PLATTFORM INDUSTRIE 4.0

DISCUSSION PAPER

Usage Viewpoint of Application Scenario Value-Based Service

In collaboration with

STANDARDIZATION COUNCIL INDUSTRIE 4.0

rri ロボット革命イニシアティブ協議会 Robot Revolution Initiative

VDI VDE VDI/VDE-Gesellschaft Mess- und Automatisierungstechnik

Imprint

Publisher
Federal Ministry for
Economic Affairs and Energy (BMWi)
Public Relations
10119 Berlin
www.bmwi.de

Text and editing
Plattform Industrie 4.0
Bertolt-Brecht-Platz 3
10117 Berlin

Design and production
PRpetuum GmbH, Munich

Status
February 2018

Print
MKL Druck GmbH & Co. KG, Ostbevern

Illustrations
Shutterstock – Zapp2Photo (title)
Shutterstock – piicoro (p. 4)
Shutterstock – Art24hrDesign (p. 6)
iStock – bluecinema (p. 10)

Zertifikat seit 2002
audit berufundfamilie

The Federal Ministry for Economic Affairs and Energy was awarded the audit berufundfamilie® for its family-friendly staff policy. The certificate is granted by berufundfamilie gGmbH, an initiative of the Hertie Foundation.

FSC
www.fsc.org
MIX
Paper from responsible sources
FSC® C108626

This publication as well as further publications can be obtained from:
Federal Ministry for Economic Affairs
and Energy (BMWi)
Public Relations
E-mail: publikationen@bundesregierung.de
www.bmwi.de

Central procurement service:
Tel.: +49 30 182722721
Fax: +49 30 18102722721

Content

Foreword

In the context of Industrie 4.0 and Connected Industries, on the one hand, there are quite detailed technical concepts and solution approaches available. On the other hand, there are often quite abstract and generic descriptions of the benefits for a user from these concepts and solutions. Thus, there is a need to better combine these two perspectives.

We like to thank the members of the working group "modeling examples" of VDI/VDE Society Measurement and Automatic Control (VDI/VDE-GMA) Technical Committee 7.21 "Industrie 4.0 – Terms, Reference Models and Architecture Concepts" and the "Use Case Task Force" in the International Standardization Action Group, Robot Revolution Initiative (RRI), for having taken this approach and the members of the working group "Research and Innovation" of the Plattform Industrie 4.0 for their contribution and open discussion. These activities are part of the Germany-Japan cooperation.

The presented elaboration is an important part for moving forward to close the gap, which is required to explain the benefits of technical concepts and solution approaches as well as to derive requirements for necessary standardization activities. And its results are supported by the strong committee of VDI/VDE GMA, the Plattform Industrie 4.0, and the Robot Revolution Initiative thanks to the open minded and integrating procedure chosen.

We also would like to thank the Standardization Council Industrie 4.0 (SCI4.0) for initiating and orchestrating the activities and partners within the project GoGlobal Industrie 4.0. This project strives for global harmonization and interlinkage of German Industrie 4.0-concepts with regional partnerships and strategic standardization development organizations.

Prof. Dr. Ulrich Epple
Johannes Kalhoff
Prof. Emeritus Dr. Eng. Fumihiko Kimura
Toru Ishikuma

Introduction

Background

In the context of Industrie 4.0 for some time now, the recognition is aware that – in addition to a technologically driven bottom-up approach – one must complement the topic of digitization in manufacturing industries[1] also by a top-down driven approach. In such a top-down approach the starting point are possible future business scenarios, from which more technically use case descriptions are derived. These use cases are the basis to derive new products, solutions, and services as well as standardization requirements.

In the context of the so-called "smart grids", this approach has already been used, where the use cases have been described based on the template proposed by IEC 62559-2, see [1]. However, the topic "smart grid" is much more focused with respect to possible business scenarios than the digitization of manufacturing industries. Therefore, a direct application of this template for the description of use cases seems not to be purposeful, because it requires upfront a too high depth of detail.

On the other hand, it is recognized that the application scenarios of Plattform Industrie 4.0, see [2] and [3], provide a representative overview of the new business opportunities in the context of the digitization in manufacturing industries. Therefore, need for action from a methodological point of view is less at the level of the business scenarios, but to now concretize these business scenarios from a technical user's point of view.

Objectives

It was therefore our goal to leave the level of business scenarios and to describe on a technical level in the form of use cases the interplay of actors with a technical system. We have set the scope of our consideration by a concrete application scenario of Plattform Industrie 4.0 – in particular the application scenario Value-Based Service, see [4]. We are not concerned with the description of a concrete manifestation in the form of a project, but with a description of general principles and concepts.

1 Our understanding of "manufacturing industries" is according to code C of ISIC, see www.isic.org. This includes discrete manufacturing as well as process industries.

Our goal was to find a suitable level of abstraction for the description of the use cases under the following boundary conditions:

- Understandable for persons outside of the author team
- Completeness (in the sense of an 80 % rule) with respect to the application scenario considered
- Manageable size (no more than 20 pages per application scenario)

The target audience of this document is *users* who want to better understand the differences between a business and a technical perspective in order to streamline the manifold discussions in the context of digitalization in manufacturing industries.

The present results were initiated by the Working Group Modeling Example of the GMA Technical Committee 7.21 "Industrie 4.0 – Terminology, Reference Models, and Architectural Concepts", which had already described some use cases on a high abstraction level for the application scenario Value-Based Service, see [5]. In the present document, the description of the use cases was completed, while maintaining the abstraction level and the application scenario. Afterwards, these considerations were intensively discussed and refined together with the "Use Case Task Force" in the International Standardization Action Group, Robot Revolution Initiative, so that these results are now available as a joint publication. The activities are part of the Germany-Japan cooperation within IEC TC65 Smart Manufacturing and were moderated by the Standardization Council Industrie 4.0.

Terms and Definitions

In the general discussions about digitization in manufacturing industries in Germany, the term "use case" is used in completely different understandings. At least the following terms should be better distinguished:

- *Business-Scenarios*[2] that primarily describe a business context. Here the basis is a value-network of business stakeholders and each business stakeholder is characterized by his own business model. Relations between the business stakeholders within the value-network are characterized by value propositions. Especially the application scenarios of the Plattform Industrie 4.0 are scenarios in this sense[3]. Another example where scenarios are discussed in this sense can be found in [6].
- *Use cases*, which primarily describe the interaction of technical stakeholders (later called "roles" in this paper) with a technical system[4]. The technical system must not be a physical system. An example of a description of a use case using the template proposed by IEC 62559-2 can be found in [7]. It details aspects of the application scenario Adaptable Factory of the Plattform Industrie 4.0.
- Concrete *projects* that implement as examples aspects of scenarios and/or use cases. Examples of projects are for example on the homepage of the Plattform Industrie 4.0, see [8], or on the homepage of the Robot Revolution Initiative, see [9].

2 Business-scenarios in this sense must not be confused with scenarios according to the template proposed by IEC 62559-2.

3 The application scenarios have grown historically and are not all as sharp as to describe business relationships only.

4 This understanding of "use case" is aligned with the understanding according to Wikipedia.

Additional Information

Introduction to IIRA

The Industrial Internet Reference Architecture (IIRA), see [10], provides guidance and assistance in the development, documentation, communication, and deployment of IIoT systems. The corresponding document is primarily for IIoT system architects, which can use the IIRA systematically as an architectural template to define their unique IIoT system requirements and design concrete architectures to address them.

At the core of the IIRA are the so called IIRA viewpoints, see Figure 1:

- Business viewpoint – attends to identification of stakeholders and their business vision, values, and objectives in establishing an IIoT system in its business and regulatory context.

- Usage viewpoint – addresses expected system usage. It is typically represented as sequences of activities involving human or logical users that deliver intended functionality to ultimately achieve the fundamental system capabilities.

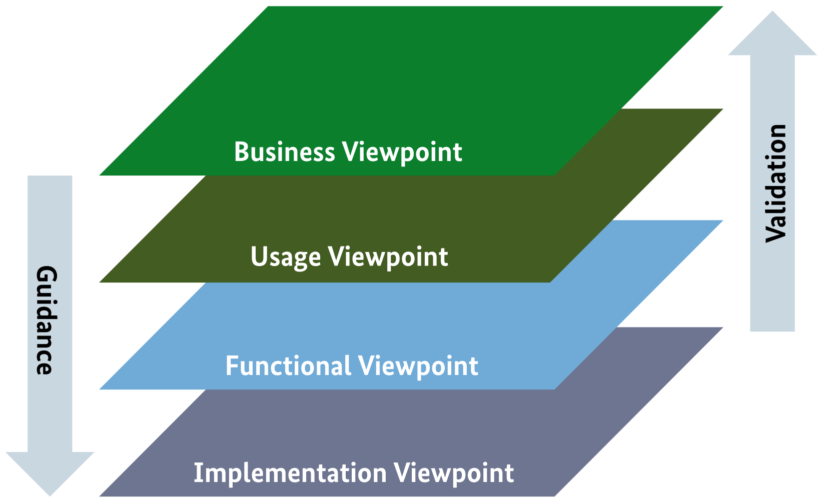
- Functional viewpoint – focuses on the functional components in an IIoT system, their structure and interrelation, the interfaces and interactions between them, and the relationships and interactions of the system with external elements in the environment, to support the usages and activities of the overall system.

- Implementation viewpoint – deals with the technologies needed to implement functional components, their communication schemes, and their lifecycle procedures. These elements are coordinated by activities (usage viewpoint) and support the system capabilities (business viewpoint).

There are cause and effect dependencies between the viewpoints. Typically a viewpoint guides the design of the viewpoint below and a viewpoint serves for validation of the viewpoint above.

We will use this architecture framework for our description. If focusing on the business viewpoint of IIRA the result will be a set of business scenarios and if focusing on the usage viewpoint of IIRA the result will be a set of use cases according to the chapter Terms and Definitions.

Figure 1: Industrial Internet Architecture Viewpoints (according to [10])

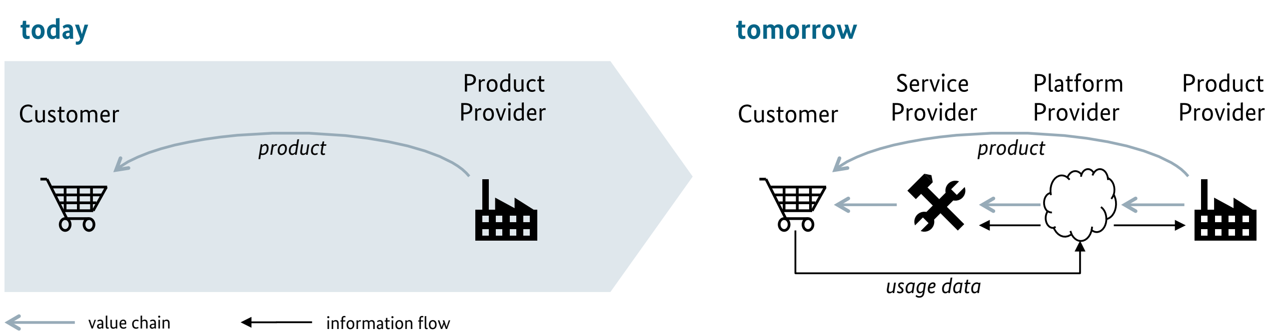


Source: IIC

Introduction to Application Scenario Value-Based Service

Today typically a product provider delivers a product to a customer and does not have any feedback from the usage of his product by the customer. The application scenario Value-Based Service is based on the innovation hypothesis that in the future delivered products will be connected to a so-called service platform, data from the usage of the product by the customer will be fed to the service platform, and based on the usage data a service provider can offer (data-driven) value-added services to the customer. Figure 2 illustrates the participating stakeholders[5], the underlying value network, and the new information flow from the customer to the service platform as the basis for new data-driven services. For more details we refer to [4].

Figure 2: Value-network of application scenario Value-Based Service (Plattform Industrie 4.0)



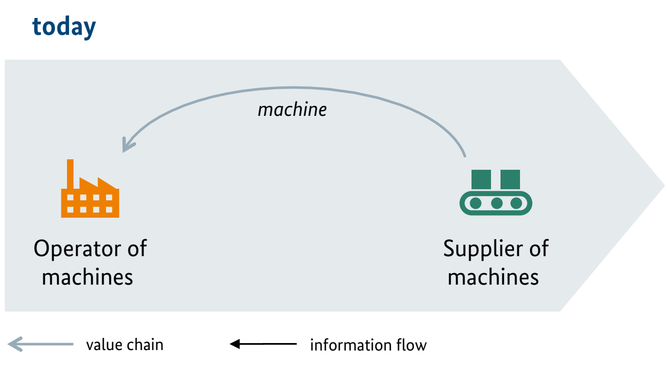
Source: Plattform Industrie 4.0

5 To be more precise there should be distinguished between platform provider and platform operator. These different roles could be implemented by different companies. For more details we refer to [11]

Overview of Business Viewpoint of Application Scenario Value-Based Service

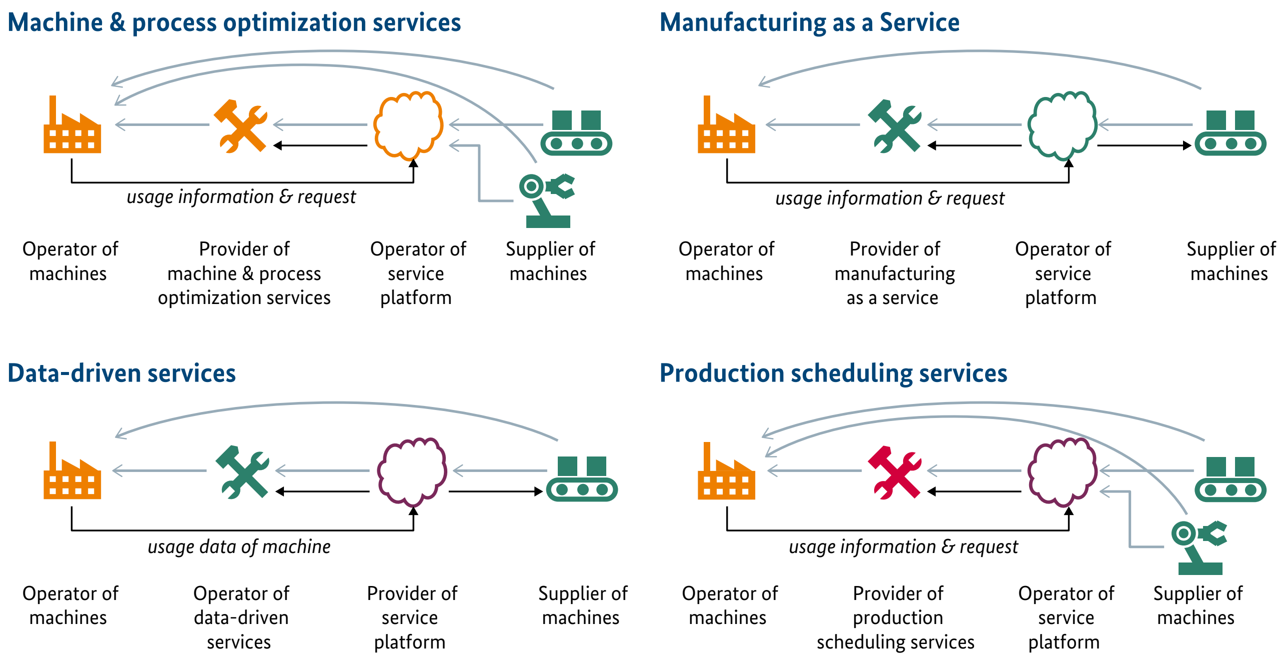
Since the discussions are ongoing we will give a short introduction to the business viewpoint of the application scenario Value-Based Service to keep this document consistent and self explanatory. Figure 3 illustrates how we apply the application scenario Value-Based Service as shown in Figure 2. The product under consideration is a machine. We distinguish two different business stakehold-

Figure 3: Usage of application scenario Value-Based Service (according to [5])



Source: Plattform Industrie 4.0

Figure 4: Examples for variety of different business setups (based on [11])



Source: Plattform Industrie 4.0

ers indicated by the two different colors: the supplier of the machine (green) and the operator of the machine (orange)[6].

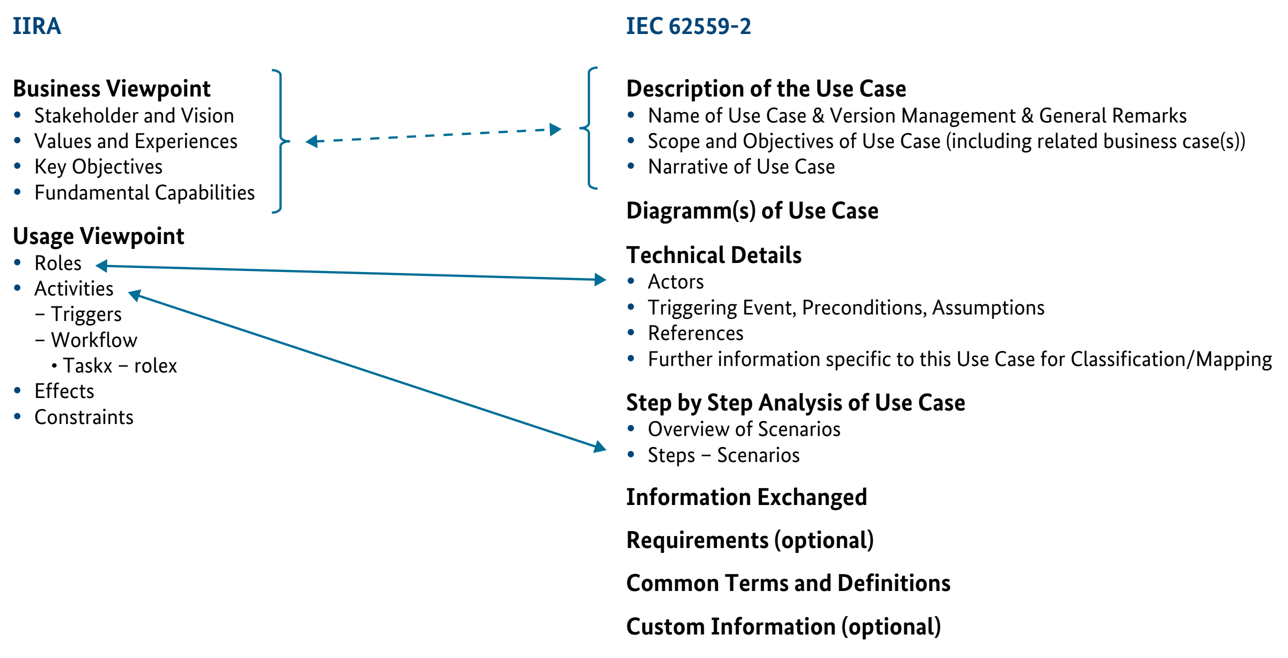
The application scenario introduces two additional business roles: the operator of the service platform and the provider of data-driven services. Now it has to be discussed who will implement these additional business roles in the future. It would be possible that the existing business stakeholders, namely the supplier of the machine or the operator of the machine, implement these roles, but it is also conceivable that other business stakeholders will do this.

As described in [11] a variety of different business setups is possible. For each business setup there are other value-networks and value propositions. Figure 4 illustrates some of the possible business setups. In this figure same colors indicate that the respective roles are implemented by the same business stakeholder.

Description of Use Cases

We have decided to use the concepts of the usage viewpoint of IIRA to describe the use cases. Nevertheless there is a mapping possible between the concepts of the usage viewpoint and the template as proposed by IEC 62559-2. Figure 5 illustrates that on a specific level of abstraction there is no mismatch of the different concepts. But it becomes obvious that the template proposed by IEC 62559-2 requires more details.

Figure 5: Comparison of IIRA and IEC 62559-2 Concepts



Source: Plattform Industrie 4.0

6 It is also possible to apply the application scenario Value-Based Service where the product according to Figure 2 is an entire plant and the customer according to Figure 2 operates various plants distributed all over the world. In this case customer and product provider would be the same business stakeholder, but in the context of this paper we assume that customer and product provider are different stakeholder.

Usage Viewpoint of Application Scenario Value-Based Service

The usage viewpoint comprises the following concepts, for details see [10]:

- The basic unit of work is a *task*. A task is **carried**[7] out by a party assuming a role.

- A *role* is a set of responsibilities assumed by an entity to initiate and participate in the **execution** of, or consume the outcome of, some tasks or functions in an IIoT system as required by an activity. Roles are assumed by parties.

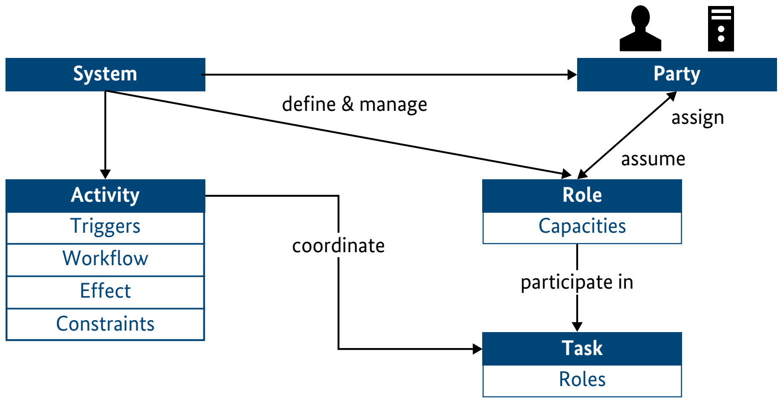
- A *party* is an agent, human or automated, that has autonomy, interest and responsibility in the **execution** of tasks. A party **executes** a task by assuming a role that has the necessary authorizations for the execution of the task. A party may assume more than one role, and a role may be fulfilled by more than one party.

- An *activity* is a specified coordination of tasks required to realize a well-defined usage or process of an IIoT system. An activity has the following elements:
  - A *trigger* is one or more condition(s) under which the activity is initiated.
  - A *workflow* consists of a sequential, parallel, conditional, iterative organization of tasks.
  - An *effect* is the difference in the state of the IIoT system after successful completion of an activity.
  - *Constraints* are system characteristics that must be preserved during execution and after the new state is achieved.

The tasks according to [10] include a Functional Map referring to the Functional Viewpoint and an Implementation Map refereeing to the implementation Viewpoint. Since we are focusing on the Usage View-point only, we do not consider Functional resp. Implementation Maps.

7 The **bold** marked terms refine and illustrate the single term “participate-in” in Figure 6.

Figure 6: Overview of Usage Viewpoint (according to [10])



Source IIC

The business stakeholders described in the business viewpoint should not be confused with the roles resp. parties introduced in the usage viewpoint. The business stakeholders are legal entities engaged in a business mandate, whereas the roles resp. parties execute technical tasks. Depending on the specific business scenario according to Figure 4, however, the roles resp. parties can be assigned to business stakeholders.[8]

As described in more detail in [5], see Figure 29 in particular, the application scenario Value-Based Service focuses on an application in the intersection of the applications addressed by the Plattform Industrie 4.0 and the Industrial Internet Consortium (IIC). Therefore, we will use the terms IIoT system and asset[9] as they are used by the IIC.

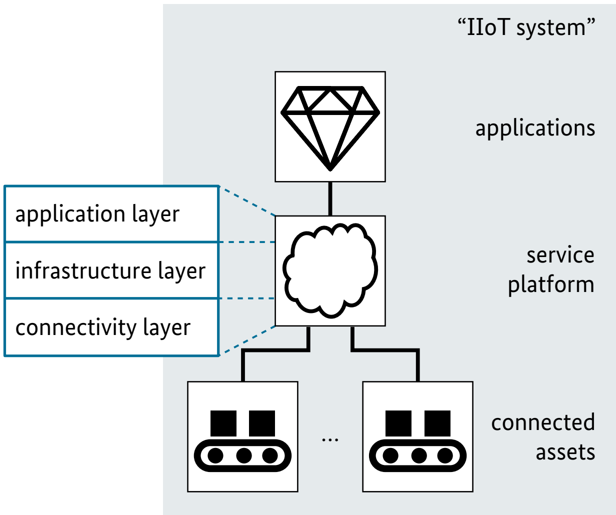
System under Consideration

For the system under consideration, i.e. the IIoT system, we refer to a common logical structure as shown in Figure 7.

The center of the logical structure is a so-called *service platform* organized in three layers:

- Connectivity layer: This layer offers the capabilities to connect assets distributed all over the world and to collect usage data from the connected assets. We assume that the connection of assets requires similar capabilities as the integration of assets into a technological process, e.g. the integration of machines into a production system.

Figure 7: System under consideration for Usage Viewpoint of application scenario Value-Based Service



Source: Platform Industrie 4.0

8 In this context, there is an interesting question of validation, in particular from a scientific point of view: To which extent does the description of the usage viewpoint in this paper actually implements the description of the business viewpoint?

9 In the context of the Plattform Industrie 4.0 an asset is an entity which has a value for a business stakeholder, in the context of the IIC an asset is an entity which is managed by an IIoT solution. More details are described in a white paper "Lifecycle Perspectives", which is currently elaborated by the Joint Task Group 1 "Products, Production Sys-tems and IIoT Solutions" of Plattform Industrie 4.0 and IIC.

- Infrastructure layer: This layer offers the capabilities to manage and analyze data collected from the connected assets and provides the necessary computing execution capabilities, e.g. cloud infrastructure (public, private, or on-premise). The capabilities for managing and analyzing the data will be offered in form of function blocks[10] to be used by applications. The infrastructure layer offers development capabilities to create such function blocks and to embed function blocks developed outside of the service platform. The creation of such function blocks requires in particular programming and data analytics skills. In addition, the infrastructure layer will offer capabilities to configure applications.

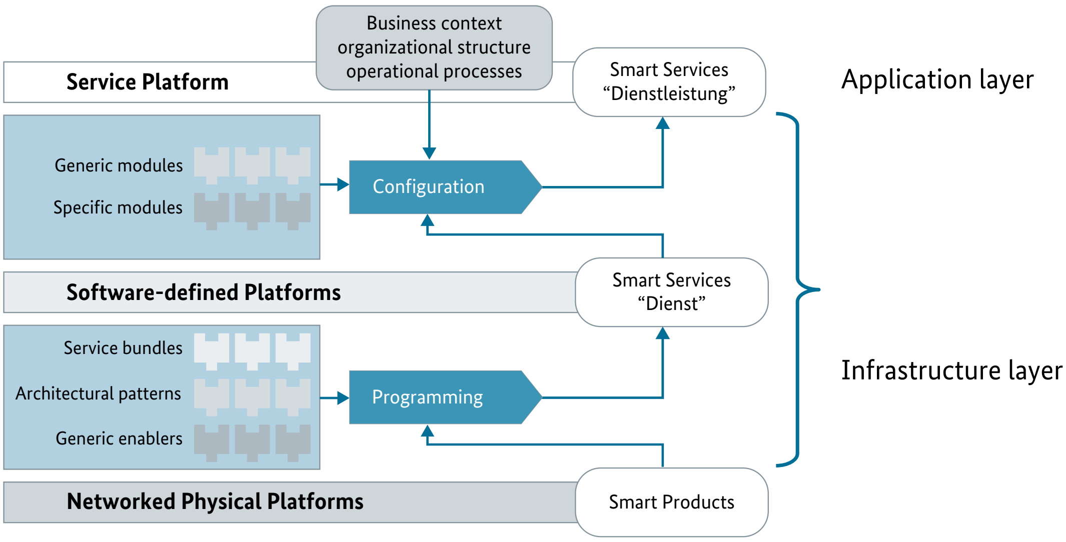
- Application layer: This layer comprises the various applications. These applications can be configured based on the capabilities provided by the infrastructure layer; furthermore, the applications can be executed based on the execution and computing capabilities of the infrastructure layer. The applications can make use of the data collected from the assets and the data analysis capabilities offered by the function blocks provided by the infrastructure layer. We assume that no specific programming skills are necessary to engineer these applications, i.e. the applications can be created by configuration of the function blocks offered in libraries and it is not necessary to program new function blocks.

Connected assets are an integral part of a production system (synonymously factory or plant). The production system has been established to manufacture (or produce) a product. In addition to this role the production system may be connected to a service platform in order to improve the usage of the asset based on the analysis of usage data of the asset.

Applications are the basis from a technical perspective in order to offer data-driven services as described in the business viewpoint.

Figure 8 illustrates that the distinction of skills required to use the infrastructure and application layer of the service platform is aligned with the "Layer Model of Digital Infrastructures" as developed by the future project Smart Service Welt, see [12][11].

Figure 8: Alignment with Smart Service Welt (according to [12], page 92 figure 15)



Source: Siemens

10 The term "function block" is borrowed from the domain "automation technology". Other domains also speak of "building blocks". The principle is that an application is created by basic elements, which are linked together without having to understand the internal structure of the basic elements.

11 Note that the term "service platform" as used in the context of the Smart Service Welt addresses only a part of the service platform as it is used in this paper.

The association of the logical elements of the system under consideration to business stakeholders depends on the specific business scenario as illustrated in Figure 4.

Roles

We have identified the following roles to model the usage viewpoint of the application scenario Value-Based Service and grouped them into three clusters.

There is a first cluster of roles, which is related to the usage of the assets. These roles are very similar to a typical setup today, especially if we look in manufacturing industries and consider an asset to be a machine:

- Operator of an asset[12]: This is the operator of an asset, typically a machine or the entire plant. He uses the asset according to a given usage profile and schedule provided by the production manager, monitors the actual process-data related to the asset, guarantees quality assurance with respect to the manufactured product, he executes service and maintenance tasks related to the asset and needs support in case of anomalies (e.g. unplanned events, trends, etc.).

- Production manager (of the manufacturing company): He manages the overall manufacturing process (planning and scheduling of the production), he plans and initiates maintenance activities to keep the assets up to date, he designs and initiates major asset reconfiguration activities triggered by business considerations (e.g. changing the capacity of the plant because of market demands, offering other products to the market, etc.), and finally he decides on and initiates the implementation of recommendations provided by the role "asset usage advisor".

- Supplier of an asset: He is the supplier of the physical asset and is an expert of the (technical) capabilities of the asset.

- Asset integrator: He is able to connect an asset to a service platform using the capabilities offered by the connectivity layer of the service platform and the asset itself. The connection is developed based on the specific requirements delivered by some stakeholder, mainly by the production manager. As already mentioned in the description of the connectivity layer of the service platform we assume that the connection of assets requires similar capabilities as the integration of assets into a technological process, e.g. the integration of machines into a production system.

There is a second cluster of roles, which is related to the infrastructure layer of the service platform and the usage of the service platform as a whole:

- Developer of a function block[13]: He is able to design, implement, test, and improve a function block using the development capabilities offered by the infrastructure layer of the service platform to create resp. embed functions blocks. He has to combine data analytics skills (analyzing the usage data of the connected assets) and domain knowledge (typically delivered by the supplier and operator of an asset and/or the asset usage advisor) with computer sciences and modeling skills to develop algorithms and integrate the algorithms into a function block.

- Operator of the service platform: He manages and operates all capabilities provided by a service platform. This includes support and consulting activities for the usage of the different layers of a service platform[14].

- Computing resource: A computer used to execute software code in an automatic way in order to provide the necessary computing execution capabilities of the service platform. Each layer of a service platform requires computing resources for execution.

12 It could be useful to split this role into different roles like e.g. the user of an asset and the maintenance engineer of an asset. This essentially depends on the level of detail of the description of the Usage Viewpoint.

13 Sometimes this role is described as a data scientist. It is essential that this role works with domain-specific knowledge.

14 In a next level of detail it could be useful to split this role into different roles, since the different layers of the service platform are offered to different roles.

The third cluster contains a role related to the applications configured based on function blocks:

- Asset usage advisor: This is an expert role, who transforms the insights of the technical analysis of the usage data of connected assets into some recommendations offered as a service to the operator of the asset. He is involved based on schedule or spontaneously on request. A combination of various expertises is requested, but especially assessment skills are necessary. He has to turn information about an asset into actionable recommendations for the operator of an asset including explaining the benefits and risks of his recommendations. He will be supported by appropriate applications. These applications will be configured by the expert himself using the libraries of function blocks and configuration tools offered by the infrastructure layer of the service platform.

Figure 9: Overview of the roles

The association of the roles to business stakeholders depends on the concrete business scenario under consideration as illustrated in Figure 4.

Parties

A party is an agent executing tasks by assuming a role. Parties strongly depend on the business setup and the internal organization of the companies involved. For example, depending on the size and complexity of a company, the roles "operator of asset" and "production manager" may be implemented by the same person or the responsibilities of these roles have to be distributed to several persons. Therefore we do not address the association of parties in this paper.

Activities

Overview

We distinguish technical and commercial activities.

We have identified the following major technical activities, which we subdivide into two categories. The activities of the first category are associated with the engineering resp. setup and the reconfiguration of an asset and the IIoT system. The activities of the second category are associated with the operation resp. usage and the maintenance of the asset and the IIoT system:

- Engineering resp. setup and reconfiguration of an asset and the IIoT system:
  - Connection of an asset (core)
  - Reconfiguration of an asset
  - Configuration of an application (e.g. an analysis algorithm of usage data of an asset) including its improvement
  - Development of a library of function blocks (including the embedding function blocks developed outside of the service platform)
  - Development of a service platform

- Operation of an asset and operation and maintenance of the IIoT system:
  - Collection and analysis of usage data of an asset (core)
  - Recording additional data on spontaneous request
  - Operation and maintenance of a service platform
  - Generation of recommendations resp. requests for action (core)
  - Execution of recommendations resp. requests for action (core)
  - Benchmarking of assets

We believe that the activities marked by "core" represent the core activities of the usage viewpoint of the application scenario Value-Based Service.

The technical activities must be supplemented by various non-technical, commercial activities[15]. Without any claim of completeness these are for example

- Negotiation of a service contract
- Accounting of services

We focus solely on the technical activities in this paper and will not detail the commercial activities.

In the next subsections we illustrate the activities by figures. In the figures we show the system under consideration and the involved roles. For relations between the system under consideration and its sub-systems we use black-colored lines and for the interaction of a role with the system and its subsystems as well as the interaction between different roles we use blue arrows.

Activity "Connection of an asset"

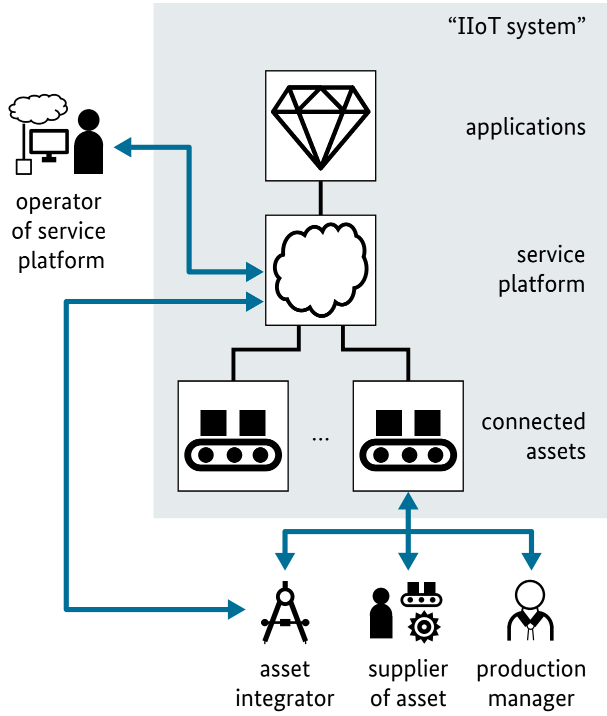
Figure 10 illustrates the activity "connection of an asset":

Triggers: This activity will be initiated, designed and scheduled by the role production manager in an explicit way. He will define the requirements regarding data to be transferred from the asset to the service platform.

Workflow

- Task 1 "Define data to be transferred to service platform (including transfer protocol) based on the requirements of the production manager": role asset integrator & supplier of asset
- Task 2 "Connect asset to service platform (including providing configuration capabilities to manage a virtual representation of the asset over its lifecycle in the service platform)": role asset integrator
- Task 3 "Provide access to usage data of asset": role operator of service platform

Figure 10: Activity *"connection of an asset"*



Source: Plattform Industrie 4.0

- Task 4 "Validate connection of asset": role asset integrator & operator of service platform & supplier of asset
- Task 5 "Acceptance of connection of an asset": role asset integrator & production manager

Effects: This is a basic precondition for collecting usage-data of an asset

Constraints

- The connection of the asset to the service platform has to be done in such a way that adaptations in the connection caused by reconfigurations of the asset (as they are executed today typically by the operator of the asset) can be executed in the same way as today. Hence, if today the reconfiguration can be executed by the operator of the asset without any help of the asset integrator, then no support of the asset integrator is requested even if the asset is connected to a service platform.

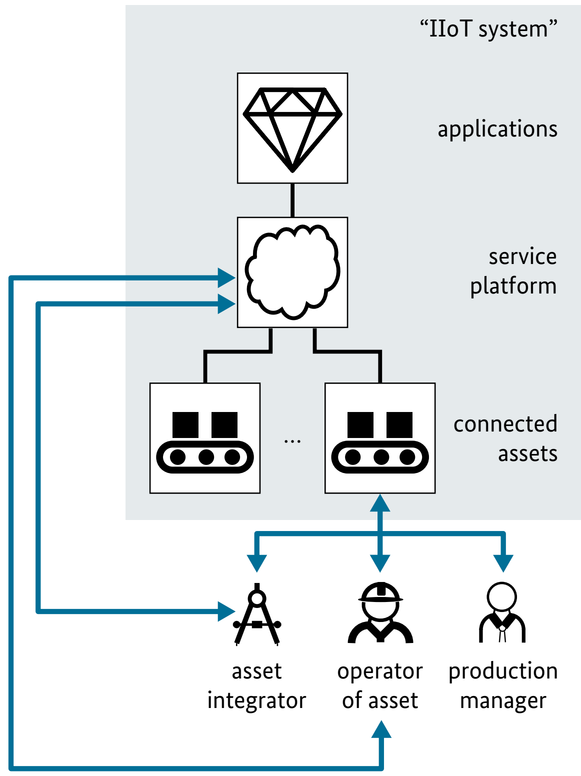
15 The commercial activities have to be clearly distinguished from the business context described in the Business Viewpoint.

- The connectivity layer of the service platform has to provide capabilities that the asset integrator can test the connection of an asset without help of other roles (in case of problems he will request for support by the operator of the service platform)

Activity "Reconfiguration of an asset"

Typically assets are subject of permanent reconfiguration, e.g. changing parameters, components, or tools. Today, some of these reconfigurations are executed by the operator of the assets, for other reconfiguration an asset integrator is required. Figure 11 illustrates the activity "reconfiguration of an asset":

Figure 11: Activity *"reconfiguration of an asset"*



Source: Plattform Industrie 4.0

Triggers: This activity will be initiated by the role production manager (or operator of asset, if the reconfiguration is his scope of responsibility, e.g. changing a parameter or a tool) in an explicit way

Workflow

- Task 1 "Identify the virtual representation of the asset in the service platform to be reconfigured": role asset integrator (or operator of asset)
- Task 2 "Reconfigure the asset, i.e. execute necessary work to be done with the asset, this includes work in the physical world as well as in the digital world, but no activities related to the service platform": role asset integrator (or operator of asset)
- Task 3 "Update the virtual representation of the asset in the service platform according to the reconfiguration of the asset according to step 2 (in order to be able to deliver the data-driven services)": role asset integrator (or operator of asset)
- Task 4 "Acknowledge the reconfiguration of the asset": role production manager (or operator of asset)

Effects: This is necessary to ensure consistency between an asset and its virtual representation in the service platform

Constraints

- If necessary, the plant has to be stopped at the beginning of the workflow and restarted after the workflow
- The connection of the asset to the service platform has to be done in such a way that the role asset integrator is needed only if the original reconfiguration requests for the role of the asset also

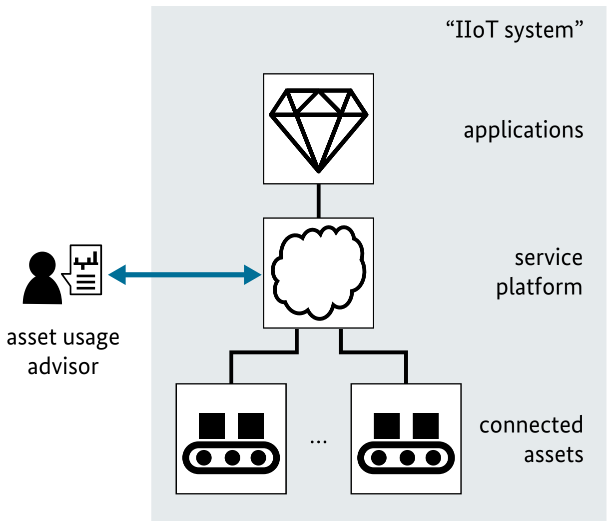
General comments

- Depending on the concrete realization, the tasks executed in the virtual world (i.e. 1, 3, and even possibly 4) can be automated
- The reconfiguration of the asset includes management of consumable, auxiliary, and supplier materials situationally

Activity "Configuration of an application"

Applications allow the asset usage advisor to automatically evaluate data acquired at usage time of an asset and then to use the evaluation results to make recommendations regarding an optimized usage of the asset. An example of such an application is a prediction algorithm that predicts the health status of an asset as a function of its usage. Figure 12 illustrates the activity "configuration of an application":

Figure 12: Activity *"configuration of an application"*



Source: Plattform Industrie 4.0

Triggers: This will be requested by the business responsible of the role asset usage advisor in an explicit way

Workflow

- Task 1 "Design a concept for an application based on the business requirements (traditional design task)": role asset usage advisor
- Task 2 "Configure the application using the configuration capabilities offered by the infrastructure layer of the service platform": role asset usage advisor
- Task 3 "Deploy and test the application using the capabilities provided by the service platform": role asset usage advisor
- Task 4 "Continuous improvement of the application based on the gained experiences and evolving business requirements (traditional improvement task, e.g. an extended or new analysis algorithm of usage data of an asset)": role asset usage advisor
- Effects: This is a precondition that the work of the asset usage advisor is supported by automated execution of the analysis of usage-data of an asset provided by the capabilities of the service platform

Constraints

- The asset usage advisor may be supported by the developer of a library of function blocks with respect to the usage of these function blocks and the operator of the service platform with respect to the usage of the service platform
- The asset usage advisor may be supported by the supplier of the asset with respect to capabilities of the asset and the operator of the asset or production manager with respect to the usage of the asset

Activity "Development of a library of function blocks"

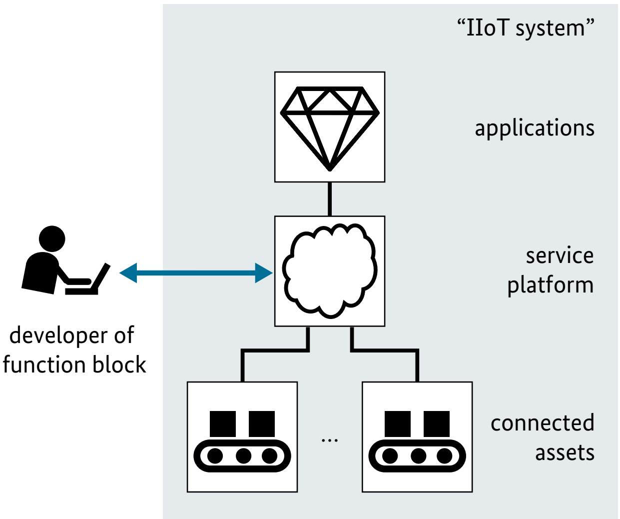
Function blocks encapsulate algorithms mainly characterized by data analytics capabilities and strongly influenced by technological opportunities. They are the basis for various applications. Depending on the business model libraries can be provided by the operator of a service platform or a separate business stakeholder. Figure 13 illustrates the activity "development of a library of function blocks":

Triggers: This will be requested by the business responsible of the developer of function blocks in an explicit way

Workflow

- Task 1 "Design a concept for a library of function blocks based on the business requirements and technological opportunities (traditional design task)": role developer of function block

Figure 13: Activity *"development of a library of function blocks"*



Source: Plattform Industrie 4.0

- Task 2a "Develop the function blocks using the development capabilities offered by the infrastructure layer of the service platform": role developer of function block
- Task 2b "Embed function blocks developed outside of the service platform using the development capabilities offered by the infrastructure layer of the service platform": role developer of function block
- Task 3 "Deploy and test the library of function blocks based on the capabilities provided by the service platform": role developer of function block
- Task 4 "Continuous improvement of the library of function blocks based on the gained experiences, new technological opportunities, and evolving business requirements (traditional improvement task)": role developer of function block

Effects: A library of function blocks is a precondition that an asset usage advisor can configure an application

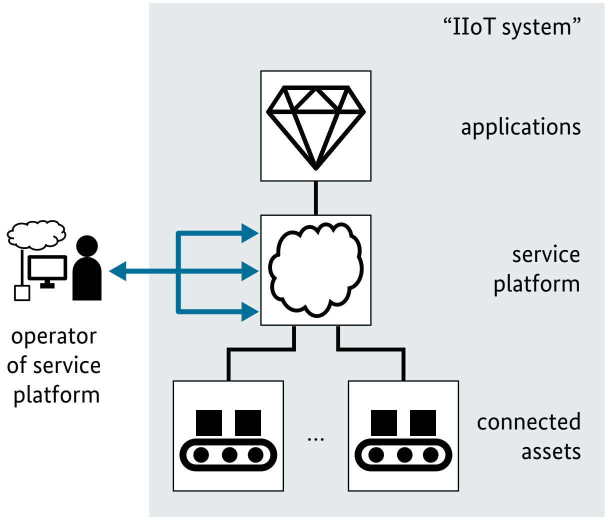
Constraints

- The developer of a function block may be supported by the operator of the service platform with respect to the usage of the service platform

Activity "Development of a service platform"

Figure 14 illustrates the activity "development of a service platform":

Figure 14: Activity *"development of a service platform"*



Source: Plattform Industrie 4.0

Triggers: This will be requested by the business responsible of the operator of service platform in an explicit way

Workflow

- Task 1 "Design a concept for a service platform based on the business requirements and technological opportunities (traditional design task)": role operator of service platform
- Task 2 "Develop the layers of the service platform and implement all required capabilities": role operator of service platform

- Task 3 “Deploy and test the service platform”: role operator of service platform

- Task 4 “Continuous improvement of the service platform based on the gained experiences, new technological opportunities, and evolving business requirements (traditional improvement task)”: role operator of service platform

Effects: A service platform is the basic precondition for the application scenario Value-Based Service

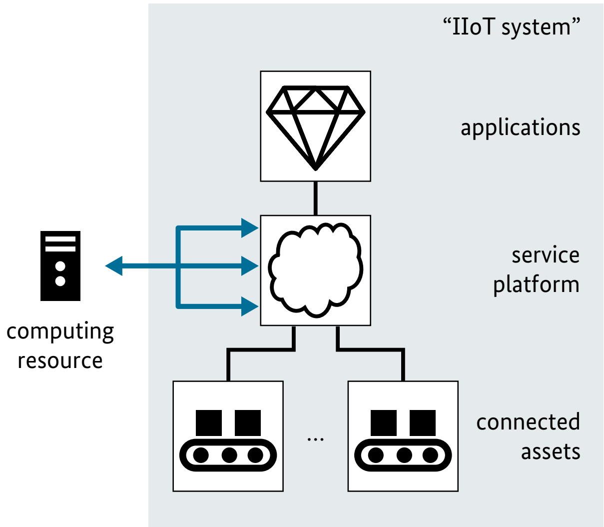
Constraints:

- The constraints re outside of the focus of this paper.

Activity “Collection and analysis of usage data of an asset”

Figure 15 illustrates the activity “collection and analysis of usage data of an asset”:

Figure 15: Activity *“collection and analysis of usage data of an asset”*



Source: Plattform Industrie 4.0

Triggers: This activity is triggered cyclic by a scheduler component of the infrastructure layer or acyclic based on events within the assets or connectivity layer. Scheduling and event handling procedures are configured by the asset usage advisor when configuring the associated applications or by the asset integrator when connecting assets to the service platform.

Workflow

- Task 1 “Execution of the associated applications, e.g. an analysis algorithm or a reporting algorithm regarding usage data of the asset”: role computing resource

- Task 2 “Depending on the application e.g. generation of an alarm in the case that some threshold is passed or updating diagrams displayed to the asset usage advisor”: role computing resource

Effects: This ensures an up-to-date status of the information about an asset regarding an intended purpose of an application

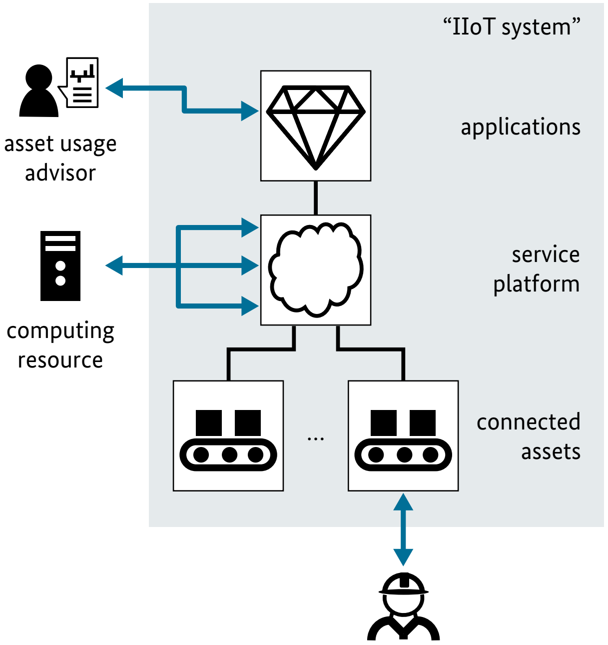
Constraints

- The execution time of the application, e.g. a complex analysis algorithm, has to be aligned with the cycle time resp. the possible time courses of the incoming measurement events and the available computing power

Activity “Recording additional data on spontaneous request”

Additional information could be helpful to generate recommendations to the operator of an asset. That information has to be analyzed on request by the asset usage advisor. In this case the operator of the asset connects temporally additional sensors to the asset without changing the current automation solution of an asset, records the required data and submits the data to the asset usage advisor. Figure 16 illustrates the activity “recording additional data on spontaneous request”.

Figure 16: Activity *"recording additional data on spontaneous request"*



Source: Plattform Industrie 4.0

Triggers: This activity will be triggered by the role asset usage advisor in an explicit way

Workflow

- Task 1 "Request for specific data": role asset usage advisor
- Task 2 "Select suitable sensor(s)": role operator of asset
- Task 3 "Connect sensor(s) to asset": role operator of asset
- Task 4 "Record required data and provide recorded data to asset usage advisor": role computing resource
- Task 5 "Disconnect sensor(s) from asset": role operator of asset
- Task 6 "Analyze the additional data (this may require the configuration of appropriate applications)": role asset usage advisor

Effects: This ensures the availability of temporally recorded data to the asset usage advisor

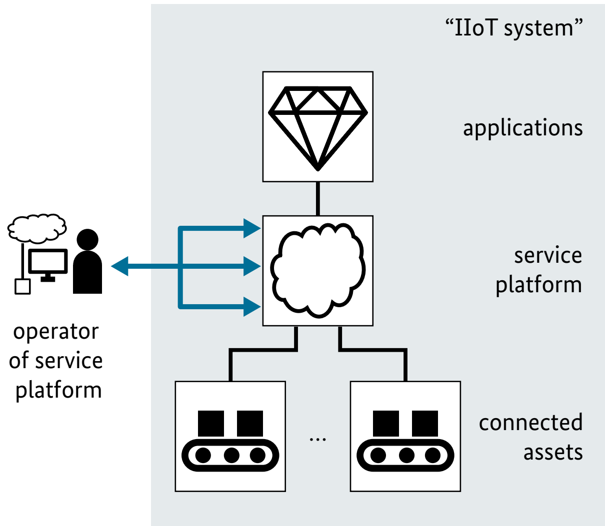
Constraints:

- The additional sensor have to be provided as assets and to be connected to the service platform using the capabilities offered by the connectivity layer
- Specific function blocks have to be provided for processing resp. analyzing the data provided by the additional sensors using the capabilities offered by the infrastructure layer
- An application has to be configured to process resp. analyze the data provided by the additional sensors using the capabilities offered by the infrastructure layer

Activity "Operation and maintenance of a service platform"

Figure 17 illustrates the activity "operation and maintenance of a service platform":

Figure 17: Activity *"operation and maintenance of a service platform"*



Source: Plattform Industrie 4.0

Triggers: This activity may be triggered event-based or based on a schedule

Workflow

- Task 1 "Perform measures to guarantee requested service level of service platform": role operator of service platform

Effects: This ensures a reliable availability of all capabilities of the service platform according to a guaranteed service-level agreement

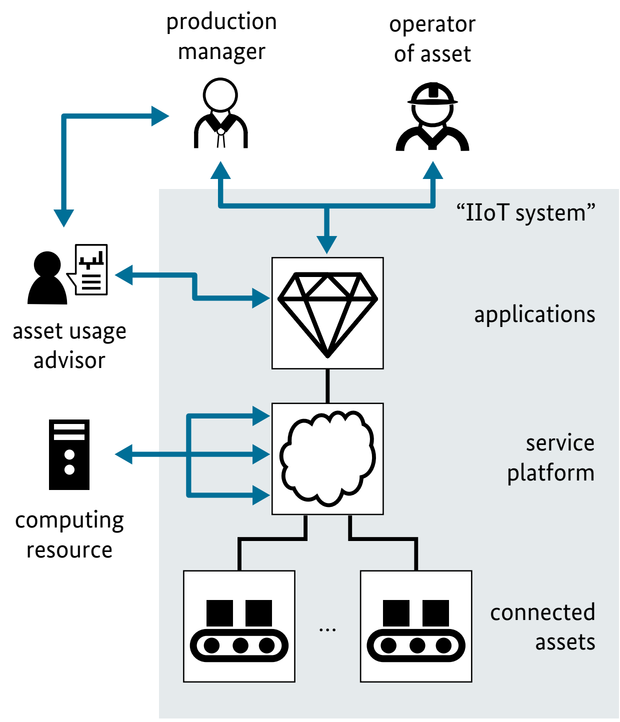
Constraints:

- The constraints re outside of the focus of this paper.

General comments

- Typical measures to guarantee the requested service level of the service platform are the configuration of the access to the service platform, i.e. user management, or the configuration of the storage of the data.

Figure 18: Activity *"generation of recommendations resp. requests for action"*



Source: Plattform Industrie 4.0

Activity "Generation of recommendations resp. requests for action"

Figure 18 illustrates the activity "generation of recommendations resp. requests for action":

Triggers: This action is triggered based on some specific event generated by some application executed by the service platform

Workflow

- Task 1 "Transforming specific events into a recommendation for resp. request for action by the operator of the asset": roles computing resource & asset usage advisor
- Task 2 "Provision of recommendation to production manager or operator of the asset" (optional): role asset usage advisor
- Task 3 "Discussion of recommendation with production manager or operator of the asset" (optional): roles asset usage advisor & production manager or operator of asset
- Task 4 "Accounting of delivered service" (optional): roles asset usage advisor & production manager

Effects: providing data-driven services to production manager or operator of an asset based on specific findings of analysis of usage data of the asset

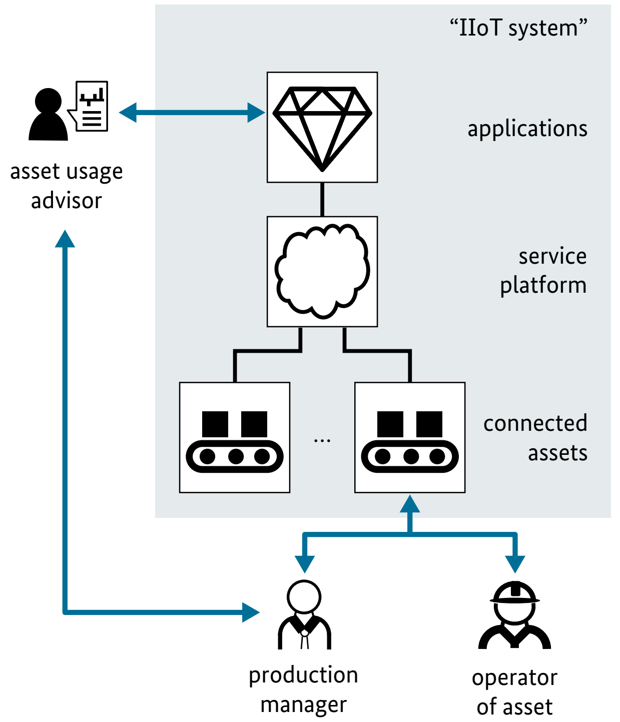
Constraints

- The execution of the optional tasks mainly depend on the underlying business model

Activity "Execution of recommendation resp. request for action"

Figure 19 illustrates the activity "execution of recommendation resp. request for action":

Figure 19: Activity *"execution of recommendation resp. request for action"*



Source: Plattform Industrie 4.0

Triggers: This action will be initiated by a recommendation resp. request for action caused by the asset usage advisor

Workflow

- Task 1 "Schedule execution": role production manager
- Task 2 "Execute execution": role operator of asset
- Task 3 "Acknowledge execution with respect to asset usage advisor (optional)": role production manager or operator of asset

Effects: ensuring the execution of a recommendation resp. request for action by the operator of an asset

Constraints

- The execution of the optional tasks mainly depend on the underlying business model

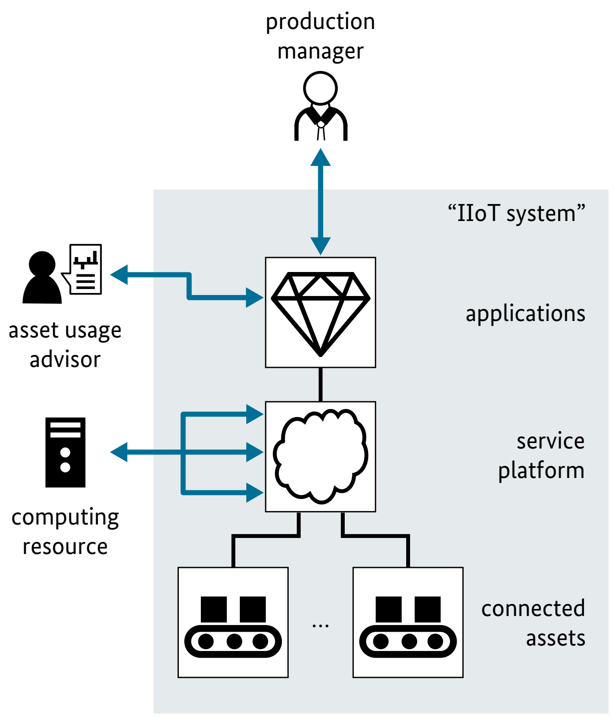
Activity "Benchmarking of assets"

Benchmarking of assets is a core value of the application scenario Value-Based Service caused by the network effect of platforms. This activity is based on the following assumptions:

- From the perspective of the supplier of an asset there are many assets used by different asset operators typically distributed all over the world. We assume that these assets are comparable, i.e. they are instances of the same type, for details see [13].
- From the perspective of the operator of an asset resp. his production manager most of these assets (i.e. instances) are installed and used outside of his site by other operators. For him, the other operators resp. production managers are anonymous and not disclosed to him.
- The operator of an asset resp. his production manager grants access to specific usage data of his asset to the supplier of the asset.
- We assume that all assets of the supplier are connected to the service platform so that the supplier of the asset has access to the granted usage information of each asset. Based on this information the supplier of the asset is able to do benchmarking between all instances of a type.

Figure 20 illustrates the activity “benchmarking of assets”:

Figure 20: Activity *“benchmarking of assets”*



Source: Plattform Industrie 4.0

Triggers: This action is triggered cyclic or event-based as configured by asset integrators when connecting the various assets to the service platform and the asset usage advisor when configuring the underlying benchmarking application

Workflow

- Task 1 “Providing an appropriate benchmarking application”: role asset usage advisor
- Task 2 “Transforming the specific information about the usage of an asset into a general performance indicator of the asset”: role computing resource
- Task 3 “Provision of the concrete performance indicator value of an asset to the production manager; this concrete value is related to the (anonymous) distribution of the values of all assets supplied by the supplier of the asset: role computing resource
- Task 4 “Displaying the computed information via an appropriate dashboard delivered by the benchmarking application”: roles computing resource & production manager
- Task 5 “Accounting of the data-driven benchmarking service” (optional): roles production manager

Effects: providing data-driven services to the operator of an asset based on the anonymous benchmarking of all assets supplied by the supplier of the asset

Constraints

- The specific benchmarking application has to be developed according to the Activity “Configuration of an application”
- The triggering and updating of dashboard information has to be aligned with the number of connected assets, which depends on the scalability of the service platform
- The access rights regarding the specific performance indicator values has to be managed appropri-ately
- The execution of the optional task mainly depend on the underlying business model

References

[1] IEC 62559-2, https://webstore.iec.ch/publication/22349

[2] Aspects of the Research Roadmap in Application Scenarios, http://www.plattform-i40.de/I40/Redaktion/EN/Downloads/Publikation/aspects-of-the-research-roadmap.html

[3] Fortschreibung der Anwendungsszenarien der Plattform Industrie 4.0, http://www.plattform-i40.de/I40/Redaktion/DE/Downloads/Publikation/fortschreibung-anwendungsszenarien.html

[4] Proposal for a joint "scenario" of Plattform Industrie 4.0 and IIC, http://www.plattform-i40.de/I40/Redaktion/DE/Downloads/Publikation/joint-scenario.html

[5] Exemplification of the Application Scenario Value-Based Service following IIRA Structure, https://www.plattform-i40.de/I40/Redaktion/DE/Downloads/Publikation/exemplification-i40-value-based-service.html

[6] Wegweiser Smart Service Welt – Smart Services im digitalen Wertschöpfungsnetz, http://www.acatech.de/fileadmin/user_upload/Baumstruktur_nach_Website/Acatech/root/de/Publikationen/Kooperationspublikationen/acatech2017_Smart_Service_Welt_Wegweiser.pdf

[7] Industrie 4.0 Plug-and-Produce for Adaptable Factories: Example Use Case Definition, Models, and Implementation, https://www.plattform-i40.de/I40/Redaktion/DE/Downloads/Publikation/Industrie-40-Plug-and-Produce.pdf?__blob=publicationFile&v=5

[8] Map of Industrie 4.0 use cases, http://www.plattform-i40.de/I40/Navigation/EN/InPractice/Map/map.html

[9] Online Map, http://usecase.jmfrri.jp/#/

[10] The Industrial Internet Reference Architecture Technical Report, https://www.iiconsortium.org/IIRA.htm

[11] Benefits of Application Scenario Value-Based Service, https://www.plattform-i40.de/I40/Redaktion/DE/Downloads/Publikation/benefits-application-scenario.html

[12] Smart Service Welt, Final Report, Recommendations for the Strategic Initiative Web-based Services for Businesses, http://www.acatech.de/fileadmin/user_upload/Baumstruktur_nach_Website/Acatech/root/de/Projekte/Laufende_Projekte/Smart_Service_Welt/Smart_Service_Welt_2015/BerichtSmartService2015_D_lang_bf.pdf

[13] IEC 62890, https://www.beuth.de/de/norm-entwurf/din-en-62890/269121145

AUTHORS AND GUESTS

From the German side the status report has been elaborated in the working group "Modeling Example" of the VDI/VDE-GMA Technical Committee 7.21 "Industrie 4.0 – Terms, Reference Models, and Architecture Concepts", especially by the following members and guests:
Dr. Annerose Braune; TU Dresden | Guido Hüttemann; RWTH Aachen University | Matthias Klein; Universität Stuttgart | Dr. Ulrich Löwen; Siemens AG, Erlangen | Mario Thron; ifak – Institut für Automation und Kommunikation e.V., Magdeburg

GUESTS

Tobias Manger; evosoft GmbH, Nürnberg | Dr. Michael Okon; Fraunhofer-Institut IOSB, Karlsruhe

CO-AUTHORS AND ADVISORS

From the Japanese side, some additional ideas were contributed by the following members of the "Use Case Task Force" in International Standardization Action Group, Robot Revolution Initiative:
Prof. Fumihiko Kimura; Tokyo University | Toru Ishikuma; Azbil Corporation | Dr. Hitoshi Komoto; National Institute of Advanced Industrial Science and Technology | Hirozumi Eki; JTEKT Corporation | Dr. Kiyotaka Takahashi; Hitachi, Ltd. | Mitsushiro Fujishima; Mitsubishi Electric Corporation | Takenori Baba; Mitsubishi Electric Corporation | Hiroyuki Itoh; DAIKIN INDUSTRIES, Ltd. | Dr. Shigetoshi Noritake; Toyota Central R&D Labs., Inc. | Yutaka Manchu; Robot Revolution Initiative

ADVISORS

Shinji Oda; Yokogawa Electric Corporation | Dr. Youichi Nonaka; Hitachi, Ltd.

ACKNOWLEDGEMENT

The authors would like to thank Dr. Jan Stefan Michels (Weidmüller Interface GmbH & Co. KG) for his valuable comments.

This working paper has been elaborated in the working group "Modeling Example" of the VDI/VDE-GMA Technical Committee 7.21 "Industrie 4.0 – Terms, Reference Models, and Architecture Concepts" together with the "Use Case Task Force" in the International Standardization Action Group, Robot Revolution Initiative in cooperation with the working group on research and innovation (Plattform Industrie 4.0). The activities and partners were initiated and orchestrated by the Standardization Council Industrie 4.0 (SCI4.0) within the project GoGlobal Industrie 4.0.

www.plattform-i40.de