LNI 4.0 Testbed Edge Configuration – Business View

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1 Overall Objectives of Testbed Edge Configuration

The testbed Edge Configuration was established to prepare the standardization in the context of the manufacturing industry with respect to the emerging edge computing technology. The testbed does not address edge computing technology in itself but focuses on *edge configuration*. For this purpose, concepts will be developed, practically implemented and validated. The results and experiences will be made available to the standardization activities to feed them into the further or new development of standards.

From an architectural point of view, the testbed Edge Configuration is based on a layered architecture as shown in Figure 1:
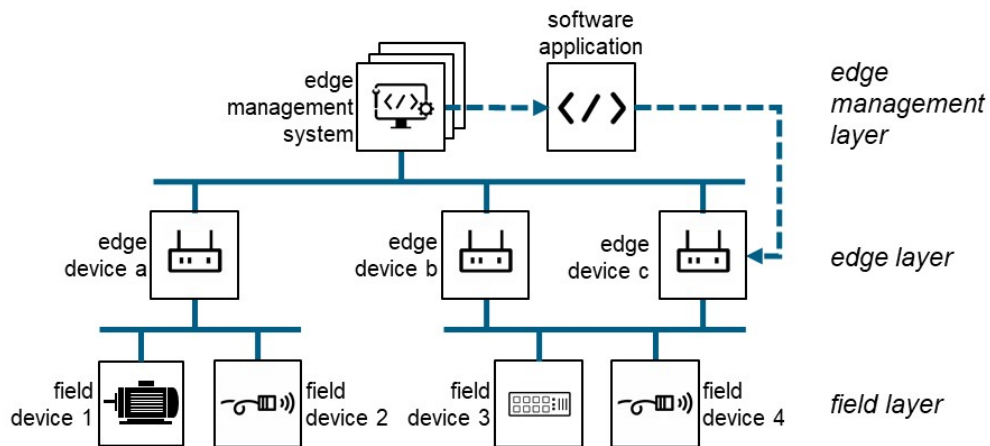
Figure 1. Layered architecture of the proposed testbed Edge Configuration

- The focus of the testbed Edge Configuration is on the configuration of the interaction between the edge and edge management layer. Currently there does not exist a suitable standard for this focus and the testbed will develop proposals for this aspect in the form of functional primitives including parameter sets (functional view), which afterwards must be implemented (implementation view).

- In the interaction between field and edge layer, although today no standard has prevailed in practice, we currently see OPC-UA as a promising candidate to design this interaction in the future, both technologically and via companion specifications. For this reason, this interaction is *not* the focus of the testbed Edge Configuration (functional view).

2 Purpose of this Document

The purpose of this document is to describe the overall business context of the testbed Edge Configuration. Thus, this document defines the contextual driving business requirements for all activities in the testbed and possibly derived standardization activities. In accordance with the Industrial Internet Reference Architecture [1] this document describes a so-called *business view*, see Figure 2. We assume that this business view remains stable throughout the life of the testbed Edge Configuration.
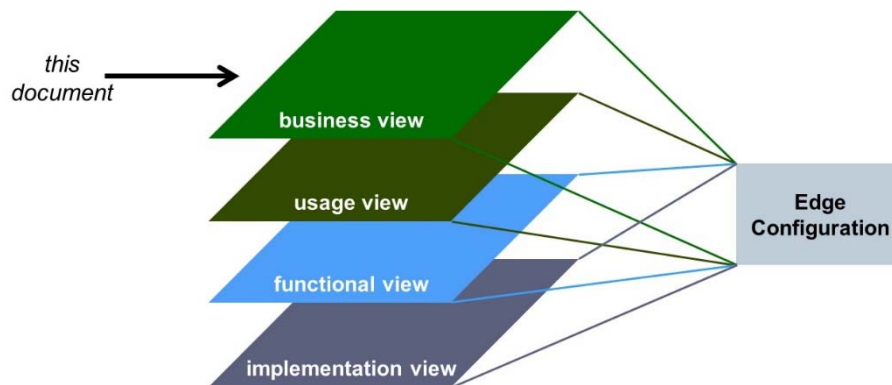

Figure 2. Classification of the document following the Industrial Internet Reference Architecture, see [1]

Regardless of the business context there also exists a description of the application context (in the terminology in Figure 2 called a usage view [2]). Note that business view and usage view frame *different* perspectives but have well-defined relationships. These relationships are described in the annex of this document.

Also various concepts (in the terminology in Figure 2 called a functional view) and solution approaches (in the terminology in Figure 2 called an implementation view) will be developed and discussed in additional documents.

3 Business View of Testbed Edge Configuration

3.1 Structure of the document

There are several ways to specify a business view. We follow the methodology proposed by the Working Group "Digital Business Models" of the German Plattform Industrie 4.0 [3]. Their overall recommendation is to start with the consideration of a *value network* representing all companies involved in the system under consideration (in this context Edge Configuration) and then discussing the *business models* of the different companies.

We applied this by elaborating the following structure:

- Description of an overall value network in manufacturing industries, see section 3.2.

- Considering the changes (conceivable in the future) in the value network and the underlying business interests, see section 3.3.

3.2 Overall value network in manufacturing industries

Figure 3 illustrates the underlying overall value network in manufacturing industries. Each icon represents a business role and the arrows between the different business roles represent a value chain, i.e. a value proposition of one business role to another business role. We distinguish between value chains, where physical products are major part of the value proposition, and value chains based on data and services. The non-colored icons represent business roles, which are new because of the topic "edge configuration". They can be assumed by different companies, partly also by companies indicated by the colored icons.
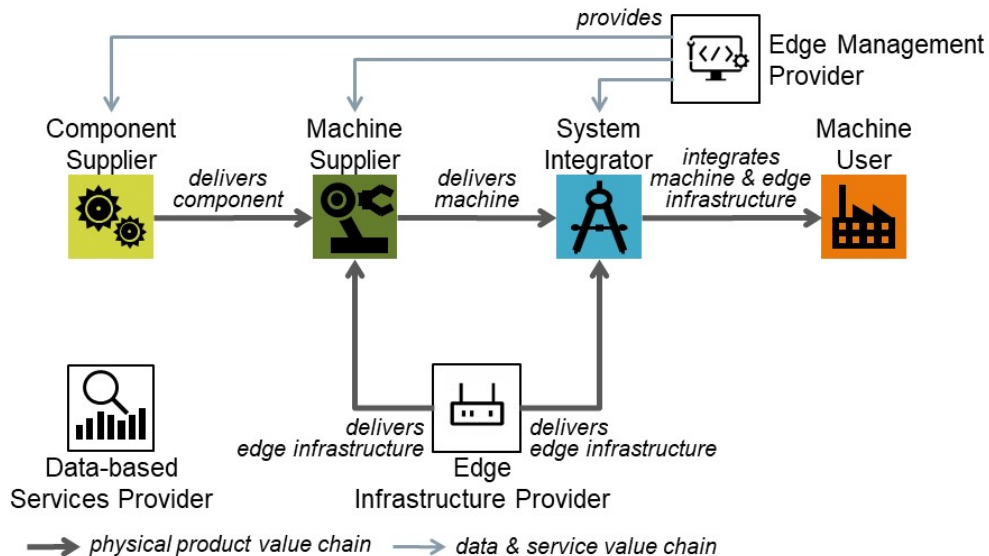

Figure 3: Overall value network in manufacturing industries

We consider the following "traditional" business roles:

- Component Supplier: This business role is typically assumed by a manufacturing company offering components like gearings, sensors or drives to a Machine Supplier (or System Integrator) to be integrated in a machine (or factory) by a Machine supplier (or System Integrator). Typically, the Component Supplier receives a one-time payment for the delivery of the component.

- Machine Supplier: This business role is typically assumed by a manufacturing company offering machines like robots, machine tools or conveyor systems to a System Integrator to be integrated in a factory by that System Integrator. Typically, the Machine Supplier receives a one-time payment for the delivery of the machine from the Machine User.

- System Integrator: This business role is typically assumed by a service company offering system integration services according to the specific needs of a Machine User. This includes integration of

physical systems as well as software application development and integration services. The System Integrator is paid for the integration service by the Machine User.

- Machine User: This business role is typically assumed by a manufacturing company operating a factory. Typically, the Machine pays for the physical components and systems integrated in the factory and the system integration services.

With respect to the topic Edge Configuration we additionally introduce the following "new" business roles:

- Edge Infrastructure Provider: This business role will be typically assumed by a manufacturing company offering an edge infrastructure. More technical details of such an edge infrastructure are elaborated in [2]. We assume that these edge infrastructures are delivered either to a Machine Supplier to be integrated in a machine or to a System Integrator to be integrated in a factory. Typically, the Edge Infrastructure Provider receives a one-time payment for the delivery of an edge infrastructure.

- Edge Management Provider: This is a new business role, which offers a so-called edge management system. More technical details of such an edge management system are elaborated in [2]. The Edge Management Provider will be paid for the usage of the edge management system, where different revenue mechanisms are conceivable, for example pay-per-use. The usage of the edge management system by the different business roles will be explained in section 3.3.

- Data-based Service Provider: This is a business role in form of a service provider, which offers data-based services. These services are based on some software application, which must be deployed somewhere in a machine or factory. The Data-based Service Provider will be paid for the usage of the data-based service, where different revenue mechanisms are conceivable, for example subscription-based or pay-per-use. In section 3.3 different exemplifications of such data-based services will be explained.

3.3 Predicted changes in the value network

In the following subsections the changes (conceivable in the future) in the value network and the underlying business interests will be explained. This is elaborated separately from the perspectives Component Supplier, Machine Supplier, System Integrator and Machine User.

3.3.1 Perspective Component Supplier

Figure 4 illustrates the future value network from the perspective of a Component Supplier, for example for gearings or sensors.
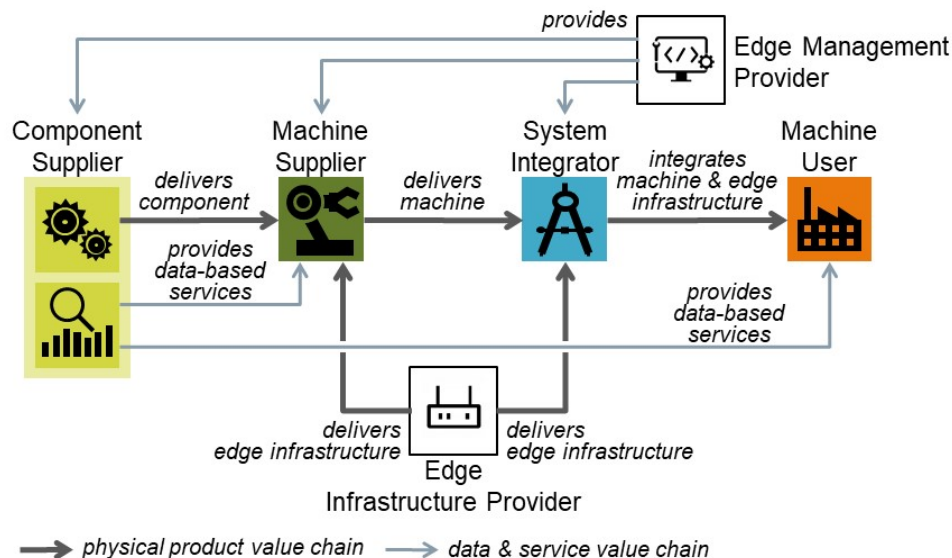

Figure 4: Future value network from the perspective of a supplier component

The overall business interest of the Component Supplier is to offer in addition to the existing component *new data-based services*. In the case of a purely mechanical component, for example gearings, this may require integrating additional sensing capabilities to the component. We assume that it is in the

interest of the Component Suppliers to offer these new services themselves. Therefore, the Component Supplier will additionally assume the business role Data-based Service Provider, which is expressed in Figure 4 by the same color scheme[1].

Potential customers of these new services are the Machine Supplier or Machine User. The customer of these new services, for example a condition monitoring service, benefits due to an improved use of the component based on the new services and will therefore pay for the use of these new services to the Data-based Service Provider.

In order to offer these new data-based services, the Data-based Service Provider will provide a software application. It is not in his interest to provide own computing capabilities to deploy this software application. Instead, he requests for suitable computing capabilities provided by the Machine Supplier (if the new services are offered to the Machine Supplier) or by the Machine user (if the new services are offered to the Machine User). The Component Supplier will contractually define the use of the provided computing capabilities.

Therefore, from the perspective of a Component Supplier there is a request for *standardized* edge management capabilities (offered by an Edge Management Provider) in order to offer data-based services independent of specific computing capabilities provided by a Machine Supplier or Machine User. The Component Supplier will pay the Edge Management Provider for the use of the offered edge management capabilities.

3.3.2 Perspective Machine Supplier

Figure 5 illustrates a future value network from the perspective of a Machine Supplier, for example for robots.
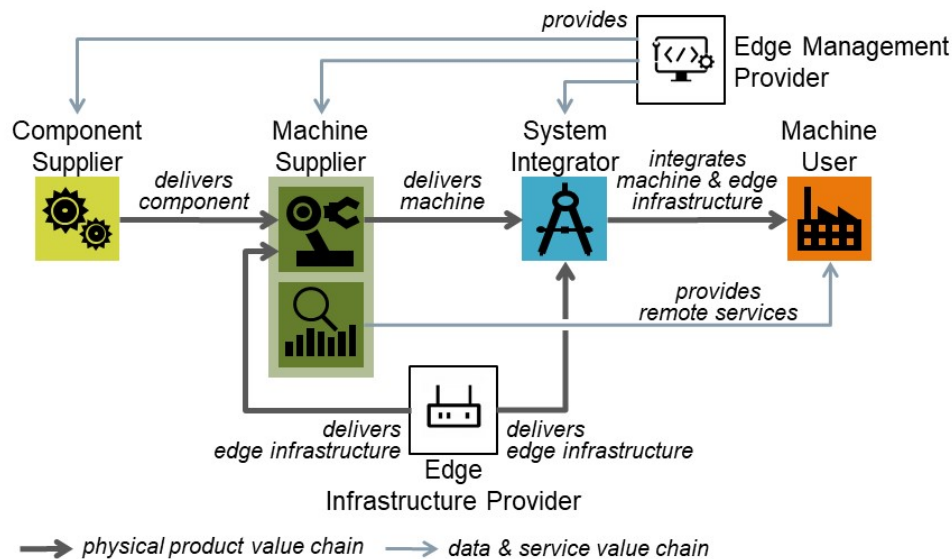

Figure 5: Future value network from the perspective of a supplier machine (I)

The overall business interest of the Machine Supplier is to *improve* the offer of remote services for the delivered machines. Today there are many different technical connectivity solutions to offer remote services in place. Sometimes these solutions are dictated by the Machine User, who follows its own IT guidelines, sometimes this also depends on the System Integrator, who has integrated a machine into a factory. As a result, the specific remote service of a Machine Supplier must be provided based on a wide variety of technical solutions, which is simply inefficient. The Machine Supplier therefore expects the *standardization* of such connectivity solutions through the new edge computing technology, which would result in an optimization of its internal business processes.

Figure 6 illustrates another future value network from the perspective of a Machine Supplier.

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[1] The possibility that such new services could be offered by an independent third party is addressed by the consideration of the System Integrator in section 3.3.3.
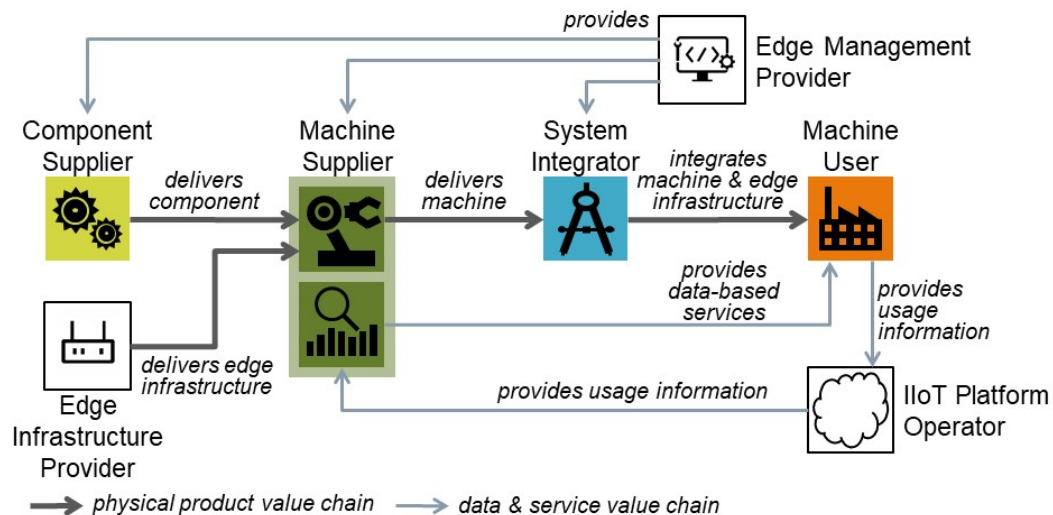
Figure 6: Future value network from the perspective of a supplier machine (II)

Here the overall business interest of the Machine Supplier is to offer in addition to the existing machine *new data-based services*. Similar as in the consideration of the Component Supplier we assume that it is in the interest of the Machine Suppliers to offer these new services themselves.

Potential customers of these new services are Machine User. The customer of these new services, for example a condition monitoring service, benefits due to an improved use of the machine based on the new services and will therefore pay for the use of these new services to the Data-based Service Provider.

In order to offer these new data-based services, the Data-based Service Provider will develop a software application and will integrate additional computing capabilities based on an edge infrastructure into the machine. The software application will be deployed on the edge infrastructure and will perform process-related pre-processing of usage information of the machine. There is used an additional edge infrastructure so that the Machine Supplier can keep the sovereignty over the machine. The preprocessed information from the machines, which are typically installed world-wide, will be gathered using a suitable connectivity solution – symbolized in Figure 6 by the business role IIoT Platform Operator. By analyzing this information new data-based services can be offered to the customer and on the other hand, based on the knowledge about the concrete usage of the machines, insights can be gained to further improve the machine technically. We do not discuss at this point whether the Machine Supplier also assumes the role IIoT Platform Operator or instead integrates someone into the value network who offers this to the market. The Machine Supplier will contractually define the access to and usage of information provided by the Machine User.

Note that this scenario is not directly a driver for the *standardization* of edge management capabilities because the Machine Supplier can select a specific Edge Infrastructure Provider along with a proprietary edge management to implement this scenario.

3.3.3 Perspective System Integrator

Figure 7 illustrates a future value network from the perspective of a system integrator.
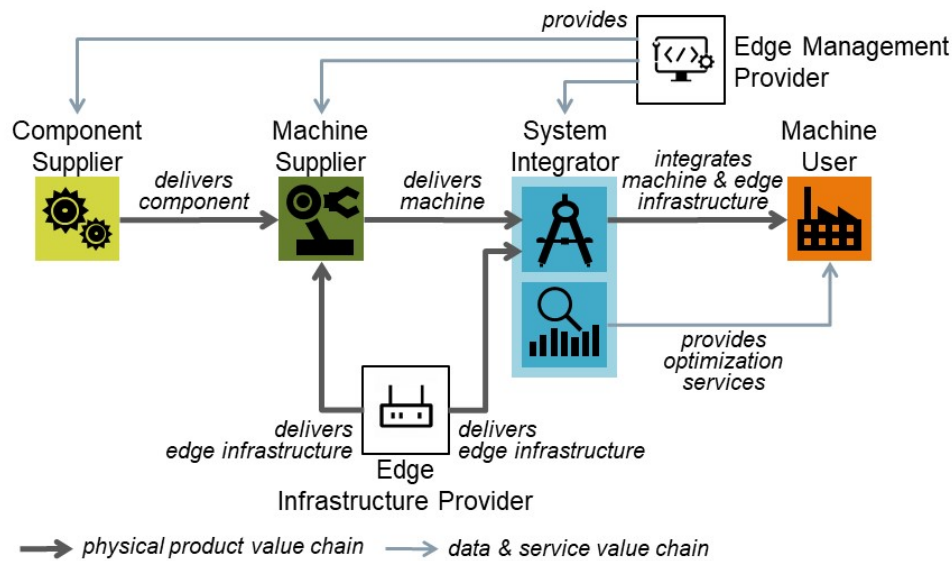
Figure 7: Future value network from the perspective of a system integrator

Based on the increasing "plug & operate" capabilities of machines and devices the effort for integration services declines. On the other hand, however, this is an opportunity to implement additional optimization services that previously could not be offered economically due to the high costs for the "basic" integration services. Thus, there is an opportunity for the System Integrator to compensate the decline in sales based on traditional integration services through *new, higher-value optimization services*. In contrast to services discussed in section 3.3.1 and 3.3.2, which are component- or machine-centered, here the focus is typically on the entire factory in order to optimize the value-added processes across machines.

Potential customers of these new services are Machine User. The customer of these new services, for example a service to optimize the throughput of a factory, benefits due to an improvement of value processes based on the new services and will therefore pay for the use of these new services to the Data-based Service Provider.

In order to offer these new optimization services, the Data-based Service Provider will provide a software application. Typically, it is not in his interest to provide own computing capabilities to deploy this software application. Instead, he requests for suitable computing capabilities provided by the Machine User. If the System Integrator also offers and implements the basic system integration services, he can consider this early in the offer and overall concept. If, on the other hand, such services are provided later – for example when retrofitting an existing factory – and existing computing capabilities are requested, the System Integrator contractually defines the use of the provided computing capabilities.

Therefore, from the perspective of a System Integrator there is a request for *standardized* edge management capabilities (offered by an Edge Management Provider) in order to offer optimization services independent of specific computing capabilities provided by a Machine User. The System Integrator will pay the Edge Management Provider for the use of the offered edge management capabilities.

3.3.4 Perspective Machine User

Figure 8 illustrates a future value network from the perspective of a Machine User.
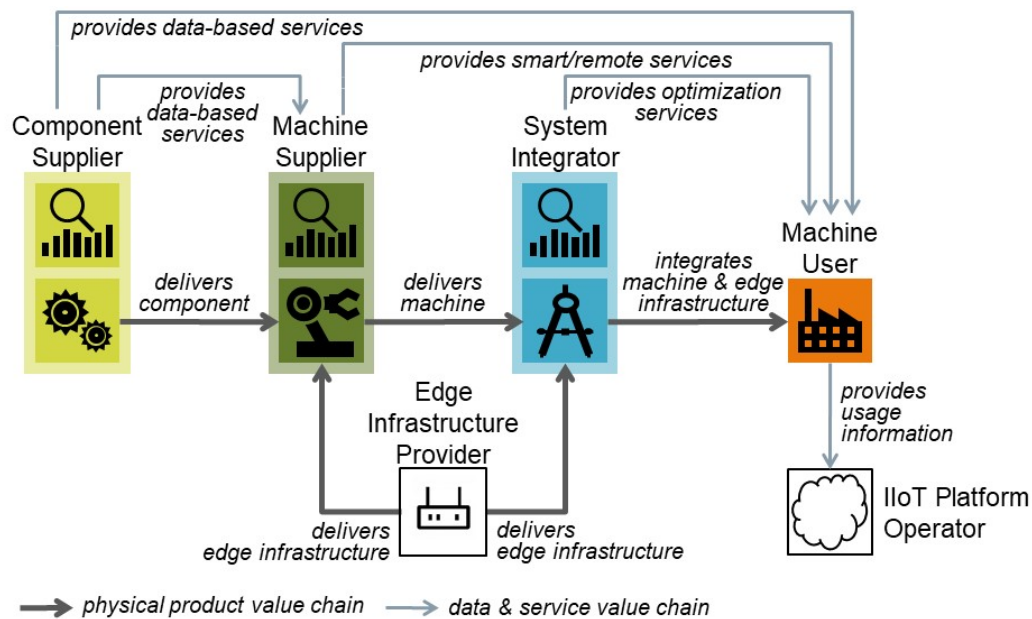
Figure 8: Future value network from the perspective of a user machine

In principle a Machine User is interested in the optimized usage of the machines and the overall factory. Therefore, a Machine User is interested in any service that supports the optimized usage, be it remote services, data-based services or optimization services, be it offered by a System Integrator, a Machine Supplier or a Component Supplier. On the other hand, a Machine User has a fundamental interest in mastering the increasing complexity arising from these various services and software applications offered by different companies, for example IT security concerns or update management.

In order to master the increasing complexity, the Machine User requests for *standardized* computing capabilities and *standardized* edge management capabilities as a lever to counteract this increasing complexity.

3.4 Conclusion

These elaborations of the business view primarily serve to sharpen the focus on the broad topic of edge configuration and to anchor the technical concept and implementation pursuit by the testbed "Edge Configuration" in a business perspective.

The considerations have shown that it is possible to derive and justify the need for standardized edge management from different perspectives. As a conclusion, we state that the emphasis should be on a unified management of software applications. Software applications should be able to be *developed independently* of a specific computing capability and *later be deployed* on a specific computing capability in the form of an edge device.

This high-level orientation, which is based on a business perspective, is now technically substantiated from an application perspective [2]. The next step is to develop together conceptual implementation within this high-level orientation.

4 Relation between Business and Usage View

Figure 9 illustrates the relationship between the business view and usage view of the testbed "Edge Configuration". In the center of Figure 9, the overview of the system under consideration and the considered roles according to [2] is shown. In addition, Figure 9 illustrates the relationships between the business roles of the business view and the (technical) roles of the usage view by showing the affiliation of a (technical) role to a business role. Note that business roles are assumed by companies as legal entities, while the roles of usage view are assumed by technical systems, humans, organizations or even a combination of these.
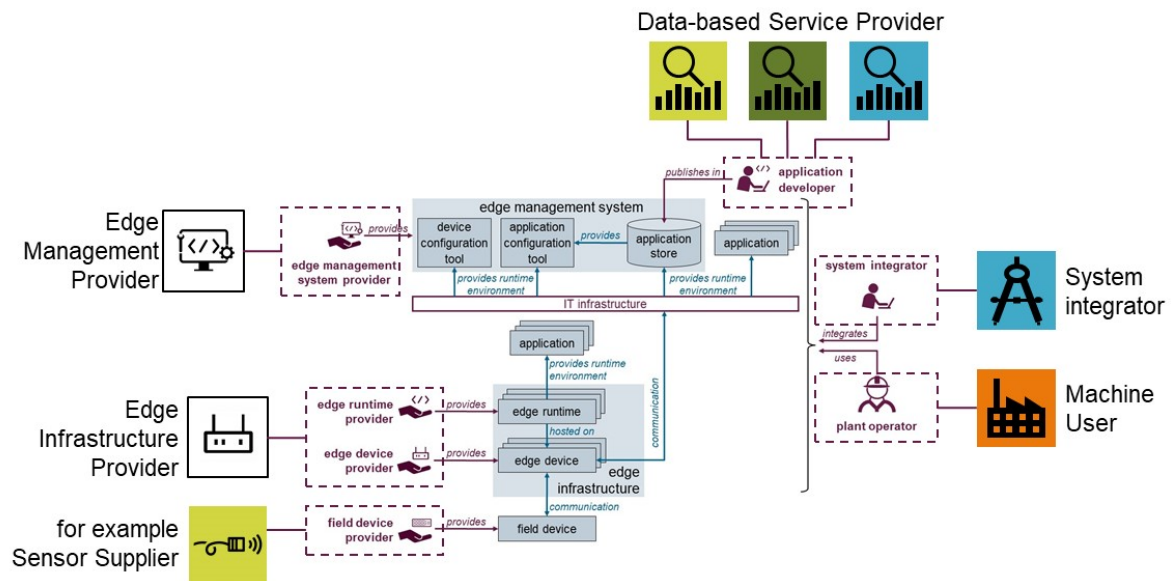
Figure 9: Illustration of relationship between business and usage view

5 References

[1] The Industrial Internet Reference Architecture Technical Report, Link

[2] LNI Testbed Edge Configuration – Usage View

[3] Digital business models for Industrie 4.0, Link

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7 Annex: Selected Examples from Companies

Still in elaboration.