform Overview

SAP is positioning SAP Cloud Platform as a unified PaaS by keeping already developed solutions and services in its "Neo" ecosystem but, going forward, using only Cloud Foundry and leveraging established best-of-breed cloud providers such as Amazon Web Services and Microsoft Azure. By leveraging Cloud Foundry, SAP ensures that it can easily bind/use any services and solutions provided by other PaaS offerings with Cloud Foundry, such as IBM Bluemix, Google Cloud Platform, Pivotal Web Services, Swisscom Application Cloud, or other cloud providers, including Oracle Cloud, Force.com App Cloud, and others.

SAP has built SAP Leonardo solutions and services on top of SAP Cloud Platform (a strategy used by all other cloud providers). SAP has seated application development on SAP Cloud Platform for the side-by-side extensions next to the SAP Leonardo Digital Innovation System solutions and services, thereby providing extensions within easy reach of emerging technologies such as services for machine learning, IoT, blockchain, and mobile—all of which are high on businesses strategic imperatives watchlists.

According to the new official definition, SAP Cloud Platform is now the key strategic PaaS infrastructure that provides the foundation for SAP Leonardo and end-to-end microservices for machine learning, analytics, big data, security, UX, user management, and backend integration services to optimize IT landscapes, drive agility, and accelerate digital transformation. With numerous possibilities and a large scope of innovation, the possible use cases for SAP Cloud Platform center on three main areas (see Figure 12.8):

1. **Building brand-new cloud applications**
   The main idea here is to leverage SAP HANA capabilities for, for example, advanced analytics and IoT and to build enterprise collaboration solutions (e.g., connect SAP JAM or use SAP JAM predefined UI widgets or REST/OData APIs) to add social capabilities into applications and business processes and connect users, information, and processes.
2. **Extending cloud and on-premise solutions**
   Protecting existing investments into on-premise solutions while at the same time taking advantage of new technologies and recent innovations is the key demand of any client. The extension is focused mainly on extending cloud solutions (SAP Hybris Cloud for Customer, SAP S/4HANA Cloud, SAP SuccessFactors, Concur, SAP Fieldglass, SAP Business ByDesign, and other products in the roadmap) and on-premise solutions (SAP and non-SAP, including SAP Business Suite and on-premise SAP S/4HANA). The other key aspects of extension include innovative UX using SAP Fiori apps and mobile-enabled solutions developed on top of SAP Cloud Platform Mobile Services. It also helps you to take advantage of standard SaaS offerings to differentiate your business from the competition by building or enabling unique processes. It's a seamless integration with the same look and feel as in the core application, but it's built as a side-by-side scenario.
3. **Integrating applications and data**
   By taking advantage of integration technologies on SAP Cloud Platform, your business processes and data can be harmonized in a very secure and reliable environment. Also, provisions to commercialize integration content (prepackaged), adapters for integration with cloud- or on-premise SAP applications, and third-party applications provide an edge.

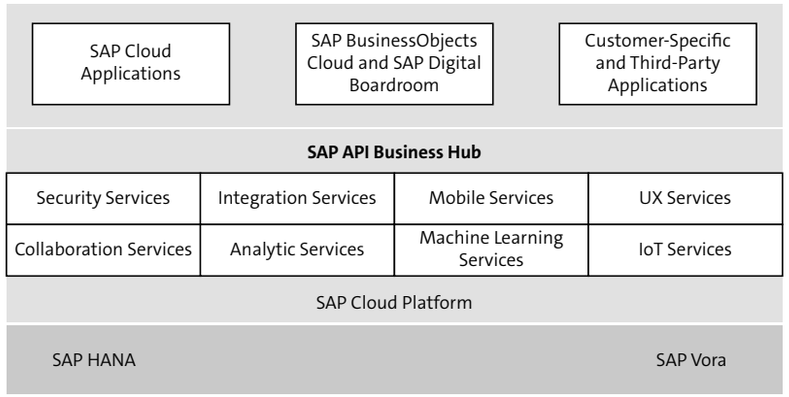


Figure 12.8 SAP Cloud Platform Capabilities

SAP Cloud Platform has evolved over the years into a comprehensive PaaS offering capable of simplifying the development and operation of new cloud applications and building extensions for existing SAP solutions, both on-premise and in the SaaS model. This has now turned into a designated extension, integration, and, most importantly, digital innovation platform for SAP's entire portfolio and forms the technical foundation for a whole set of new applications and products evolving around machine learning and IoT. Also, support for Cloud Foundry and OpenStack as the technologies for deployment and management simplifies deployment of business applications built with or on top of SAP Cloud Platform, including adding flexibility to select the data center of your choice and generating greater business value at a lower development and ownership cost while leveraging a multitude of innovations, such as bring your own language (BYOL). Overall, SAP Cloud Platform in combination with Cloud Foundry services and new SAP Leonardo services offers choice, flexibility, and enterprise-grade innovation.

In addition to providing a wide variety of services, SAP Cloud Platform with the Cloud Foundry environment enables developers to develop extensions or new solutions with different programming languages, runtimes, and frameworks, including the following:

- Java
- XSJS
- Ruby

- Node.js (with the Node.js package)
- HTML5
- SAPUI5 (now with more ready-to-use templates)
- Python (with library support for data manipulation, machine learning, and analysis)
- BYOL (bring your own language and runtime of choice)

With enhanced IDEs and new toolkits, you now have more power and can use less effort to build new applications or extend your existing applications. Some of your options are as follows:

- **SAP Web IDE**
  The newly improved SAP Web IDE now includes support for HTML5, SAPUI5 (with drag-and-drop controls on canvas), JavaScript, Node.js, Java (deploy only), and SAP HANA design artifacts (SQLScript and CDS, along with the calculation view modeler), with a rich, integrated Git client, including a history of committed changes, cherry picking, comparing commits, and so on.
- **SAP HANA Web-Based Development Workbench**
  SAP HANA Web-Based Development Workbench is a browser-based IDE for creating, editing, and debugging SAP HANA objects that can be used in place of SAP HANA Studio.
- **SAP IoT Application Enablement Toolkit plug-in**
  The SAP IoT Application Enablement Toolkit inside SAP Cloud Platform Web IDE supports rapid development of IoT applications through a wizard-based approach; no coding is necessary for this.
- **Hybrid Application Toolkit plug-in**
  The Hybrid Application Toolkit inside SAP Cloud Platform Web IDE supports quick development of Apache Cordova hybrid apps, with the support of templates, including live preview on a device emulator or a mobile device.
- **SAP Build**
  SAP Build is an open-source design tool that allows you to collaborate and develop prototypes based on design-thinking principles and understand the designing process. The tool also includes provisions to capture user feedback, and you can jumpstart designing by choosing one of the prototype examples from the gallery.

12.3 Internet of Things and Cognitive Analytics

IoT services are designed to facilitate and support the implementation of IoT applications. These services provide interfaces for registering devices and their specific data types, sending data to and storing data in a database running on SAP Cloud Platform, and providing easy access to the data stored. They support replication to and synchronization with remote databases into a consolidated SAP HANA database in the cloud. For example, you can consolidate sensor data from a remote database and build an analytical application on top for analytics and monitoring. In the context of IoT, SAP Cloud Platform provides capabilities to process high-volume data from any kind of machine, device, or sensor and then combine this information with the transactional data from the system of record or with additional information from social media, for example. The following are key features of IoT services:

- **Text analysis**
  Extract and process unstructured text data from various files with support for up to 31 languages. This allows you to identify a sentiment on seven different levels (e.g., strong positive, minor problem, etc.) in a tweet and analyze social media data. This is done by using language-based, full-text search text indexing and fuzzy search.
- **Geospatial processing**
  Store, process, manipulate, share, and retrieve spatial data by using SAP HANA.
- **Operational intelligence**
  Manage operational risk with end-to-end process visibility and better analytics supported by decision support and real-time insights.
- **Series data processing**
  Measure data and forecast trends (e.g., utilities and smart metering) with native series data storage and high-volume processing.
- **Graph engine modeling**
  Discover, manage, and analyze complex relationships for proximity- and location-based analytics.
- **Multitenant architecture**
  Logically isolate databases while sharing underlying system resources to optimize efficiency.

To extend IoT to manage and process IoT data, a set of services is available via SAP Cloud Platform to provide full control over your IoT lifecycle:

- **Remote device management**
  Manage devices from onboarding to decommissioning. Receive device information, configure devices remotely, and send commands to devices.
- **Message management services**
  Support various transport protocols and messaging formats to send, receive, and store IoT data in the persistence layer of SAP Cloud Platform.
- **Application enablement**
  Apply functionalities for remote device management and message management in your applications through APIs.

SAP Cloud Platform also can be leveraged to build cognitive solutions in multiple ways. All types of data can be leveraged using the SAP Cloud Platform IoT service to connect devices and sense the world or by performing text analysis using the built-in SAP HANA text analytics functionality. Of course, all other methods of analyzing business data using SAP HANA are also available. Although no computer vision service is yet available, SAP Cloud Platform makes it easy to tap into the API economy and leverage its connectivity service to integrate with, for example, IBM's Watson Developer Cloud to identify objects within an image.

Forming hypotheses isn't supported out of the box in SAP Cloud Platform. However, SAP HANA offers the powerful Predictive Analytics Library, which the developer can use to build models for testing hypotheses and training the cognitive solution. These models can be layered; for example, an SAP Cloud Platform solution might evaluate a hypothesis in a health care scenario, such as "Patient condition is worsening," based on an IoT stream of medical devices that signal an increase in temperature combined with textual analysis of the diagnosis. The solution then correlates that information with its medical knowledge to determine that temperature is a critical factor in the condition diagnosed.

Because SAP Cloud Platform is an ideal single place to gather data, it's easy to have solutions continually learn from new data fed into retraining the hypothesis model. SAP Cloud Platform makes it easy to develop SAP Fiori apps that allow users to give feedback on the recommendations and support they received from their cognitive solutions. The cognitive solution on SAP Cloud Platform can then periodically retrain itself.

The wide range of IoT services on SAP Cloud Platform lets you securely onboard devices over an extensive variety of protocols with full flexibility to process IoT data and derive relevant data either at the edge of the network or on SAP Cloud Platform.

Additional services on SAP Cloud Platform enable you to feed the relevant data into IoT applications, including real-time IoT analytics. SAP Leonardo on SAP Cloud Platform is the latest "digital transformation system" from SAP to enable IoT.

12.4 SAP Leonardo and Machine Learning

SAP recently acquired the Plat.One IoT platform and launched SAP Leonardo, which embraces different technology components such as design thinking, machine learning, big data, IoT, data intelligence, Blockchain, and analytics to make machines smarter and drive the end-to-end digital transformation across enterprises. SAP Cloud Platform as the strategic PaaS infrastructure provides the underlying framework for the SAP Leonardo foundation.

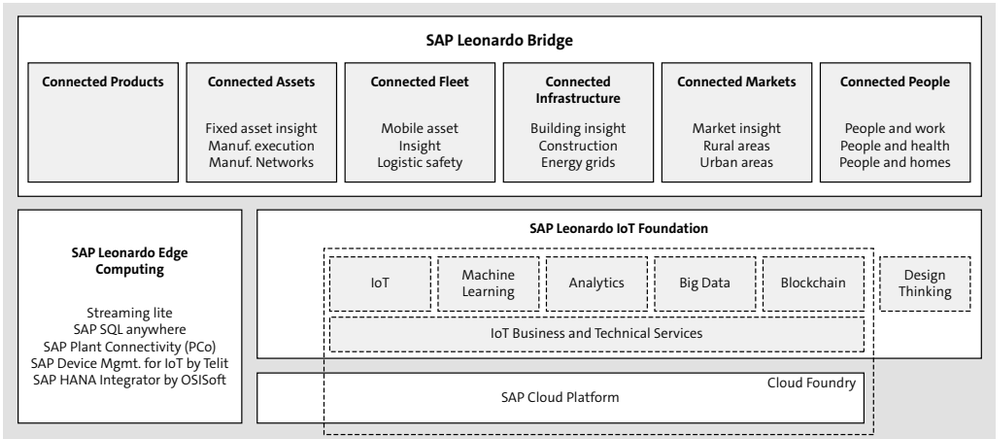


Figure 12.9 SAP Leonardo Innovation Portfolio

SAP Leonardo, as the innovation portfolio for IoT, is most relevant in the context of developing a side-by-side SAP S/4HANA IoT extension using SAP Cloud Platform and is well-structured to enable the Internet of Everything. SAP Leonardo includes the following components:

- **SAP Leonardo IoT Bridge**
  SAP Leonardo IoT Bridge blends real-time data from connected things with business processes and turns them into a live supply chain environment. Basically, it offers a range of enterprise-ready end-to-end packaged solutions.

- **SAP Leonardo IoT Edge**
  SAP Leonardo IoT Edge acts as an IoT gateway to collect data irrespective of connectivity, latency, or device protocol concerns.
- **SAP Leonardo IoT Foundation**
  SAP Leonardo IoT Foundation is at the center of the SAP Leonardo IoT portfolio. It's a combination of business services to build IoT solutions rapidly by creating digital twins, reusable application services, and applying predictive algorithms; and core technical services to perform stream analytics and run predictive scenarios. These new services run on the Cloud Foundry stack on SAP Cloud Platform.

  SAP Leonardo IoT Foundation technical services available on SAP Cloud Platform provide developers with efficient capabilities for a wide range of protocol support, including conversion, device management, scalable messaging, streaming analytics, big data connectors, integration services, user management, security, and IoT application enablement services.

Machine learning has been around for many years. With recent advances in cloud computing, there has been significant movement in the past decade, starting with IBM Watson and the explosion of machine-learning services since the start of 2016.

SAP Leonardo Machine Learning Foundation basically provides two different categories of machine-learning services including business and functional services that cover a wide range of capabilities to understand the content and meaning of a variety of data types, such as image, video, audio and speech, tabular and time-series, natural language data, and so on. The underlying technology of these machine learning APIs is based on Google's TensorFlow machine intelligence framework.

The new SAP Leonardo machine-learning services can add new dimensions and unseen analytics to any side-by-side extensibility of SAP S/4HANA on SAP Cloud Platform.

The SAP Leonardo machine-learning business services are meant for comprehensive tasks—for example, smartly classifying and processing an incoming ticket for a support center, routing it to the most appropriate agent, and suggesting possible solutions, thus reducing repetitive manual tasks and shortening the time to resolution. Available services include the following:

- The SAP Intelligent Financing API can be used to analyze the financial health score of a user based on historical activities.
- SAP Service Ticket Intelligence—Classification can be used to classify the type of ticket, especially at customer support centers.

- SAP Service Ticket Intelligence—Recommendation can be used to recommend possible solutions for customer support tickets, especially at customer support centers.

The SAP Leonardo machine learning functional services run on pretrained models and are more useful for image classification, topic detection, product image classification, time-series changepoint detection, language detection, similarity scoring, and so on. In side-by-side extensibility of SAP S/4HANA on SAP Cloud Platform, using these kinds of functional services can help businesses make decisions more intuitively, and these services run on a self-learning model. Available services include the following:

- Document Feature Extraction API, to extract feature vectors from a document and use them for comparison or clustering.
- Image Classification API, to return classifications for a given image, including probability for correct classification.
- Image Feature Extraction API, to extract feature vectors for a given image for comparison.
- Language Detection API, to detect language for a given text.
- Product Image Classification API, to classify a given image based on preset categories.
- Product Text Classification API, to classify products into specific categories based on product descriptions.
- Similarity Scoring API, to compare vectors extracted through Image Feature Extraction or Document Feature Extraction to find similarity between images or documents.
- Time-Series Changepoint Detection API, to return the probability of a changepoint for each data point in time-series data.
- Time Series Forecast API, to predict the next data points for the given time-series data.
- Topic Detection API, to extracts and return the score for the most relevant topic in a document.
- Translation API, to translate a given string from one language to another.

These machine-learning services are available as RESTful APIs and exposed through SAP API Business Hub (see Figure 12.10). Therefore, while developing an extension or new application on SAP Cloud Platform, you can add machine-learning dimensions to your solution via these RESTful APIs.

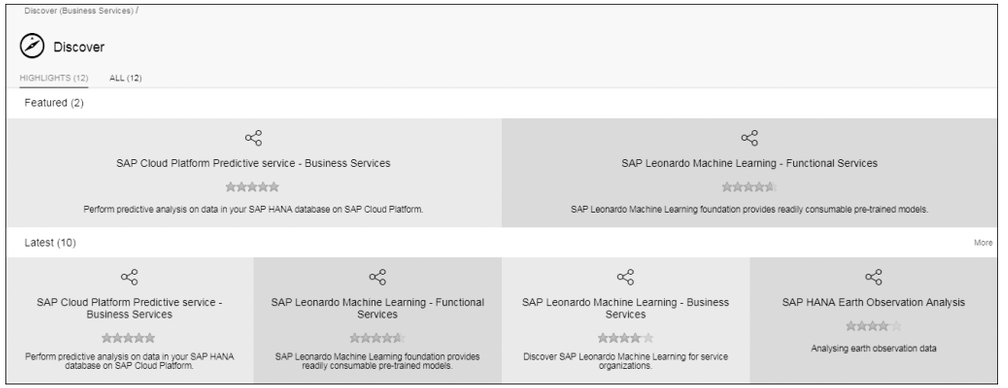


Figure 12.10 SAP Cloud Platform API Business Hub

Click the tile **SAP Leonardo Machine Learning—Functional Services** tile (Figure 12.11) and switch to the **Artifacts** tab. Here, you'll see a list of all the functional SAP Leonardo machine-learning APIs.

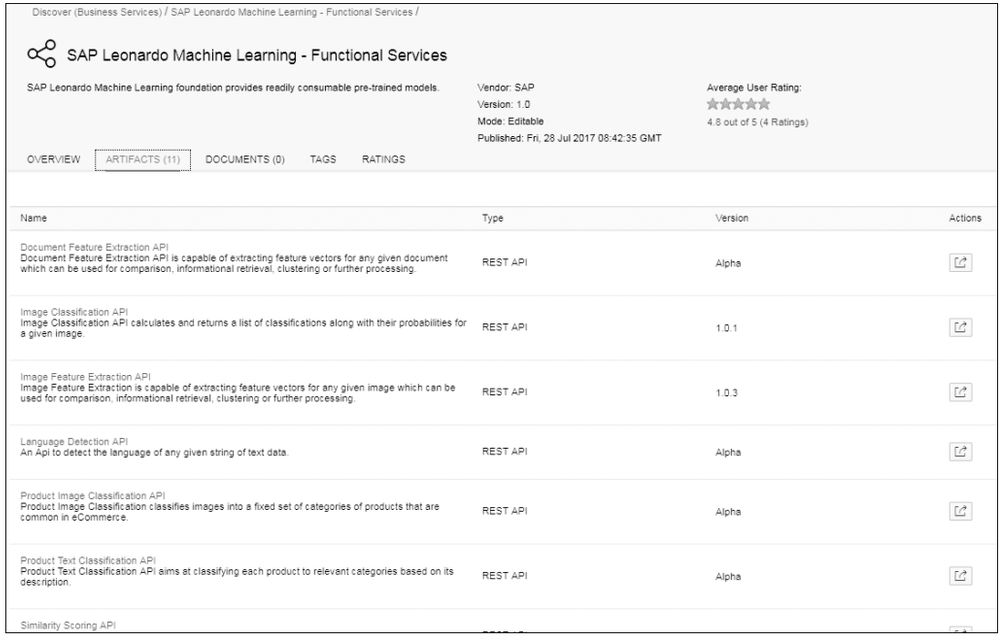


Figure 12.11 SAP Leonardo Machine Learning—Functional Services

Note

For more details on how to use machine-learning services, see *http://bit.ly/2fyfyNu*.

A possible side-by-side SAP S/4HANA IoT extension on SAP Cloud Platform can include IoT and machine learning along with other extension components by using SAP Leonardo IoT Foundation; the possible architecture of such an extension will look like that shown in Figure 12.12.

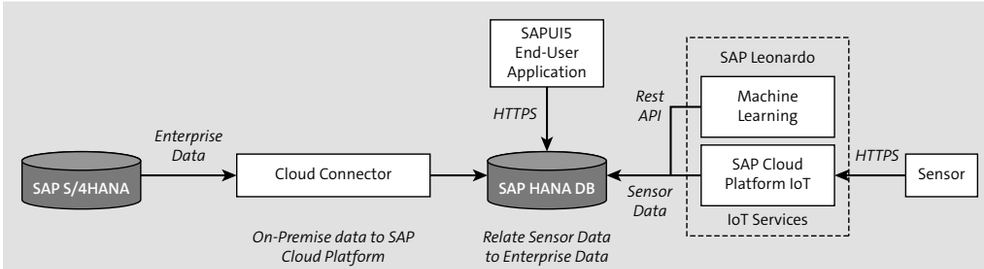


Figure 12.12 SAP S/4HANA IoT Extension Architecture

This kind of extension will help you onboard and manage your sensors and the data coming from them. You will be able to access the SAP Cloud Platform Cockpit to perform the following activities:

- Replicate on-premise data to SAP Cloud Platform using SAP Cloud Connector through destination configuration.
- Set up IoT message types and device types and register sensor devices.
- Bind IoT services to SAP HANA.
- Create HTTP destinations for IoT services and SAP HANA data services.
- Set up HTTP destinations to access machine-learning services.
- Consume on-premise data from SAP HANA databases on SAP Cloud Platform.
- Apply appropriate SAP Leonardo machine-learning REST-based services from SAP Cloud Platform API Business Hub to add intelligence on top of regular business logic.
- Develop UI extensions with SAPUI5 using SAP Web IDE to display the necessary business data.
- Integrate your extension into SAP Fiori launchpad.

12.5 Summary

In this chapter, we discussed the extension possibilities for future SAP solutions and covered how SAP S/4HANA can be extended via in-app and side-by-side extensions. We also took a detailed look at the strategy and purpose of both extension possibilities. We outlined possible side-by-side scenarios to illustrate the different options available via SAP Cloud Platform, including SAP Leonardo on SAP Cloud Platform, which is the latest digital transformation system from SAP and which supports IoT and machine learning. Finally, we took a quick look at SAP Leonardo.

Contents

Foreword from Uwe Grigoleit 19
Foreword from Cameron Art 21
Preface 23

1 The Digital Transformation: An Introduction 29

1.1 Defining the Digital Transformation 30
1.2 Business Value Scenarios 36
1.2.1 Customer Centricity and Experience 39
1.2.2 Customer Insight and Improved Decision-Making 46
1.2.3 Digitally Enabled Supply Chain 50
1.3 Architecture at a Glance 55
1.4 Summary 60

2 Finance 61

2.1 Industry Pain Points and SAP S/4HANA Benefits 61
2.1.1 Integration of Information 62
2.1.2 Enterprise Cost Reductions 64
2.1.3 Measuring Business Performance 64
2.1.4 Optimize Planning, Budgeting, and Forecasting 66
2.1.5 Continuous Finance Process Improvements 66
2.1.6 Provide Inputs to Enterprise Strategy 67
2.1.7 Develop Talent in the Finance Organization 68
2.2 Key Functionalities 70
2.2.1 Universal Journal 70
2.2.2 Material Ledger and Transfer Pricing 74
2.2.3 New Asset Accounting 78
2.2.4 Cash Management 79

2.2.5 SAP BPC for SAP S/4HANA Finance 82
2.2.6 Profitability Analysis 86
2.2.7 Central Finance 92
2.2.8 Real-Time Data and Soft Close 100

2.3 Outlook 102

2.4 Summary 104

3 Manufacturing 105

3.1 Industry Pain Points and SAP S/4HANA Benefits 105

3.2 Key Manufacturing Functionality 110
3.2.1 MRP Live 110
3.2.2 Product Master Optimization 113
3.2.3 Embedded Production Planning and Detailed Scheduling 114
3.2.4 Complex Manufacturing 115
3.2.5 Demand-Driven MRP 116
3.2.6 General Process Optimization/Simplification 116

3.3 Outlook 118

3.4 Summary 119

4 Supply Chain 121

4.1 Industry Pain Points and SAP S/4HANA Benefits 121

4.2 Key Supply Chain Functionality 125
4.2.1 Data Model Simplification 125
4.2.2 Simplified Inventory Valuation 126
4.2.3 Embedded EWM 127
4.2.4 Transportation Management 135

4.3 Outlook 137

4.4 Summary 138

5 Sales, Marketing, Commerce, and Service Management 139

5.1 Industry Pain Points and SAP S/4HANA Benefits 139

5.2 Key Sales Functionality 142
5.2.1 Data Model Simplification 142
5.2.2 Sales Order Fulfillment Cockpit 144
5.2.3 Condition Contract Settlement 145
5.2.4 Advanced ATP 146
5.2.5 General Process Optimization/Simplification 153

5.3 Key Marketing and Commerce Functionality 154
5.3.1 Customer Relationship Management 155
5.3.2 SAP Billing and Revenue Innovation Management 156

5.4 Key Service Management Functionality 157
5.4.1 Optimized Service and Service Master Data Management 157
5.4.2 Service Parts and Service Agreement Management 158

5.5 Outlook 158

5.6 Summary 159

6 Sourcing and Procurement 161

6.1 Industry Pain Points and SAP S/4HANA Benefits 161

6.2 Key Sourcing and Procurement Functionality 164
6.2.1 Operational Purchasing 164
6.2.2 Invoice and Payables Management 169
6.2.3 Sourcing and Contract Management 170
6.2.4 Supplier Evaluation and Analytics 171

6.3 Outlook 173

6.4 Summary 173

7 Research and Development and Asset Management 175

7.1 Industry Pain Points and SAP S/4HANA Benefits ... 176

7.2 Key Research and Development Functionality ... 178
- 7.2.1 SAP Innovation Management ... 178
- 7.2.2 SAP Portfolio and Project Management ... 179
- 7.2.3 SAP Commercial Project Management ... 180
- 7.2.4 SAP Product Lifecycle Costing ... 180

7.3 Key Asset Management Functionality ... 181
- 7.3.1 Maintenance Planning and Scheduling ... 181
- 7.3.2 Maintenance Operation and Execution ... 182
- 7.3.3 Mobile Asset Maintenance ... 182

7.4 Outlook ... 183

7.5 Summary ... 185

8 Industry Solutions 187

8.1 Retail ... 187
- 8.1.1 Technical Simplifications ... 188
- 8.1.2 Available Functionality ... 190
- 8.1.3 Removed and Nonstrategic Functionality ... 192
- 8.1.4 Retail Integration ... 193
- 8.1.5 SAP S/4HANA 1709 ... 193

8.2 Oil & Gas ... 195
- 8.2.1 Technical Simplifications ... 195
- 8.2.2 Upstream and Downstream ... 196
- 8.2.3 Trader's and Scheduler's Workbench ... 198
- 8.2.4 Transportation and Distribution ... 199
- 8.2.5 Secondary Distribution ... 200
- 8.2.6 SAP S/4HANA 1709 ... 200

8.3 Summary ... 201

9 SAP S/4HANA Architecture 203

9.1 The Journey from SAP ERP to SAP S/4HANA ... 203
- 9.1.1 The Evolution of SAP S/4HANA ... 203
- 9.1.2 SAP S/4HANA as the Digital Core ... 209
- 9.1.3 The Roadmap to SAP S/4HANA and Innovations ... 212

9.2 SAP HANA Platform ... 216
- 9.2.1 SAP HANA Database ... 216
- 9.2.2 Virtualization ... 220
- 9.2.3 Scalability ... 224
- 9.2.4 Recoverability ... 226
- 9.2.5 SAP HANA Operations ... 234
- 9.2.6 SAP HANA Logical Deployment Options ... 239
- 9.2.7 SAP HANA Platform Services ... 242

9.3 SAP S/4HANA Security ... 245

9.4 SAP S/4HANA Core Data Models ... 248

9.5 User Interface and User Experience ... 249

9.6 Data Lifecycle Management ... 253

9.7 DevOps ... 254

9.8 Summary ... 259

10 Deployment Options 261

10.1 Cloud Concepts ... 261

10.2 SAP S/4HANA Versions ... 264
- 10.2.1 On-Premise SAP S/4HANA ... 264
- 10.2.2 SAP S/4HANA Cloud ... 271
- 10.2.3 Hybrid Model ... 274

10.3 Cloud Vendor ... 275

10.4 Integration ... 277

10.5 Summary ... 278

11 SAP S/4HANA Cloud 281

11.1 Value Proposition 281

11.2 Current Scope of the Solution 283

11.3 Deployment 284

11.3.1 Fit-to-Standard 285

11.3.2 Deployment Resources 286

11.3.3 SAP Best Practices Explorer 290

11.3.4 Self-Service Configuration User Interface 291

11.4 Extensibility 291

11.5 Content Lifecycle Management 291

11.6 Summary 294

12 Extending SAP S/4HANA 297

12.1 Extensions for SAP 298

12.1.1 Overview 298

12.1.2 In-App Extensibility 301

12.1.3 Side-by-Side Extensibility 303

12.2 SAP Cloud Platform 308

12.3 Internet of Things and Cognitive Analytics 312

12.4 SAP Leonardo and Machine Learning 314

12.5 Summary 319

13 Adopting SAP S/4HANA 321

13.1 New Implementation Options and Approach 323

13.1.1 Business Scenario Recommendations 323

13.1.2 SAP S/4HANA Value Advisor 324

13.1.3 SAP S/4HANA Transformation Navigator 325

13.1.4 Getting Started 326

13.1.5 Sizing Requirements 326

13.1.6 SAP S/4HANA Implementation Guidelines 327

13.2 System Conversion Options and Approach 329

13.2.1 Scenarios 330

13.2.2 Adoption Paths 330

13.2.3 Tools for System Conversion 333

13.2.4 Code Remediation, HANAtization, and Optimization 339

13.2.5 Application-Specific Conversion Steps 344

13.3 SAP S/4HANA Conversion Prerequisites 345

13.3.1 SAP S/4HANA Transformation Considerations 346

13.3.2 SAP S/4HANA Application Prerequisites 347

13.3.3 SAP S/4HANA Functional Restrictions 348

13.4 Housekeeping Activities 354

13.5 System Conversion Considerations 356

13.5.1 Greenfield Implementation 356

13.5.2 Brownfield Implementation 358

13.6 SAP S/4HANA Migration Cockpit 360

13.6.1 On-Premise SAP S/4HANA 361

13.6.2 SAP S/4HANA Cloud 363

13.7 Tools and Techniques for Minimizing Downtime 364

13.7.1 Data Volume Management 365

13.7.2 Optimizing Database Migration Option Performance 365

13.7.3 Near-Zero Downtime 366

13.8 Summary 368

14 Using SAP Activate 369

14.1 SAP Activate Overview 369

14.2 SAP Activate Methodology 374

14.2.1 Prepare 375

14.2.2 Explore 376

14.2.3 Realize 377

14.2.4 Deploy 378

14.2.5 Quality Gates 379

14.3 SAP Best Practices for SAP Activate 380

14.4 SAP Activate Tools 384

14.4.1 Self-Service Configuration 385

14.4.2 Expert Configuration 386

14.4.3 SAP Solution Builder Tool 386

14.4.4 SAP Solution Manager 387

14.5 Summary 387

15 SAP S/4HANA and the SAP Landscape 389

15.1 Sourcing and Procurement: SAP Ariba 390

15.1.1 Sourcing and Contracts 390

15.1.2 Requests and Purchases 392

15.1.3 Invoices and Payments 394

15.1.4 SAP Ariba and SAP S/4HANA 396

15.2 Contingent Workforce Management: SAP Fieldglass 398

15.2.1 Vendor Management System 399

15.2.2 SAP Fieldglass and SAP S/4HANA 400

15.3 Travel and Expense Management: Concur 401

15.3.1 Spend Management 401

15.3.2 Concur and SAP S/4HANA 402

15.4 Human Resources: SAP SuccessFactors 402

15.4.1 Employee Data 403

15.4.2 Talent Management 403

15.4.3 SAP SuccessFactors and SAP S/4HANA 406

15.5 Customer Relationship Management: SAP Hybris 408

15.5.1 Commerce 409

15.5.2 Marketing 410

15.5.3 Revenue and Billing 412

15.5.4 Sales and Service 414

15.5.5 SAP Hybris and SAP S/4HANA 414

15.6 Master Data Management: SAP Master Data Governance 415

15.7 Supply Chain Planning: SAP Integrated Business Planning 417

15.7.1 Sales and Operations Planning 417

15.7.2 Demand Planning 419

15.7.3 Inventory Planning 419

15.7.4 Response and Supply Planning 420

15.7.5 Control Tower 422

15.7.6 SAP IBP and SAP S/4HANA 423

15.8 Summary 423

16 Analytics and Reporting 425

16.1 Evolution of Analytics 426

16.2 Operational Reporting 429

16.2.1 ABAP-Based Reports 430

16.2.2 Embedded Analytics 430

16.2.3 Native SAP HANA Applications 435

16.2.4 Embedded SAP BW and SAP BPC 436

16.3 Enterprise-Wide Reporting 438

16.3.1 SAP HANA Enterprise Analytics 439

16.3.2 SAP Business Warehouse on SAP HANA 439

16.3.3 SAP BW/4HANA 441

16.3.4 SAP Analytics Cloud 442

16.4 Cognitive Analytics 442

16.5 Big Data Analytics and Data Lakes 444

16.5.1 Data Lake 444

16.5.2 SAP Vora 447

16.6 Summary 448

17 Building a Transformation Roadmap 449

17.1 Envisioning the What and the Why 451

17.1.1 Digital Transformation 451

17.1.2 Business Value ... 458
17.1.3 Making the SAP S/4HANA Case ... 458

17.2 Developing Your Roadmap ... 462
17.2.1 Engage Phase: Analyzing the Current Mode of Operations ... 465
17.2.2 Envision Phase: Exploring the Target Operational Model ... 466
17.2.3 Evaluate Phase: A Deep Dive into the Transformation Approach ... 467
17.2.4 Enable Phase: Build Your Roadmap ... 467

17.3 Understanding the Current Mode of Operations ... 468
17.3.1 Pain Points ... 468
17.3.2 Objectives ... 469
17.3.3 Approach ... 469

17.4 Defining the Future Mode of Operations ... 471
17.4.1 Considerations ... 471
17.4.2 Approach ... 471

17.5 Choosing How to Adopt SAP S/4HANA ... 474
17.5.1 Evaluate Phase ... 474
17.5.2 Enable Phase ... 475

17.6 Summary ... 476

18 Customer Case Studies ... 477

18.1 Multinational Industrial Company ... 477
18.1.1 Vision ... 479
18.1.2 IT Project ... 480
18.1.3 Benefits ... 480
18.1.4 Path Forward ... 481

18.2 Multinational Service Company ... 482
18.2.1 Vision ... 483
18.2.2 IT Project ... 483
18.2.3 Benefits ... 483
18.2.4 Path Forward ... 486

18.3 Manufacturing Company ... 486
18.3.1 Vision ... 487
18.3.2 IT Project ... 487

18.3.3 Benefits ... 488
18.3.4 Path Forward ... 489

18.4 Food Industry Group ... 489
18.4.1 Vision ... 489
18.4.2 IT Project ... 490
18.4.3 Benefits ... 491
18.4.4 Path Forward ... 491

18.5 Automotive Company ... 491
18.5.1 Vision ... 491
18.5.2 IT Project ... 492
18.5.3 Benefits ... 492
18.5.4 Path Forward ... 492

18.6 Summary ... 493

The Authors ... 495
Index ... 499

Index

A

ABAP 70, 487
ABAP Development Tools (ADT) 303
ABAP Test Cockpit 340
ABAP-based reports 430
Account-based CO-PA 73, 86–87, 90, 480
Accounts Payable (AP) 169, 481
Accounts Receivable (AR) 481
Accounts receivable manager 48
Actionable insights 428
Adobe Document Server 168
Adobe Forms 168
Adoption scenario 451, 473
Adoption strategy 215
Advanced analytics 449
Advanced ATP (AATP) 146
Advanced DataStore object (ADSO) 441
Aggregate table 249
Agile implementation method 372
ALE technologies 416
Analysis Path Framework (APF) 432
Analytical app 248, 250
Analytical landscape 428
Analytics 210, 425, 458
Application enablement 313
Application layer 248
Application lifecycle management (ALM) 203, 365, 475
Application programming interfaces (APIs) 407
Application rationalization 445
Application services 242
Archiving 355
Ariba Network 162, 167, 169, 391–392, 397
ASAP methodology 370
Asset Accounting 78, 344
Asset maintenance mobility 182
Asset management 175, 486
  challenges 177
  key functionality 181
  outlook 184
Asset networks 185
Asset resource scheduling 181
Asset strategy 184
Assign Product to Product Allocation app 152
Asynchronous 232
Atomicity consistency isolation durability (ACID) transactions 243
Auctions 392
Audit logging 247
Authentication 246
Automated Test Tool app 290
Available to promise (ATP) 109–110, 123
  check 153

B

B2B2C 412
Backorder processing (BOP) 147
Backup and recovery 227
BAdI 92
Bank Account Management 79
Bank Account Management Lite 80
Bank Accounting (FI-BL) 79
Bank automation 396
Batch data communication (BDC) 339
Batch processing 101
Big data 33–34, 50, 321, 389, 444, 452–453, 458
Bill of materials (BOM) 115
Billing 412
Blockchain 309
Bring your own language (BYOL) 310
Brownfield implementation 358
Build SAP Like a Factory 235
Building block 383
Bundles 412
Business Function Library 249
Business model 30, 457
  traditional 31
Business partner 163, 169, 189
  addresses 189
Business performance 64, 68
Business process 458

Business process as a service (BPaaS) 32, 263
Business Process Model and Notation (BPMN) 387
Business Rule Framework plus (BRFplus) ... 168
Business rules 94
Business scenario recommendations report 38, 323
Business to consumer (B2C) 453
Business value 36
Business-to-business (B2B) 408, 410
payments 396
Business-to-consumer (B2C) 408, 410

C

Capacity planning 106, 112
Capacity requirements 64
Career development planning 405
Case study 477, 482, 486, 489
Cash flow analysis 65
Cash Management 65, 79–80
Cash Operations 80
Catalog 392
Catalog management 392
Catch weight management 191
CDS views 430, 433
Central Finance 92–93, 97, 103, 360, 416, 479, 481
lift and shift 100
reconciliation reports 96
unified system 99
Central Journal 480
Change management 490
Change Request Management (ChaRM) 258
Cleansing 355
Cloud adoption 271
Cloud computing 32, 452
Cloud computing reference architecture ... 261
Cloud Foundry 310
Cloud readiness 271
Cloud vendor 275
Cloud-first strategy 60
Cluster manager 232
Code Inspector 337–338, 340, 343
Code optimization 329, 340
Code pushdown 143, 441
Code remediation 339
Coding block 71
dimension 72
measure 72
Cognitive analytics 442–443
Cognitive computing 34, 427, 452–453, 458
Collaboration 140
Collaboration and activity management 172
Column partition 219
Columnar storage 216, 484
Columnar structure 219
Commerce 139
Common Object Layer Framework 156
Complex manufacturing 115
Compliance 401
Component business model (CBM) 473
CompositeProviders 441
Compressed data 217
Concur 47, 212, 396
Concur Data Insights 402
Concur Expense 401
Concur Invoice 401
Concur Travel 401
Condition contract settlement 145
Configure BOP Segment app 147
Configure BOP Variant app 147
Configure Product Allocation app 152
Consolidation 416, 478
Content lifecycle management 291
Contingent workforce management 398
Continuous improvement 183
Contract Accounts Receivable and Payable (FI-CA) 156
Contract lifecycle management 392
Contract Line Item app 170
Contract management 170, 392
Contract repository 392
Contract worklists 162
Contracts 412
Core Data Service (CDS) view 57, 210, 249, 327
Core Data Services (CDS) view 204
ABAP-based 204
Cost Center Accounting 66
Cost component 89
Cost of goods sold (COGS) 71
posting 88

Costing-based CO-PA 87
Costs 215
Country regulatory templates 402
CPU utilization 242
Create Optimal Orders for Shipment app ... 114
Create Purchase Requisition app 167
Current mode of operations (CMO) ... 449, 465, 468–469, 475
Custom code 346
Custom code migration worklist 338
Custom code remediation 197
Custom Fields and Logic app 302
Customer centricity 39
Customer engagement 410
Customer engagement executive (CEE) 292
Customer insight 46
Customer journey 410
Customer orders 140
Customer relationship management 408
Customer ticketing system 409
Customer/vendor integration 169, 189
Cutover 378

D

Dangerous goods 131
Dashboards 68
Data acquisitions 426
Data aging 253
Data collation 200
Data Dictionary (DDIC) 339
Data exploration 426
Data flow 478, 491
Data footprint 46
Data foundations 426
Data harmonization 97
Data integration services 243
Data lake 444–445
Data lifecycle management 253
Data migration 371
Data migration strategy 328
Data model 203
Data model simplification 142
Data redundancy 128, 131, 487
Data replication 305
Data Replication Framework 416
Data selection 216
Data synchronization 409
Data temperature 442
Data tiering 442
Data volume 215
Data volume management (DVM) 365
work center 365
Database hint 341
Database layer 248
Database migration option 365
Database Migration Option (DMO) 335
Software Update Manager (SUM) 332
Database Shared Library (DBSL) 232
Database size 268
Days payable outstanding (DPO) 395, 485
Days sales outstanding (DSO) 395
Decentralized SAP EWM 131
Decision Wizard 399
Delivery request (notification) 131
Delivery schedules 117
Dell Boomi 278
Delta shipping 232
Demand-driven MRP 116
Deployment path 321
Depooling/declustering 342
Depreciation posting 78
Descriptive reporting 426
Design thinking 33, 474
Device personalization 414
DevOps 254, 259, 457
Digital backbone 46
Digital core 209, 389, 452, 456
Digital strategy 35
Digital transformation 29, 31, 37, 389, 450–451, 454, 472
definition 31
objectives 35
strategy 450
Disaster recovery (DR) 270
Discontinuation 112
Discount management 395
Discrete Industry Mill Products (DIMP) 58
Dispute case 65
Disruption 480
Document Relationship Browser 95
Domain Names Service (DNS) 232

Drilldowns 50
Drivers 450
Dunn & Bradstreet (D&B) 172
Dynamic data tiering 253
Dynamic tiering 245, 254

E

Electronic data interchange (EDI) 350
Embedded analytics 430, 437, 490
architecture 430
Embedded SAP BW 436
Embedded SAP EWM 127, 131, 134, 138
Employee data 403
Employee suggestion box 183
Enable phase 464, 467
Encryption 247
End of life (EOL) 213
End user training 378
Engage phase 464–465
Enterprise Search 166
Enterprise-wide reporting 425, 438
Envision phase 464, 466
Evaluate phase 464, 467, 474
Event scheduling 157
Exception handling 169
Execute phase 464
Expected goods receipt (EGR) 131
Expert configuration 384, 386
Extended production operations 115
Extensibility Cockpit 291

F

Fact sheet app 248, 250
Fashion management wholesale 193
Feature Package Stack (FPS) 336
Field service 158
Financial architecture 478
Financial Closing app 102
Financial Closing Cockpit 67
Financial reporting 101–102, 480, 483
Financial standards 490
Financial statement 65
Fit/gap workshop 377, 382
Fit-to-standard 285
Focused Build 256
Foreign trade/customs 141, 154
Freight order management (FOM) 134
Functional core 107
Future mode of operations (FMO) 449, 465, 468, 475
Future-proofing 213

G

Gartner pace-layered application strategy 452, 456
Generally accepted accounting principles (GAAP) 126
Geospatial processing 312
GitHub repository 258
Global benefits 403
Global filter 149
Global master data 478
Goods receipt (GR) 122
Google 30
Governance 297, 478
Graph engine modeling 312
Greenfield implementation 213, 356, 468
Guided configuration 291

H

Hadoop 243, 428, 445
HANAtization 329, 339
Hard close 480
Hardware 213
High availability (HA) 227, 270
HP Quality Center 258
Hub model 416
Human capital management 406
Hybrid adoption 272
Hybrid Application Toolkit 311
Hybrid cloud 263, 274
Hypercare 378

I

IBM Ascend 464
IBM Better Transformation framework 463, 465, 468, 476
IBM's Watson Developer Cloud 313
Idea generation 178
Identity store 246
IDoc 170
In-app extensibility 300–301, 306
Inbound delivery 133
Industry solutions 187, 210
InfoCubes 84, 440
InfoProviders 437
Infrastructure 215, 269
Infrastructure as a service (IaaS) 32, 262, 264
Initial investment 273
In-memory columnar storage 53
Insert updates 217
Inspection process 133
Instance number 231
Integration-as-a-service 407
Intercompany reconciliation 102, 478, 480
Interim modes of operation (IMO) 465, 475
Internal collaboration 172, 410
Internal Orders 66
International Federation of Robotics (IFR) 29
International Financial Reporting Standard 15 (IFRS 15) 154
Internet of Everything (IoE) 34
Internet of Things (IoT) 29, 33, 46, 50, 105, 452–453
services 312
Inventory 488
Inventory data 487
Inventory level 123
Inventory management 122, 137
Inventory Management (IM) 50
Inventory planning 121
Inventory Planning Workbench 198
Inventory posting 122
Inventory valuation 124
Inventory valuation table 76, 126
Invoice 169
Invoice automation 395
Invoice processing 394
Invoice reconciliation 395
Invoicing 390, 412

J

J2EE 399

K

Key performance indicator (KPI) 164, 227, 390, 433
Key user approach 301
KPI Modeler 431

L

Lack of visibility 161
Landscape transformation 321, 371
Learning management 404
Legacy system 378
LE-TRA 135
Licensing model 264
Line of business (LoB) 486
solutions 47, 389
Liquidity forecast 65
Liquidity Management 81
Live replication mode 231
Local ledgers 479
Logical partitioning (LPar) 267
Logistic service provider 128
Logistics 50
Logistics execution 137
Logistics Information System (LIS) 59, 350
Logistics invoice verification (LIV) 169
Log-replay 232
Long material number (LAMA) 58
LSA++ 440

M

Machine learning 315
Maintenance execution 184
Maintenance operation and execution 182
Maintenance Optimizer 334
Maintenance plan 182
Maintenance planner 334
Maintenance planning 184
Make-to-stock 116

Manage Material Coverage app 111
Manage Product Allocation Planning Data app 152
Manage Purchase Contracts app 170
Manage Sources of Supply app 171
Manage Your Solution app 291
Manual purchase orders 166
Manufacturing 105
challenges 108
key functionality 110
outlook 118
Manufacturing engineering 115
Manufacturing for complex assembly 115
Mapping concept 416
Marketing 139
Marketing and commerce
key functionality 154
outlook 159
Master data 194
Master data maintenance 157
Master filter 149
Material document 125
Material flow 108, 113
Material Ledger (ML) 59, 124, 126, 190
Material master 191
Material master data 117
Material master record 117
Material number 113
Material requirements planning (MRP) 106, 113, 191, 487–488
MRP area 117
MRP area level 109
MRP run 108, 112
Materials Management (MM) 52
Measurement documents 182
Merchandise management 194
Message management services 313
Metadata Framework (MDF) 403
Metadata management 445
Microsoft Silverlight UI 135
Migration timelines 346
Minimum viable product (MVP) 378
Mobile 32, 449, 452
Model company 375
Monitor BOP Run app 147
Month-end close 478, 483–484
MRP Cockpit 108–109, 111
MRP Dispatcher 111
MRP Live 110, 113
Multidimensional reports 431
Multinationals 477
Multiple components in one database (MCOD) 267
Multiple components on one system (MCOS) 267
Multiple Components One Database (MCOD) 239
Multiple Components One System (MCOS) 239–240
Multiple ERP systems 481
Multiple valuation 74
Multitarget application archive 258
Multitenant architecture 312
Multitenant Database Container (MDC) 239–240
My Purchase Requisitions app 167

N

Native SAP HANA applications 435, 439
Native SQL 341
Near-Zero Downtime (NZDT) 366
Network 224
New business models 455
New implementation 321, 323, 371
Nomination Planning Workbench 198
Nonfunctional requirements 269
Nonuniform memory access (NUMA) 244
Notices 393

O

OData services 252, 305
Omnichannel service 414
Onboarding 404
Online analytical processing (OLAP) 37, 107, 162, 203, 210, 243
Online transaction processing (OLTP) 37, 107, 162, 203, 210, 243
Open Group architecture framework (TOGAF) 462
Open innovation 183
Open ODS views 441
Operational intelligence 312
Operational purchasing 164
Operational reporting 425, 429, 480, 487
Optical character recognition (OCR) 169
Order cockpit 488
Order fulfillment 144
Order routing 393
Organizational data 403
Output management 168

P

Pain points 458, 468
Parallel currencies 74, 76
Parallel processing 218
Parallel valuation 75–76
Parallelization 112
Partitioning 217–218
Payables processing 485
Payments 390
Payroll 403
Performance and goals management 404
Periodic actual cost 75, 77
Platform as a service (PaaS) 32, 262
Pool and cluster table 342
Position management 403
Post Goods Receipts app 167
Predictive analytics 427
Predictive Analytics Library 313
Predictive modeling 426
Prepackaged integrations 407
Prescriptive modeling 426
Pricing policies 412
Principle of one 37, 55, 58, 126
Private cloud 263, 273
Process KPIs 416
Process model 256
Process Receivables app 65
Processing services 243
Procurement 390
Procure-to-pay 162
Product allocation 151
Product Costing (CO-PC) 74
Product engineering 181
Product master data 113
Product valuation data 130
Production planning 105
Production Planning and Detailed Scheduling (PP/DS) 114, 489
Production variance 91
Production version 117
Profit and loss (P&L) 67, 98
Profit Center Accounting 66
Profitability Analysis (CO-PA) 66, 73, 86
Project stock 130
Promises-to-pay 65
Public cloud 263, 274
Purchase Contract app 170
Purchase order 162
Purchase order average time 165
Purchases 390, 392
Purchasing contract 117
Purchasing info record 117

Q

Quality check 236
Quality Inspection Engine 133
Quality management 138
Quality services 243
Query Browser 210, 433
Query Designer 210
Quick Sizer 326
Quota arrangement 117
Quotations 412

R

Rapid-deployment solution (RDS) 397
Readiness Dashboard 256
Real-time alert 110
Real-time analytics 164
Real-time data 100, 140, 458
Real-time processing 49
Real-time visibility 113
Rebate settlement 146
Rebates 143
Receivables 64
Recoverability 226
Recovery point objective (RPO) ... 227, 232, 270
Recovery time objective (RTO) 227, 232, 270

Recruiting management 403
Recruiting marketing 403
Redundant data 134
Regional Inventory Dashboard 198
Regulatory compliance 266, 272
Release for Delivery app 152
Remote device management 313
Replenishment 114, 191
Report R_S4_PRE_TRANSITION_CHECKS 336, 357
Reporting 425
Representational State Transfer (REST) 252
Requests 390, 392
Requests for information (RFI) 390, 392
Requests for proposal (RFP) 390, 392
Requests for quotation (RFQ) 170, 390, 392
Requirement classification 148
Requirements Management 257
Requisitions 399
Research and development (R&D) 175
key functionality 178
outlook 183
Resource schedule 114
Response planning 421
Responsive user experience 107
Responsiveness 269
RESTful APIs 316
Retail article 190
Revenue recognition 154
RFx 391, 399
Roadmap 449
Roadmap creation 470
Role management 246
Role-based UI 250
Row storage 216
Run SAP Like a Factory 236

S

Safety stock 52
Sales 118, 139
challenges 140
key functionality 142
outlook 159
Sales and Distribution (SD) 249
Sales order 140
Sales order fulfillment cockpit 140, 144
SAP Activate 235, 369, 372, 464
deploy phase 378
discover phase 286
explore phase 287, 376
guided configuration 369, 384
methodology 369, 374
model companies 383
prepare phase 287, 375
realize phase 288, 377
Roadmap Viewer 284
SAP Best Practices 369, 380–381
SAP Best Practices content 382
SAP Best Practices SAP Notes 381
template 373
tools 384
SAP Administration Guide for the Implementation of SAP S/4HANA 382
SAP Analysis for Microsoft Office 98, 437
SAP Analytics Cloud 428, 442
SAP API Business Hub 316
SAP Application Interface Framework 100
SAP Ariba 39, 47, 163, 304, 370, 390, 400, 473, 488
SAP Ariba Collaborative Supply Chain 393
SAP Ariba Discount Professional 395
SAP Ariba Invoice Management 395
SAP Ariba Procurement Content 397
SAP AribaPay 395–396
SAP Asset Intelligence Network 177
SAP Asset Manager 182
SAP Assortment Planning for Retail 192
SAP Best Practices 357, 376
SAP Best Practices Explorer 285, 290
SAP Biller Direct 156
SAP Billing and Revenue Innovation Management 155–156
SAP BPC for S/4HANA Finance ... 66, 68, 83, 479
SAP Build 311
SAP Business Explorer (SAP BEx) 436
SAP Business Planning and Consolidation (SAP BPC) 436
SAP Business Suite 309, 370
SAP Business Suite on SAP HANA 204, 214, 483
SAP Business Warehouse (SAP BW) 59,64, 204, 438, 478, 483

SAP Business Warehouse on SAP HANA 439
SAP BW on SAP HANA 215, 274
SAP BW/4HANA 428, 441, 462
SAP Cash Management powered by SAP HANA 344
SAP Cloud Appliance Library 277
SAP Cloud Connector 318
SAP Cloud Platform 46, 209, 212, 252, 258, 284, 308, 310, 403, 407, 415, 454, 457, 465
SAP Cloud Platform Integration 168, 407
SAP Cloud Platform Web IDE 311
SAP Collections Management 103
SAP Commercial Project Management 180
SAP Commodity Management 201
SAP Credit Management 103, 141, 154
SAP Crystal Reports 68
SAP Customer Activity Repository 191–193, 410
SAP Customer Relationship Management (SAP CRM) 155, 370, 413, 465
SAP DB Control Center 235
SAP Dispute Management 103
SAP EarlyWatch Alert 236, 470
SAP Enterprise Architecture Explorer 470, 473
SAP Enterprise Support 292
SAP ERP 55, 62, 332
SAP ERP Sales and Distribution (SD) 413
Credit Management 154
SAP ERP Warehouse Management (WM) 127
SAP EWM
batch master 129
business partner 129
decentralized 127
material master 129
SAP EWM embedded in SAP S/4HANA 210, 489
SAP Fashion Management 187
SAP Fieldglass 39, 46, 212, 398
SAP Financial Services Network 212, 278
SAP Financial Supply Chain Management (SAP FSCM) 79
SAP Fiori 39, 41–42, 65, 79, 110, 194, 203, 275, 327, 385, 416, 474, 480
analytical apps 433
analytics apps 123
SAP Fiori (Cont.)
fact sheet apps 123
transactional apps 122
UX 456, 458
SAP Fiori app 247, 249
reference library 42
SAP Fiori Cloud 209, 252
SAP Fiori launchpad 81, 129, 433
SAP for Retail 189, 192
SAP Forecasting and Replenishment for Retail 191
SAP Gateway 57, 209, 278
SAP General Ledger (G/L) 344, 481
SAP Global Trade Services (SAP GTS) 128, 141, 154
SAP GUI 42, 45
SAP HANA 203, 268, 456, 460
SAP HANA authorization 246
SAP HANA Cockpit 234, 258
SAP HANA database 217
SAP HANA database layer 205
SAP HANA E5 systems 224
SAP HANA Enterprise Cloud 276
SAP HANA host auto-failover 229
SAP HANA Live 68, 204, 435, 456
views 204
SAP HANA multitenant database containers (MDC) 267
SAP HANA on Power 219, 224
SAP HANA platform 216, 247
SAP HANA queries 143
SAP HANA Readiness Assessment 469–470
SAP HANA smart data integration (SDI) 278
SAP HANA storage replication 228
SAP HANA Studio 234
SAP HANA system replication 230
SAP HANA views 439
SAP HANA Web-Based Development Workbench 311
SAP HANA, spatial edition 245
SAP Hybris 37, 46, 155, 408, 414, 473
SAP Hybris Billing 141, 408, 412
SAP Hybris Cloud for Customer 39, 298, 370, 408, 414–415, 465
SAP Hybris Cloud for Sales 414
SAP Hybris Cloud for Service 414

SAP Hybris Commerce 193–194, 408–409, 412
SAP Hybris Commerce Cloud, data hub 194
SAP Hybris Marketing 408, 410, 412, 414
SAP Hybris Marketing Acquisition 411
SAP Hybris Marketing Data Management 410
SAP Hybris Marketing Insight 411
SAP Hybris Marketing Loyalty 411
SAP Hybris Marketing Planning 411
SAP Hybris Marketing Recommendation 411
SAP Hybris Marketing Segmentation 411
SAP Hybris Profile 411
SAP Hybris Service Cloud 184
SAP IBP for demand 419
SAP IBP for inventory 419
SAP IBP for response and supply 420
SAP IBP for sales and operations 418
SAP Information Lifecycle Management (SAP ILM) 355
SAP Innovation Management 176, 178
SAP Integrated Business Planning (SAP IBP) 109, 417, 465
SAP Integrated Business Planning for demand 201
SAP Inventory Manager 182
SAP Jam 278, 379
SAP Journey Maps 470, 473
SAP Landscape Management 238
SAP Landscape Transformation (SLT) 435
SAP Landscape Virtualization Management 238
SAP Leonardo 308, 428, 443, 454
SAP Leonardo IoT Bridge 314
SAP Leonardo IoT Edge 315
SAP Leonardo IoT Foundation 315, 318
SAP Leonardo Machine Learning Foundation 315
SAP LT Replication Server 93–94
SAP Lumira Designer 98
SAP Master Data Governance (SAP MDG) 94, 177, 193, 415, 479
SAP Material Ledger 74
SAP MDG for Retail and Fashion Management by Utopia 193
SAP Merchandise Planning for Retail 192
SAP Mobile Asset Management 177
SAP Mobile Platform 327
SAP Multiresource Scheduling 181
SAP NetWeaver 7.4 205
SAP NetWeaver 7.5 338
SAP NetWeaver AS ABAP 206, 247
SAP Portfolio and Project Management 179
SAP Predictive Analytics 68
SAP Predictive Maintenance Services 177, 185
SAP Process Orchestration (SAP PO) 168, 212, 278, 407, 415
SAP Product Lifecycle Costing 180
SAP Rapid Deployment Solutions (SAP RDS) 376
SAP Receivables Management 485
SAP Revenue Accounting and Reporting ... 141, 154
SAP S/4HANA 51
adoption 321
analytics and reporting 425
architecture 55, 203, 328
benefits 105, 121, 139, 161, 176
business scenario analysis 460
business value 40
code adaption 357
data model 125
deployment 261
extending 297
housekeeping 354
industry limitations 348
integration 277
logistics limitations 349
precheck 336
reconciliation 64
source 117
sourcing logic 117
system conversion 356, 359
SAP S/4HANA 1709 193
SAP S/4HANA Cloud 41, 59, 265, 278, 281, 323, 363, 369, 371
content schedule 293
deployment 284
deployment resources 286
extensibility 291
industry solutions 284
languages 284

SAP S/4HANA Cloud (Cont.)
localizations 284
private option 271
release cycle 291
scope 283
trial 289
upgrade schedule 294
value proposition 281
SAP S/4HANA Cloud Content Library 290
SAP S/4HANA core 172, 203
SAP S/4HANA Enterprise Management 347
SAP S/4HANA Finance 44, 61, 483
benefits 61
data conversion 344
outlook 102
prechecks 367
talent development 68
SAP S/4HANA for fashion and vertical business 187, 194
SAP S/4HANA Migration Cockpit 360
standard objects 362
SAP S/4HANA Migration Object Modeler ... 361
SAP S/4HANA Oil & Gas 195
new table structure 195
technical simplifications 195
upstream/downstream 196
SAP S/4HANA Oil & Gas for hydrocarbon management 195
SAP S/4HANA Oil & Gas for retail fuel network operations 198
SAP S/4HANA Oil & Gas for upstream contracts management 197
SAP S/4HANA Oil & Gas for upstream operations management 197
SAP S/4HANA Oil & Gas for upstream revenue management 197
SAP S/4HANA Retail 188
integration 193
technical simplifications 188
SAP S/4HANA Retail for merchandise management 187
SAP S/4HANA security 245
SAP S/4HANA Supply Chain for secondary distribution 200
SAP Screen Personas 474
SAP Smart Business apps 431
SAP Smart Business Cockpit 210
SAP Solution Builder profile 386
SAP Solution Builder tool 383–384, 386
SAP Solution Manager 235, 257, 377, 384, 387
SAP SuccessFactors 39, 46, 298, 370, 400, 402, 473
SAP SuccessFactors Employee Central 403
SAP Supplier Lifecycle Management ... 162, 172
SAP Supplier Relationship Management (SAP SRM) 397
SAP Supply Chain Control Tower 422
SAP Supply Chain Management 370
SAP Transportation Management (SAP TM) 135
benefits 136
business partner 136
SAP Treasury and Risk Management (TRM) 104
SAP Upstream Operations Management 197
SAP UX Explorer 470, 473
SAP Vora 428, 447
SAP Web IDE 311
SAP Work Manager 182
SAPphone 200
SAPUI5 ..... 135, 249, 304
Savepoint 226
Scalability 224
Scale-out 225
Scale-up 222, 225
Schedule BOP Run app 147
Scheduler Workplace 181
Season Workbench 192
Segment definition 149
Self-service configuration 384–385
Self-Service Configuration User Interface (SSCUI) 289
Self-service procurement 166
Self-service requisitioning 165
Series data processing 312
Service agreement 158
Service agreement management 158
Service maintenance plan 157
Service management 139, 158
key functionality 157
outlook 159

Service parts 158
Service parts warehousing 158
Service task lists 157
Service-orientated architecture (SOA) 170
Services procurement 398, 400
Settlement Management 141
Shared enterprise storage 224
Side-by-side extensibility 303, 306
benefits 307
Sidecar 481
Simplification 36, 480
Simplification database 337
Simplification list 335
Simulation 49
Single data source 37
Single Sign-On 246
Single source of truth 62, 97
Single system 128
Site maintenance 189
Sizing guidelines 222
Sizing requirements 326
SmartOps 419
Social media 452
Soft close 64, 78, 100, 480
Software as a service (SaaS) 32, 214, 263, 271, 309
Software Logistics Toolset (SL Toolset) 347
Software Provisioning Manager (SWPM) 347
Software Update Manager (SUM) 335
Software-as-a-service (SaaS) 390, 392, 403
Solution finder 414
Solution stability 215
Solution validation workshop 377
Source list 117
Source list entry 117
Sourcing 390
Sourcing and procurement 109, 161, 170
challenges 162
key functionality 164
outlook 173
Special purpose ledger table 70
Spend analysis 391
Spot buy 393
Stack XML 334
Standard SAP code 339
Standby host 230
Stock 108, 123
Stock levels 116, 487
Storage location MRP 116
Strategic sourcing 392
Structure history 157
Subcontracting 109
Subcontracting demand 116
Subcontracting stock 116
Succession planning 405
Supplier activity management 172
Supplier discovery 391
Supplier evaluation 172
Supplier portfolio management 171
Supply alternatives 108
Supply chain 121
challenges 123
key functionality 125
outlook 137
routing 135
Supply chain execution 393
Supply planning 421
Synchronous 231
Synchronous in-memory 232
System conversion 321, 329, 371
tool 333
System identifier (SID) 231
System Landscape Optimization (SLO) 277, 367
System of record 50
System usage 43

T

Table
/SCWM/THUTYPE 131
ACDOCA ... 62, 70, 88, 100, 127, 209, 249, 491
ANLC 207
BKPF 249
BSAD 207
BSAK 207
BSEG 249
COSP 207
COSS 207
FAGLBSIS 207
FAGLSBSAS 207
GLT0 208
GLT3 208
MATDOC 54, 125, 249
MKPF 125
MLCD 208
MSEG 125
THUTYPE 131
Tailored data center integration (TDI) 223
Talent management 403, 407
Technical assessment 470
Technical limitation 352
Technology drivers 213
Text analysis 312
Text analytics 313
Third-party vendors in landscape 477
Time-off management 403
Top-down distribution 90
Total cost of ownership (TCO) 128, 213, 472, 479, 483, 488
Trade Promotion Management (TPM) 145
Trader's and Scheduler's Workbench 195, 198
Transaction
AJRW, AJAB 368
AS91 368
BP 189
FSH_SWB 192
KE28 90
SM_Workcenter 236
SOLAR_PROJECT_ADMIN 387
SPAU 339
SPDD 339
WRP1 191
WRP1R 191
Transaction usage 43
Transactional app 250
Transformation Navigator 460
Transport scheduling 136
Transportation and distribution 199
Transportation management 137
Travel expense 396
Two-tier ERP landscape 275
Two-tier model 282

U

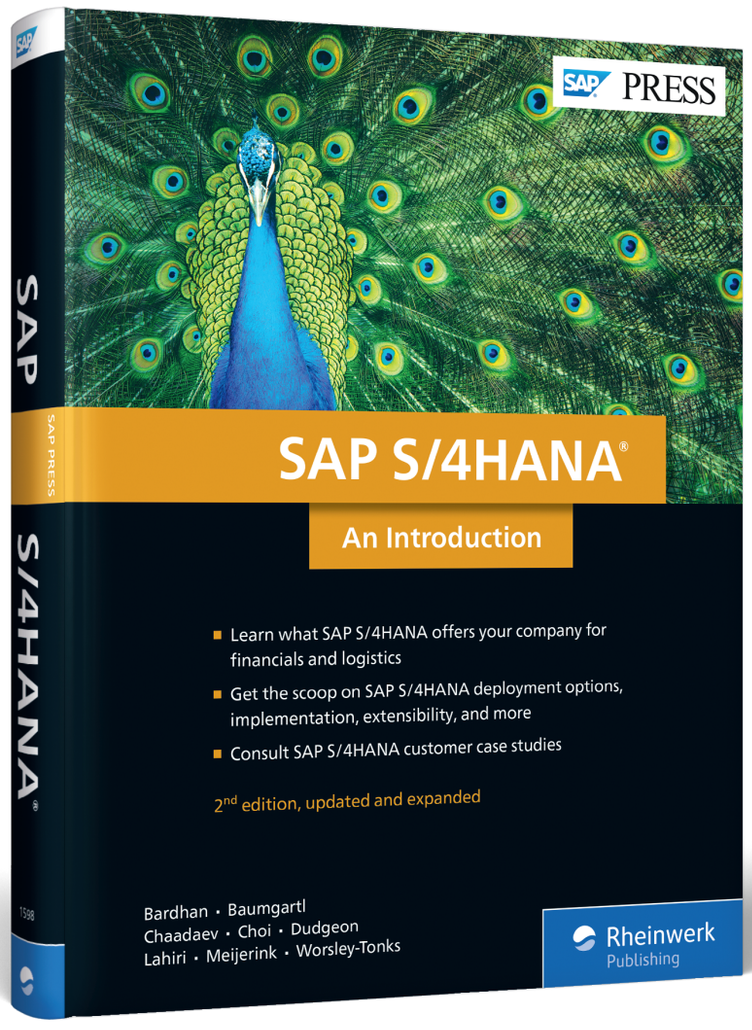
Unicode 354
Unicode conversion 332
Universal Journal 62, 68, 70, 73, 92, 209, 480
Unstructured data 34
UOM group 197
User experience (UX) 36, 321, 401, 453, 474, 480
design 37
User interface (UI) 452
User management 246
User provisioning 247

V

Valuation 90
Valuation methods 124
Vendor approvals 399
Vendor collaboration 109
Vendor Invoice Management (VIM) 169
Vendor management system (VMS) 398
Vertex 212, 278
Virtual data marts 441
Virtual data model (VDM) 204, 210, 433
Virtual machine (VM) 220, 267
Virtualization 220
Virtualization options 220
Visibility 108
Visualization 431
Volatility 108
VPRS condition 88

W

Waterfall implementation method 372
Web services 407
Whitelisted APIs 303
Workflows, reports, interfaces, conversions, enhancements, and forms (WRICEF) 288
Workforce analytics 405
Workforce planning 406
Workshop 327, 470
Write performance 217



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