



**White Paper –Edge Management –
“Options for Implementation of Business Objectives”**

**LABS NETWORK
FOR INDUSTRIE
4.0**

&

**ROBOT
REVOLUTION &
INDUSTRIAL IOT
INITIATIVE**

May 30th, 2022

In cooperation with:

 **PLATTFORM
INDUSTRIE4.0**

 **STANDARDIZATION
COUNCIL
INDUSTRIE 4.0**

Background

In February 2016, Plattform Industrie 4.0 and the Robot Revolution & Industrial IoT Initiative announced a [joint action plan](#) at the 2016 Hannover Messe. The following year, cooperation was further deepened at CeBIT and again highlighted in the [Hannover Declaration](#) (2017) between the German Federal Ministry for Economic Affairs and Energy (now Federal Ministry for Economic Affairs and Climate Action), the Japanese Ministry of Economy, Trade and Industry (METI) and Ministry of Internal Affairs and Communications (MIC). Currently, the German-Japanese partnership focuses on the topics cyber-security, international standardisation and a mutual exchange on digital business models. This whitepaper is a result of the international standardization cooperation.

The initial focus in the field of standardisation was on developing a common perspective for the use of the reference models. At the same time, the cooperation started with conceptual work such as the elaboration of the different usage perspectives to reach a common understanding on the topic of use cases. The two countries agreed that use cases are important baseline scenarios for analysing and identifying technical requirements for the implementation, extension and redevelopment of standards. The cooperation has reached a common understanding and now supports the work especially in international standardisation bodies

The partners agreed to create a common future vision of smart manufacturing standardization and establish a mechanism of proactive information exchange. Furthermore, the partners agreed to examine substantive areas in standardization and have published various publications that can be found [here](#).

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1 Abstract

The Testbed Edge Management follows an approach of describing a usage view based on an analysis of the business interests of different stakeholders, to then develop a functional and even implementation view. Based on these complementary views recommendations will be provided for the different stakeholders. In particular, the testbed will propose standardization activities on a functional and possibly also implementation level.

Since there are basically different ways of deriving and justifying the need for such standardization activities, this joint document was created because of a discussion with experts from Japan. Chapter 2 and 3 summarize the results of the analysis of the business view, see [1]. Chapter 4 provides an overview of the basic technical approach that is currently being used for the revision of the usage view, see [2]. In this context, chapter 5 then describes possible implementation paths regarding standardization.

2 Business drivers

The elaboration of the business view, see [1], can be summarized as shown in Figure 1. The three business roles component supplier, machine supplier and system integrator want – for different reasons – to offer additional services over the entire life cycle of their product (component and machine supplier) or their solution (system integrator). These additional services are based on software applications that are deployed and executed on edge devices. Typically, these three business roles cannot determine which specific edge devices are used by a machine user and how these applications are managed in

operation. For this reason, they are interested in being able to develop their software applications regardless of on which specific edge device the software applications will later be deployed and executed (“edge device agnostic”).

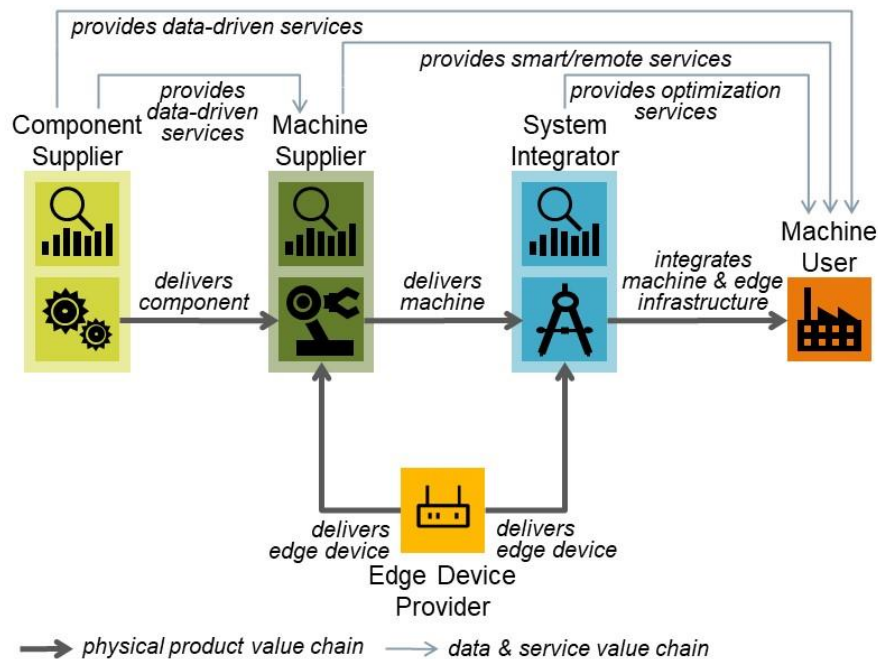


Figure 1. New service business opportunities based on software applications deployed on edge devices

3 Business approach

To implement the business objectives, it is assumed that there is a (new) business role in the form of an edge management services provider. This business role offers edge management services to be used by the other business roles. These edge management services must support the requirement, that a software application can be developed regardless of on which specific edge device it will be deployed and executed later. It is conceivable that different provider of edge management services in the market offer different capabilities. Therefore, a user can use services of different edge management service providers to achieve his goals and to satisfy the business needs of his customers. The new business role of an edge management services provider is shown in Figure 2 (for reasons of clarity the new services based on the software applications are not shown in Figure 2).

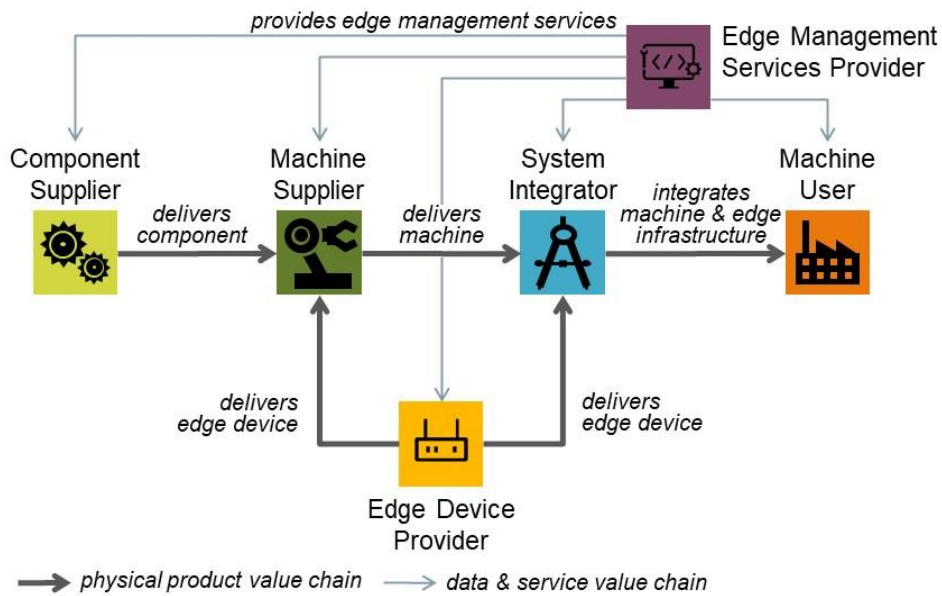


Figure 2. Business opportunity for new role edge management services provider

4 Technical solution approach

The technical solution approach will be described in a so-called usage view. There has already been published a first version, see [2], but this document is currently reworked and updated. There are described elements of a technical system together with their interactions with each other and with actors outside of the technical system under consideration. Figure 3 shows an overview of the technical solution approach.

- The elements of the technical system are shown in Figure 3 by grey boxes and the interactions between these elements by blue arrows. The edge devices are provided by edge device provider, whereas all other elements of the technical system are typically provided by one or more edge management services provider, which is elaborated in chapter 5.2 in more detail.
- The actors outside of the system under consideration are shown Figure 3 by purple icons and the interaction between these actors and the system under consideration by purple arrows. The edge device provider shown in Figure 3 is a person acting in the responsibility of a legal entity “edge device provider” according to Figure 2. The system integrator shown in Figure 3 is a person acting in the responsibility of a legal entity “system integrator” according to Figure 2. The software application developer shown in Figure 3 is a person acting in the responsibility of a legal entity “component supplier”, “machine supplier” or “system integrator” according to Figure 2.

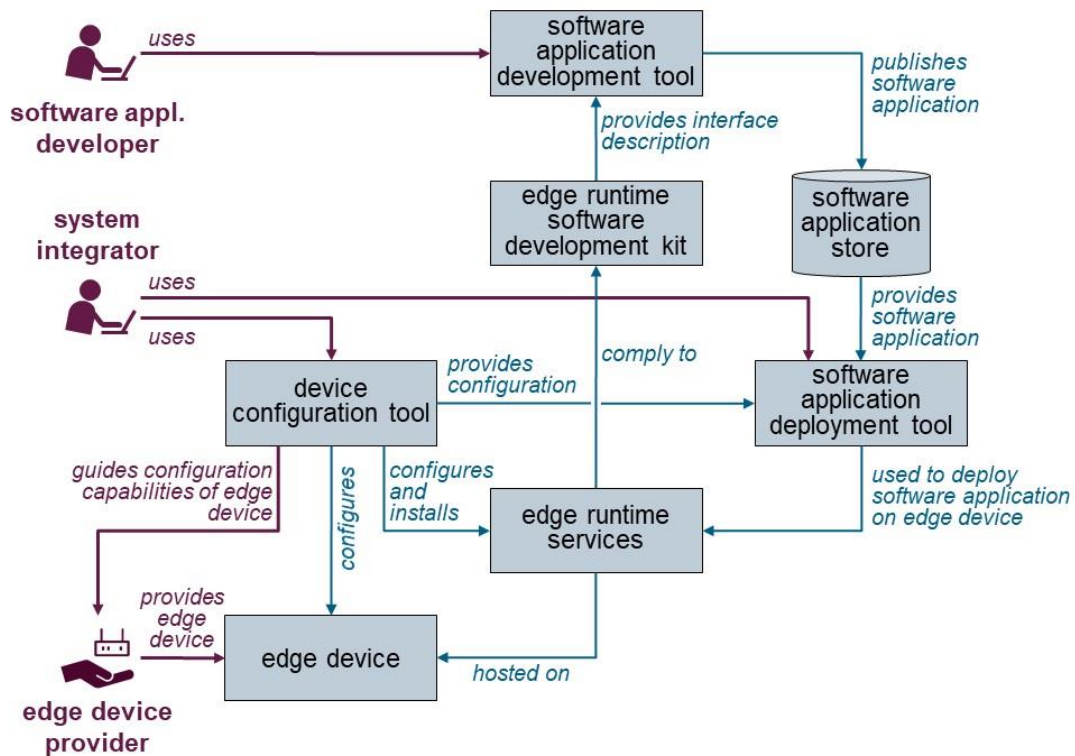


Figure 3. Overview of the technical solution approach

Figure 3 shows the following major activities:

- Development of a software application: This is done by a software application developer by using a software application development tool.
- Publishing and managing a software application in a software application store: This is done by a software application developer by using a software application development tool .
- Configuration of edge devices and their preparation for a later deployment and execution of software applications: This is done by a system integrator by using a device configuration tool. The configuration is provided to the software application deployment tool.
- Deploying a software application from the software application store and executing it on an edge device: This is done by a system integrator by using a software application deployment tool.

In addition to the activities described above, the technical solution concept also includes technical dependencies, which are marked in Figure 4 with light green and light orange background.

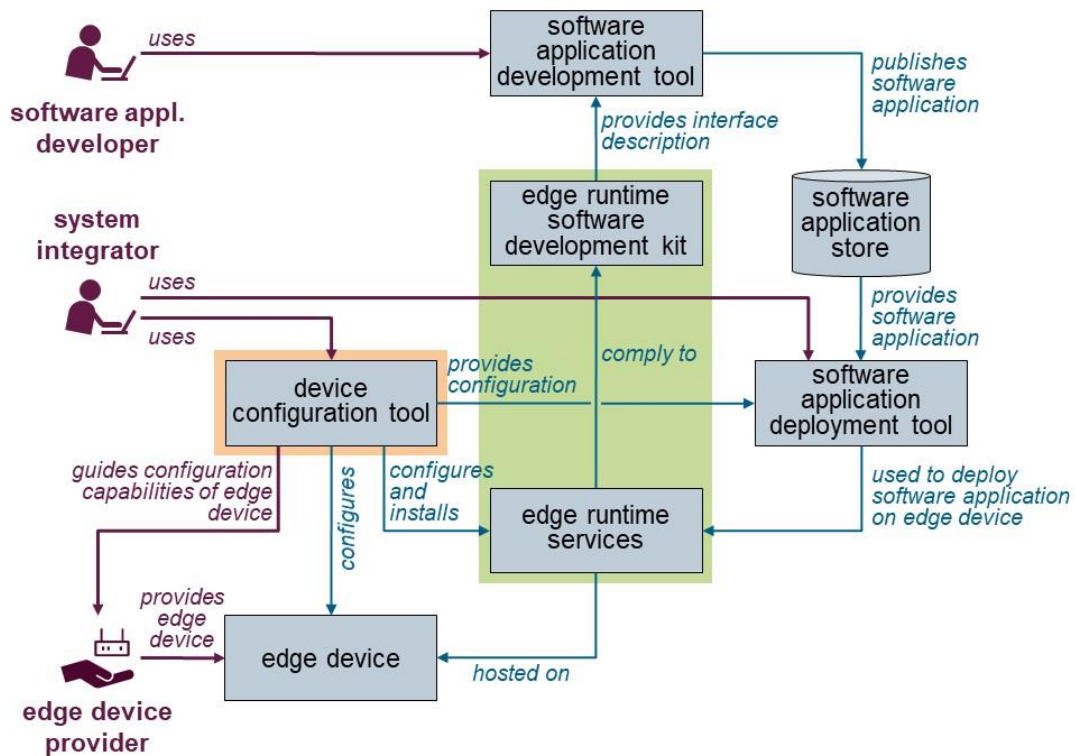


Figure 4: Technical dependencies within the technical solution approach

- The core element regarding the business drivers according to chapter 2 is represented by the light green background shown in Figure 4. There must be an agreement on edge runtime services, which are deployed and executed on every edge device on which later a software application should be deployed and executed. These edge runtime services are also specified in form of an edge runtime software development kit so that the software application developer can refer to it during the development of a software application. An edge device provider must ensure that its edge device supports these edge runtime services if the edge device provider wants to ensure the interoperability of its edge devices in the described value network.
- In addition, there must be an agreement on the configuration capabilities of a configuration tool, which is represented by the light orange background shown in Figure 4. This could be based on an international standard, but in principle it is also conceivable that it is defined by the configuration tool provider. An edge device provider must ensure that its edge device complies to the configuration capabilities agreed on if the edge device provider wants to ensure the interoperability of its edge devices in the described value network.

5 Possible implementation paths

5.1 Perspective international standardization

The development of two international standards is initiated:

- Standard for edge device configuration: The scope of this standard is indicated in Figure 4 by a light orange background. There is currently no such standard.
- Standard for edge runtime services: The scope of this standard is indicated in Figure 4 by a light green background. There is currently no such standard.

Even if there are currently no standards that meet these requirements, one should carefully consider whether existing standards can be used as a basis to be extended regarding the additional requirements. This offers the advantage of an easy migration of the installed base, which is beneficial for all stakeholders involved in the value network.

- Standard for edge device configuration: It is conceivable to suitably expand an already existing standard especially with focus on configuration of field devices.
- Standard for edge runtime services: The challenge here is to define and standardize an industry-compatible runtime architecture for edge devices. There is a high-level analogy to programmable logic controllers, where a runtime architecture for programmable logic controllers has been defined and standardized. However, it is unclear whether this approach is at all promising.

While the development of a standard for edge device configuration seems manageable, the complexity of a standard for edge runtime services should not be underestimated, since in addition to the purely functional aspects, also non-functional aspects such as security should be considered.

In addition to the technical challenges associated with the development of such international standards, the time component must be considered. Even if such two international standards should be developed, they must also be brought onto the market, which will not happen in the short term.

5.2 Perspective edge management services provider

An edge management services provider will provide the following offerings according to Figure 3:

- Software application tool including edge runtime software development kit: It is conceivable that the software application tool is made available by a 3rd party tool provider, because it can be assumed that the specific tool will not necessarily be a unique selling point of the edge management services provider.
- Software application store and software application deployment tool: These two elements are likely to be of strategic importance for the edge management services provider, since these two components are the key to retain the customers of the edge management services.
- Configuration tool: It is conceivable that this tool is made available by a 3rd party tool provider, especially if there would be at some time an international standard for edge device configuration, see chapter 5.1.

Furthermore, the edge management services provider must develop – in the current and medium-term lack of a standard – a specification of specific edge runtime services aligned with the offered edge management services. In addition, the edge management services provider must enable the edge device provider that these edge runtime services can be installed on its edge device via the configuration tool, which can then be executed at runtime. Such an enablement can take place in various ways, for example in the form of a specification of the edge runtime services only or in the form of an example implementation. In addition, accompanying certification measures must be considered.

It is subject to the strategic decision of an edge management services provider how the various offerings will be developed, especially those highlighted in Figure 4 in light orange and light green. Without claiming to be exhaustive, we illustrate in the next figures different strategic options an edge management services provider could take. Note that we indicate with a blue background the offerings provided by the edge management services provider:

- If there are neither for edge device configuration nor for edge runtime services standards established in the market, see chapter 5.1, an edge management services provider could provide an offering as shown in Figure 5. Note that it would also be possible for the edge management services provider to additionally offer a software application development tool.

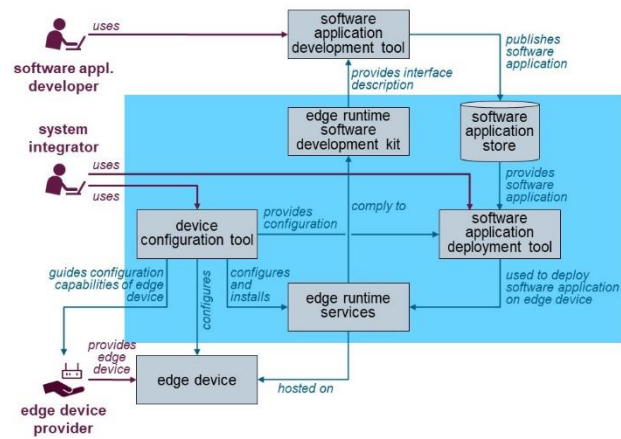


Figure 5: Offerings of edge management services provider in the absence of standards

- If there is a standard for edge device configuration but not for edge runtime services established in the market, see chapter 5.1, an edge management services provider could provide an offering as shown in Figure 6. Note that also in this case it would be possible for the edge management services provider to additionally offer a software application development tool.

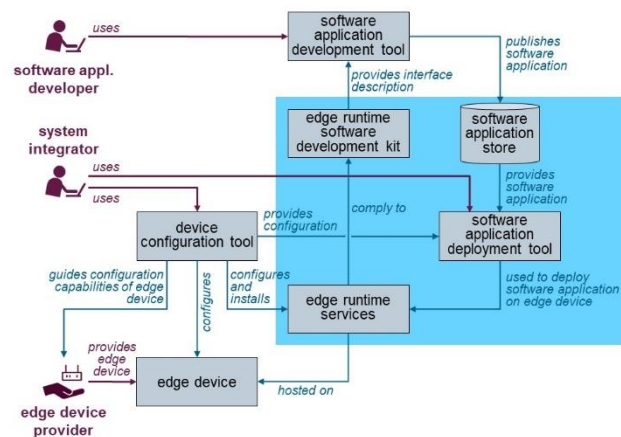


Figure 6: Offering of edge management services provider based on standard for edge device configuration

- If there are standards for edge device configuration and edge runtime services established in the market, see chapter 5.1, an edge management services provider could provide an offering as shown in Figure 7. Again, it would also be possible for the edge management services provider to additionally offer a software application development tool.

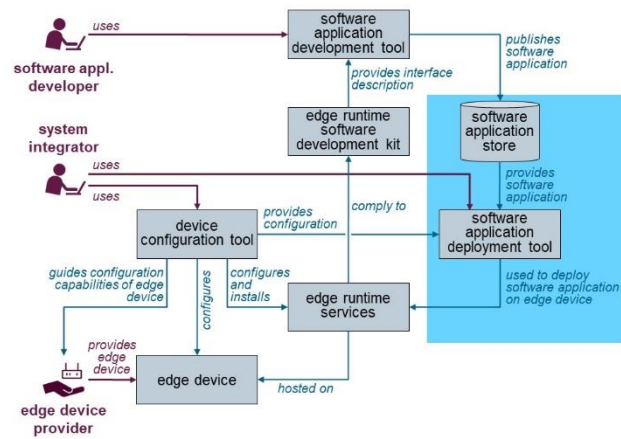


Figure 7: Offering of edge management services provider based on standards

- But instead of a standard for the edge runtime services, a proprietary commercial solution could also establish itself on the market. Figure 8 illustrates how the edge runtime services and edge runtime development kit shown in green are offered by a company independent of the edge management services provider shown in blue. The company highlighted in green could be another edge management services provider, but an IT infrastructure provider is also conceivable.

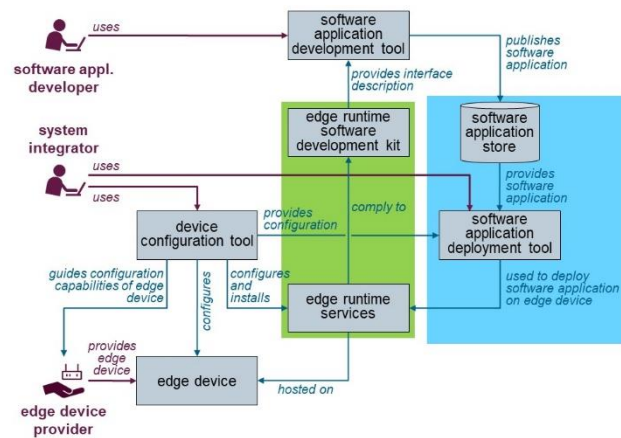


Figure 8: Offering of edge management services provider based on offering of another company

To differentiate oneself from competitors on the market, one strategy of an edge management services provider could be to convince as many edge device providers as possible to support the edge runtime services defined by him. Because the larger the supported number of edge devices, the more attractive it becomes for a user in the role of a software application developer to use his edge management services. And the more users use his edge management services, the more attractive it is for an edge device provider to support these edge management services. Thus, a so-called 2-sided platform network effect could arise, see [3] and [4], with the consequence of a lock-in effect from the edge management services provider.

In general, this possibility cannot be prevented, on the other hand, due to the heterogeneity, complexity, and dynamics of the manufacturing industries, it is not to be expected that a the-winner-takes-all situation will be established in a manageable time window.

5.3 Conclusion

From a user's perspective there is the requirement to decouple of software application development and deployment. This is illustrated by the examples described in the business view, see [1]. This results in a business opportunity for an edge management services provider. Companies seeing this as their business mission will invest in offering such edge management services on the market. It can be assumed that there will be different edge management services providers on the market, who on the one hand compete to a certain extent, and on the other hand their specific solutions will not be technically compatible.

Regarding the requirement to decouple software application development and deployment, this has the following consequences:

- On the one hand, the problem – as requested by the customer – is not completely solved because different edge management services providers are not technically compatible with each other.
- On the other hand, the edge device suppliers have an additional expense because they must support solutions from different edge management services providers.

In overall, this also detracts from the value proposition of edge management services providers in general.

A standard would help to technically harmonize the various edge management services offered on the market. However, the development of such a standard will take a longer time, see chapter 5.1.

- The experiences in the Testbed Edge Management in the context of the development of a functional view are that the specification of the edge runtime services is complex, and that the Testbed probably cannot do this at all. The specification of edge device configuration is more realistic and manageable, but this do not contribute directly to the business drives according to chapter 2.

An additional level of complexity in developing such standards is that they should not be developed from scratch. The more edge management services providers invest in their specific solutions, the more they want to secure these investments and will try to enforce their specific solution as a standard or at least incorporate it into a standard.

The developments on the market should run their course for the time being. Due to the dynamics of the topic, all these discussions of technical concepts should not be done independently of the developments in the market. In this respect, two important directions should be pursued in parallel:

- Understanding more precisely what the market really needs. Note that the exact requirements will also evolve over time.
- Better understanding of the various technical solutions being developed by the edge management services providers in terms of their similarities but also in terms of their differences.

By analyzing these developments and trends, opportunities and risks should be uncovered and incrementally transferred to proposals for concepts, solutions, and standards. The testbed Edge Management will contribute to this through updates of the Business View, see [1], and Usage View, see [2], based on experiences gained over time.

6 References

- [1] LNI Testbed Edge Management – Business View, [Link](#)
- [2] LNI Testbed Edge Configuration – Usage View, [Link](#)
- [3] Digital Platforms in Manufacturing Industries, [Link](#)
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