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Lean Services 4.0

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Imprint

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1 Management Summary

Lean Services is a management concept developed at the FIR at the RWTH Aachen University, which focuses on the avoidance of waste and the consistent alignment of service processes to achieve the highest possible customer benefit. In concrete terms, this means considering the design of lean processes while at the same time taking into account increasingly complex market and customer requirements.

The focus of Industry 4.0 is the real-time and intelligent interconnection of people, machines and software, with the aim of making complex systems transparent and managing them dynamically. Industry 4.0 can thus contribute to making the increasing complexity of service delivery manageable as a supplement to the lean services approach. However, the potential of digital technologies must first be "harnessed" by applying basic lean principles. The Lean Services 4.0 Cycle shows how companies can design this path by going through the five phases of the well-established Aachen **Lean Services Cycle**, supplemented by the three superordinate shells of **Technological Enablers**, **"Lean Services 4.0" Methods** and the **Potentials of Lean Services 4.0**.

The first phase of Lean Services 4.0 describes the continuous alignment of strategic success positions with customer benefits. Data from the customer's sphere serve as a reference variable. Output-based business models represent a promising approach within the framework of Lean Services 4.0, as they place access, use and output of a service at the center of the value proposition. Based on the definition of strategic success positions, the second phase will be used to structure and design the service offering. Marketplace approaches, as digital platform concepts, form a central key component for mastering the complexity of meeting customer-specific requirements. In the next phase of the Lean Services 4.0 Cycle, the design of efficient service delivery at process level will be considered. In a data-based image of the service organization, the digital shadow, data on service processes as well as resources used can be aggregated and made in real-time and high resolution. Mastering the complexity of service delivery at the operational level is described in the fourth phase and, according to the Lean Services 4.0 approach, requires the ability to control processes and resources using data. The concept of proactive service control offers the service provider the great advantage of identifying the optimal time for service delivery in a data-based manner and harmonizing it with their own planning and the current order situation. The pursuit of perfection forms the final phase and follows the approaches of Lean Services 4.0 of a consistent data-driven optimization of business activities. The further development of the service organization takes place step-by-step along maturity levels, ensuring that no important fundamentals are skipped while at the same time ensuring an agile and sustainable development process.

2 Reducing Complexity vs. Mastering Complexity

Over the past 20 years, lean management methods have become widely used in manufacturing companies, but also increasingly in industrial service organizations under the name **Lean Services**. By strictly focusing on customer benefit and avoiding waste ("muda"), companies can further optimize their service strategy and establish lean service processes, thus developing into a more efficient, learning service organization.

An essential aspect of the Lean Services philosophy is the fulfillment of complex market requirements with the lowest possible internal complexity in service delivery. Based on the fundamental principles of **value specification**, **value stream mapping**, **flow**, **pull** and **perfection**, the aim is to reduce the complexity of service delivery and thus improve controllability. Yet, in the context of the extensive standardization of services, processes and resources and the elimination of overcapacities companies often lose agility in practice, i.e. the ability to react to short-term changes in general conditions.

Today, however, agility is seen more than ever as a critical success factor for companies. In times of an increasing degree of digital interconnection and minimum viable products, a mentality is entering the industrial service sector that has so far only been exemplified by Internet companies (e.g. Google): New products and especially digital services are developed in highly iterative processes. To this end, customers are involved in early test phases of development and provide feedback on individual functional modules, which – in contrast to the previous approach – are only gradually assembled into a market-ready "100 percent version". But especially with the development of new digital services, companies must ensure more than ever that both the existing analog service business and the design of new digital services are geared to effectiveness and efficiency in order to meet the growing demands of customers and competitors. To achieve this, companies must not only be familiar with the products currently on the market, but also master the entire product history, which in some cases goes back more than 30 years and varies greatly from one industry to another.

Mastering this balancing act of classic and digital services, also known as ambidextry, leads to completely

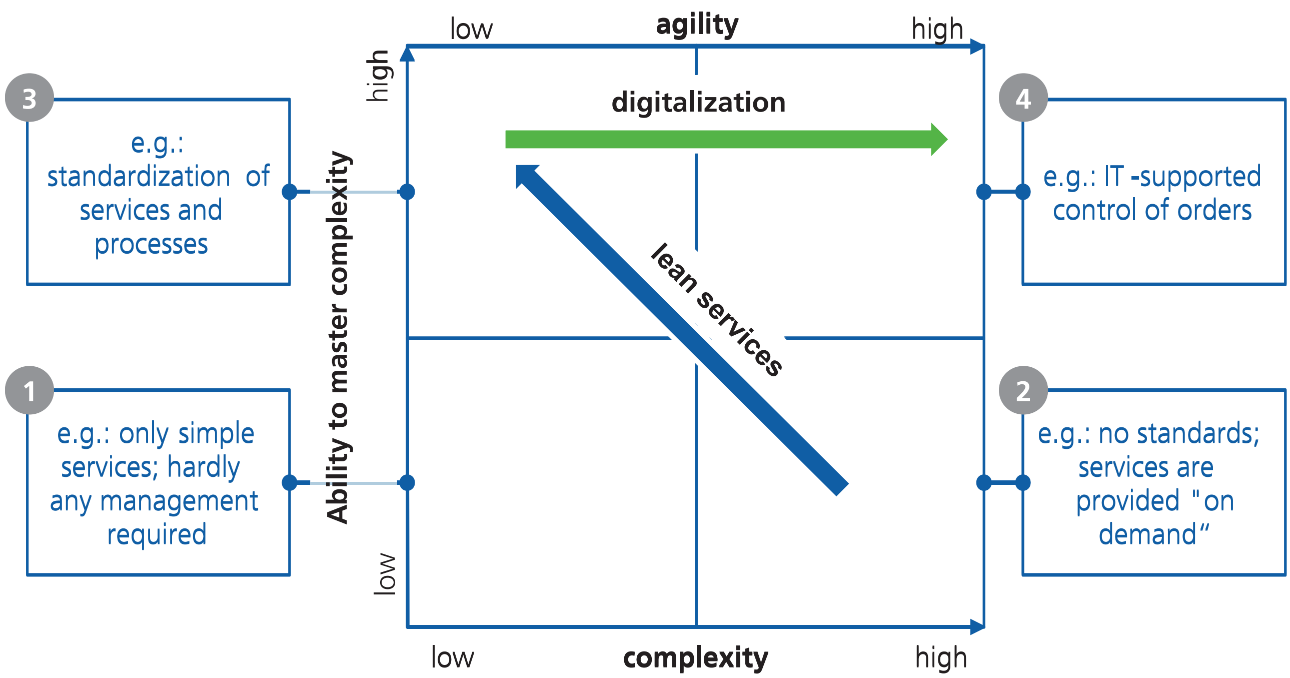
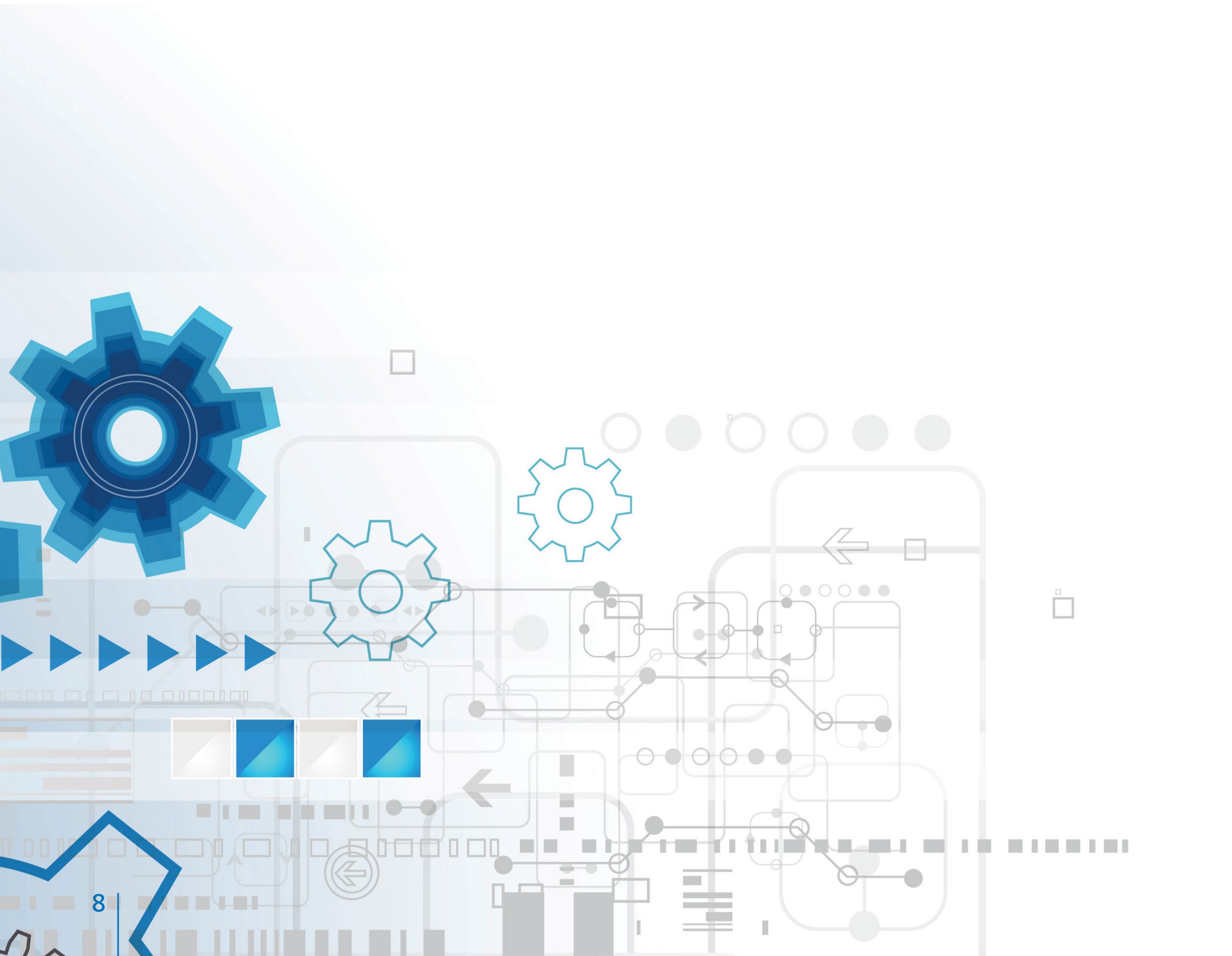


Figure 1: Mastering complexity through lean methods (own illustration following Kievet 2016, p. 43)

new demands on today's service organizations. Accordingly, existing approaches in the area of lean services must also be adapted and new approaches have to be found that enable companies to deal with these new requirements in their existing operations.

New digital technologies, which are summarized under the term "Industry 4.0", can make a significant contribution to mastering this balancing act. Here, Industry 4.0 stands for the mass combination of information and communication technologies in the manufacturing industry to create a learning, agile enterprise. In contrast to lean principles, the use of digital technologies in service is not aimed at avoiding or reducing complexity but rather at the ability of users to master existing complex systems.

While systemic complexity initially increases enormously due to comprehensive networking and automation, the mastery of complexity is delegated to digital agents that support the user via user-oriented interfaces. As a result of mastering complexity, resources are released that can be used to tailor the service organization to the individual customer. However, there is a lack of approaches that describe how to deal with this interaction in service and how to use new digital technologies effectively and efficiently in service organizations and cultures.



3 The Lean Services 4.0 concept

Lean Services 4.0 is an integrated management approach which extends on the proven tools of the existing Lean Services methodology toolkit from the FIR at the RWTH Aachen University. Adding capability through "Industry 4.0" technologies, approaches and methods. The integrated consideration of the two philosophies results in new potentials that allow companies to successfully perform the balancing act between classical and digital services. The Aachen Lean Services Cycle with its five iterative phases serves as framework for this approach. Basically, the approach is based on the insight that a service organization must first create the foundations of a professional service organization in accordance with the Lean Services principles before it can develop the potential of Industry 4.0.

The 5 phases

In phase I, the strategic positioning of the service organization in the market is defined by answering the question of what added value the service organization provides to its customers compared to the competition. Thus, the principle of **Specifying the Value** of Lean Management is taken up in this phase. Phase II includes the design and structuring of the service program, based on the strategic positioning of the service organization. The focus here is on the definition of a service program

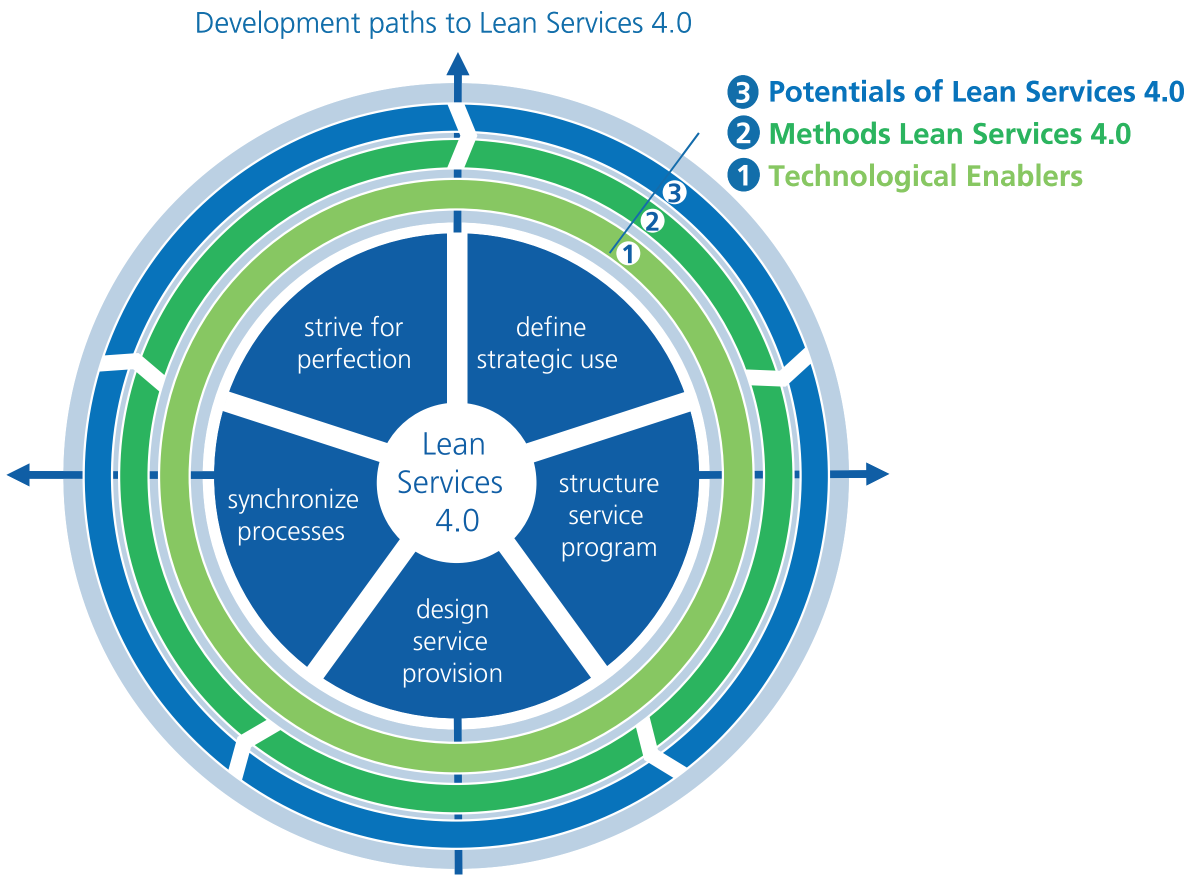


Figure 2: Layer model of the Aachen Lean Services 4.0 Cycle (own presentation following Stüer 2015, p. 183)

that best meets the customer requirements and thus also the corresponding lean principle. In phase III the processes for the efficient delivery of the service program are considered. This phase thus follows the principle of **Identifying the Value Stream**.

The planning and control of individual orders and collaboration with the customer are the contents of phase IV of the cycle. The two lean principles **Flow and Pull** are used as a basis. Finally, phase V describes the approach of continuous improvement, which follows the principle of **Perfection**.

Technologies, methods and potentials

Starting from a lean service organization, new digital technologies which make service-related data available and usable through analysis, act as a technological enabler (ring 1 in Figure 2) on the company as a whole. With the help of Lean Services 4.0 methods (ring 2 in Figure 2), waste or efficiency losses are identified specifically for each of the five phases and measures are implemented to avoid or, if necessary, reduce them, so that complexity is reduced and the potential of Lean Services 4.0 is tapped (ring 3 in Figure 2).

In the following, technological enablers will be presented first (Ring 1), before presenting both approaches (Ring 2) and potentials (Ring 3) for each of the five phases of the Aachen Lean Services 4.0 Cycle.

3.1 The “*Internet of Production*” as technological enabler for Lean Services 4.0

The first ring of the cycle describes the use of new digital technologies to manage complexity in service delivery. This enables service providers to offer their services to the market in a highly flexible, customer-specific and efficient manner. But how can companies be “enabled” to achieve a Lean Services 4.0 organization through digital technologies and what infrastructural requirements must be met to this end? These questions will be answered in the following with the concept of the “*Internet of Production*” and illustrated by means of a use case from industrial practice.

Basically, the digital transformation of a company does not mean that all IT that is already in use today will be replaced. A more promising approach is to network existing systems. After all, employees are used to their systems and many successfully deployed systems are adapted to the company's specifications. Nevertheless, it must be examined to what extent outdated systems can be extended or replaced by current software solutions.

Via a so-called “middleware+”, interfaces to the application systems as well as to the field data level can be developed. In doing so, it is important to avoid individual interfaces between individual systems while ensuring access to all relevant data sources. Data from various sources are aggregated in a comprehensive database. The aim is to create a data-based image of the entire company in real time, the so-called “digital shadow”. This requires an overarching data model of the company’s processes and resources that puts the data from different sources into a common context. In this way, a database is created across the entire company which, like a kind of “flight data recorder”, contains all relevant events and makes them accessible for analysis.

Role-specific applications are used to provide individual views of this data or analyses based on it. This can take the form of “apps” on mobile devices, dashboards in control rooms or applications on mobile assistance systems (e.g. data glasses).

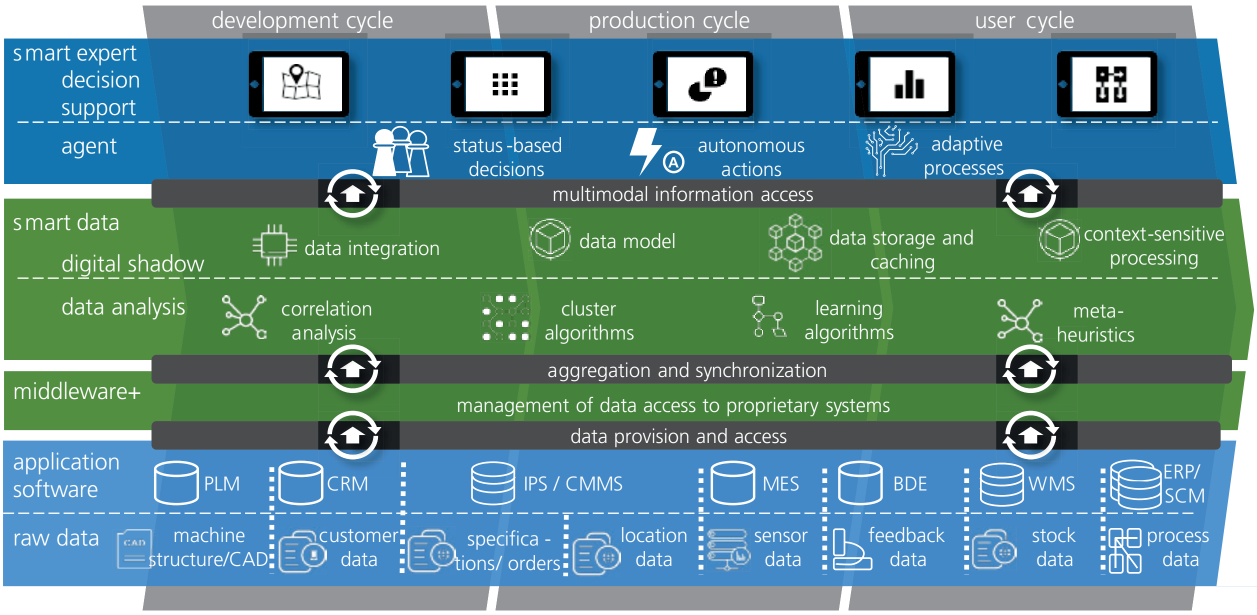


Figure 3: Technology stack of the “Internet of Production” (Schuh et al. 2017a, p. 121)

Technological enablers in a case study

In the following, we will look at a machine and plant engineering company which, as a service provider, offers reactive maintenance services along the life cycle of its plants to complement its product portfolio.

The company has designed its technology stack, i.e. the entirety of all digital technologies used in the company to provide services, in accordance with the *Internet of Production*. At the data level, the service provider uses various, sometimes completely isolated and proprietary, application systems from different providers along the service lifecycle. Two years ago, the service provider successfully implemented a service management system (SMS) as a modular extension of the existing ERP system. Recently, the service provider has been continuously equipping its customers' machine inventory with sensor and telemetry units. In addition to its own systems, it also integrates directly upstream and downstream machines from other manufacturers into the upgrade process. The company's new systems can already be read out remotely via various open interfaces and, as intelligent products, represent the carriers of future service offerings for the company.

To integrate all data sources, the service provider uses *Microsoft Azure* as the leading information system as a central cloud platform. Partially proprietarily stored raw data from the data silos are tapped via standardized interfaces and aggregated and consolidated by means of middleware (e.g. *PTC Kepware*). In accordance with the "*single source of truth*" principle, this ensures, among other things, that no duplicates are kept when data are used centrally, for example, two different customer IDs in ERP and CRM for the same customer.

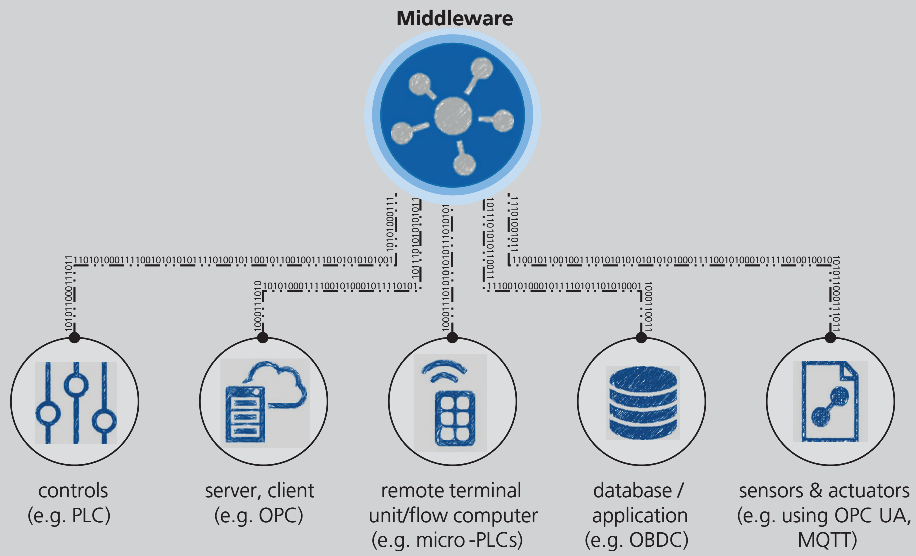


Figure 4: Integration of standard solutions using middleware (excerpt from a film (time 0:51) by Kepware Technologies / PTC Inc.)

The cloud platform provides the company with various tools for data analysis, either in the form of open programming environments or predefined analysis tools.

The company's field technicians are equipped with roaming-enabled tablets that provide real-time feedback on the current geolocation of each employee. Arrangements have been made with the works council on how to handle this data. Apps can be used to provide context-based information, such as checklists or machine parameters, on the tablets using the "push principle". Due to the underlying infrastructure of the *Internet of Production*, the apps can be developed user-specifically with little effort.

3.2 Phase I: Define strategic benefits

Principle 1: Align strategic success positions consistently with customer benefit

Just like conventional value creation, the increasingly emerging "digital value creation" must also be strictly geared to the customer benefits generated. The required ability of companies is to consistently review their own competencies again and again and to adapt them to new circumstances if necessary. This requirement is becoming more stringent against the background of increasingly shorter innovation cycles.

The approach of Lean Services 4.0 consists of continuously aligning the strategic success positions in the sense of a control loop with customer benefit. Data and information about and from customers serve as a management variable to achieve this.

Potentials: Understanding core competencies and developing new strategic success positions (SSP)

As markets become more transparent and value creation increasingly networked and dynamic, uniqueness on the market is becoming significantly more important. Companies are therefore dependent on concentrating on their core competencies even more than before. At the same time, the availability of digital technologies and the delivery of data-based, digital services are opening up new opportunities for companies to offer their competencies more efficiently on the market.

This is particularly relevant in the case of dynamic, transparent marketplaces (see also phase II), where the provider who can best satisfy individual demand wins. More than ever before, companies need to understand their own SSP or their own core competencies in the value network in order to be able to compete successfully in these new marketplaces. In this network, each organization has defined its service portfolio in isolation; according to a comparison between customer segments and the range of services to be offered in each company. However, this does not necessarily lead to customer-optimized service offerings. While traditional industrial companies, for example, have extensive domain knowledge, they are often dependent on strategic partnerships with corresponding technology providers in order to develop marketable digital services. Through dynamic collaboration in value-added networks, special competencies can be brought into a complete solution and various individual solutions can be integrated, so that companies increasingly have to distinguish themselves as competence partners or providers.

The high availability of usage data as well as process data due to the interconnection of new customer products results in new potential strategic success positions in the environment of industrial service companies. By intelligently linking data, companies can develop a uniquely deep understanding and knowledge of processes, which in turn can be used to derive implicit customer needs.[1] Thinking in terms of customer activities and processes becomes a core requirement when defining strategic benefits. In doing so, companies in all industries strive to use their resources as efficiently as possible in order to secure competitive advantages. As a result, companies ultimately expect their manufacturers and service providers to realize efficiency and productivity gains instead of simply being the operator of an asset or user of a service.

[1] s. Gebauer et al. 2017, p. 304

Approach: Output-based business models

In this context, appropriate business and value creation models must be developed: Paradigms such as “renting instead of buying” are becoming increasingly important.[2] In a first step, the data-based understanding of processes is used to realize targeted optimizations based on the available customer data. If the company strives for deeper integration into customer processes, the value proposition is supplemented by risk assumption. The prerequisite for this is the redefinition of customer benefit, in which the focus of the value proposition is no longer the physical product, but on the access, use and output of a service.

A prominent example of output-based business models is provided by *Rolls-Royce*, whose customers pay for the operating hours of the turbines instead of buying them. Another example from industrial services is provided by *Bilfinger Maintenance GmbH*, which specializes in the maintenance of plants in the process industry. Under the “aggregates pool” contract model the company offers the leasing of components such as pumps, motors and frequency converters as well as maintenance and manufacturer-independent optimization of operating conditions. The central benefit promise of this business model is the availability of the unit and compliance with defined costs.

Companies such as *Heidelberger Druckmaschinen AG* even go one step further: Within the framework of so-called “subscription business models”, an output-based business model (e.g. “pay per print”, i.e. payment for printed sheets of paper) is supplemented by the achievement of defined production and growth targets. Through digital transformation and the use of approximately 4 million data points per printing press per day, this business model is consistently oriented towards the customer. The customer no longer purchases individual products or maintenance services, but pays a fixed basic amount per output and a recurring amount for an agreed

[2] s. Tzuo u. Weisert 2018, p. 73

Company-specific strategic success positions

		Lean				Lean 4.0	
		responsiveness	performance quality	reasonable prices	integration into customer processes	customer individuality	productivity increase at the customer
importance of the SEP	up till now	2	1		3		
	starting from tomorrow				2	3	1
SEP owner	today	A	B	C	own company	D	own company

Figure 5: Redefinition of the strategic success positions (own presentation)

performance increase. In the end, both the customer and the supplier benefit equally from the increased production output of the machines and systems.

Case study

The machine and plant manufacturer is aware of the importance of analyzing customer requirements in view of the competitive market environment. Specifically, the company asks itself what contribution it can make to satisfy customer needs. In the past, the performance quality of industrial after-sales services accompanying the plants sold was identified as the central and most important feature for differentiation from competitors. Even if customers continue to demand this characteristic, it is no longer sufficient to occupy this successful position in increasingly competitive and dynamic markets. In line with the Lean Services 4.0 objective, customers are prioritizing productivity improvements in their production processes. The aim is not only to evaluate data from the customer's own plants, but also to utilize the company's in-depth technology-specific know-how to achieve sustained efficiency and productivity gains along entire production lines at the customer.

In addition, the machine and plant manufacturer wants to use the in-depth process understanding gained from the usage data of its machines for its after-sales business in order to integrate its solution even more deeply into customer processes. To this end, the company designs the productivity-enhancing services to be offered as output-based business models. The revenue for the manufacturer consists of a percentage of the savings realized by the customer in the first year after using the service.

The company is aware of its unique domain knowledge and aims to maintain its position in the value chain as the primary point of contact with the customer. For this reason, the company positions itself as a service integrator in a collaborative value network. In this network, the company aims to win over parties with strong expertise in the field of data analytics in order to be able to evaluate the recorded process data in real time. This technical know-how is not available in the company. The data in the possession of the machine and plant manufacturer are offered to other players for commercial use via standardized interfaces, which in turn enables new service offerings.

3.3 Phase II: Structuring the service program

On the one hand, the service provider's service portfolio should meet the needs of as many customers as possible by means of individual variants and needs to be comprehensible to the customer at the same time. On the other hand, it must be possible to manage the offered variance internally.

Principle 2:
Individual services through service configuration

This is done in analogy to the approach of digital platforms like *Amazon* or *eBay*: First, the offer is structured transparently. Within the given structure, the operator and third parties can offer their products and services.

The potential of Lean Services 4.0 is derived directly from the ability of companies to master the complexity of meeting customer-specific requirements. When designing the service program, both the number of service categories offered and the depth of service customization by the customer act as complexity drivers. Complexity, in turn, is directly linked to complexity costs, which consist of the provision of unused service capacities (e.g. special tools or trained employees) and additional costs for documentation and billing of an individual service.

Potentials:
Reduce complexity costs and enable customer-specific service offerings

A reduction of this cost-driving complexity in service can be achieved by increasing digital interconnection and the associated higher degree of customer integration. The automatically provided "Customer Insights" offer the potential to find out more about the real customer needs and to use these for the conscious streamlining of service offers (or variants) that are not demanded.

Furthermore, in the target image of collaborative value creation, companies gain the opportunity to make an additional value contribution to the fulfillment of individual customer needs by orchestrating service modules. For the customer, therefore, not only the service result itself represents a benefit but also the integration of different services and providers into needs-based service bundles through an intermediary.

Platform concepts represent a central key component in the context of structuring the range of services: Both own service modules can be linked in a customer-induced manner and third-party services can be integrated so that the customer perception corresponds to an individually tailored service. To achieve this, companies must make the step from rigidly defined service catalogs to dynamic marketplaces.

Approach:
Marketplace approach in the service catalog

The objective of conventional lean services approaches and methods in designing the service program is to create easy-to-use service modules that can be combined into service variants according to their combination options and interface requirements (s. DIN SPEC 77007, p. 11–12). In service level agreements, customer groups can be addressed through various, useful combination options.

By means of digital service platforms, the dynamic organization of independent components and their interfaces is successful. This first stage of customer integration offers customers the opportunity to independently

[3] s. DIN SPEC 77007, S. 11f.

put together flexible, modular service level agreements. The customer-induced configuration of linked service modules is limited by the provider's configuration systems (service configurator). These contain a knowledge base that shows whether two service modules or partial services are mutually exclusive or whether the selection of a module jeopardizes the current configuration. The creation of the rules and prohibitions requires exact knowledge of the provider about the interface requirements of the individual service modules as well as causal relationships to other resources of the company, such as employees, documents, information or operating resources. For each service module, a clear digital representation must be created that describes the service module sufficiently precisely based on its characteristics. This digital representation of the service must also show which costs and which price are to be applied in a specific combination.

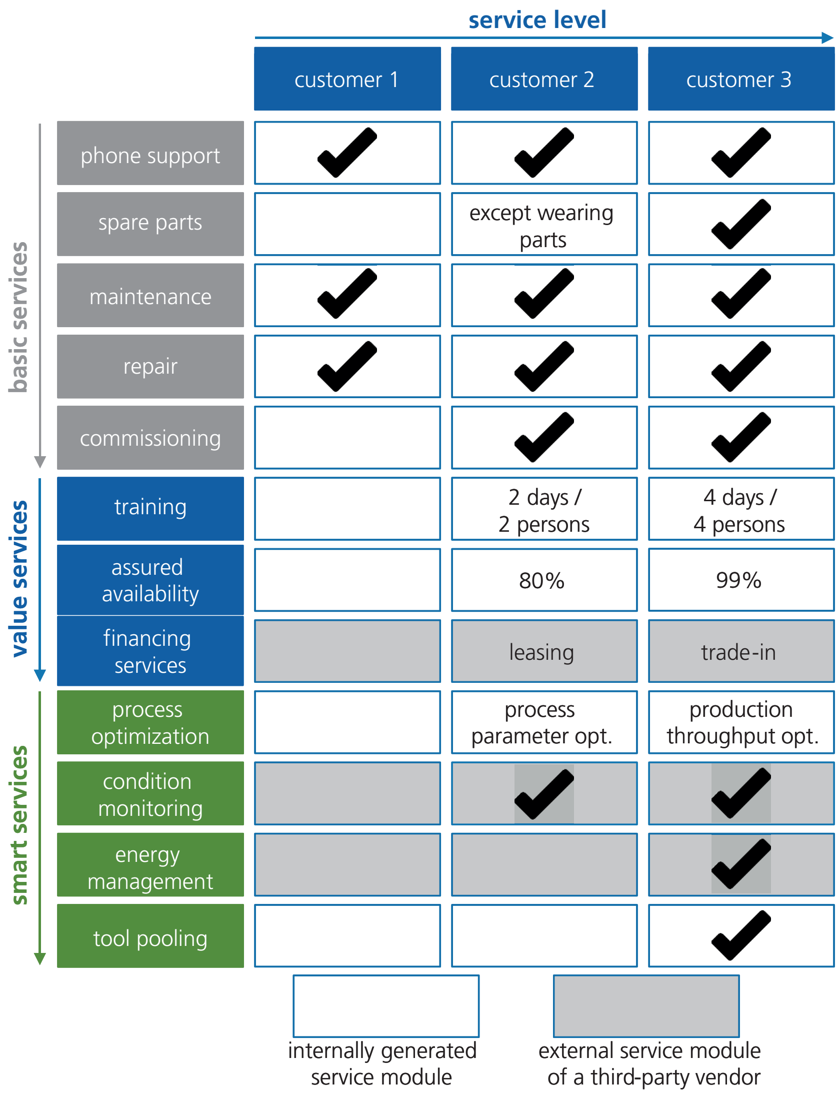


Figure 6: Example of a modular, flexible service portfolio with service level agreements involving third-party pro-viders (own presentation)

Case study

After defining its strategic positions for success, the mechanical and plant engineering company sees the necessity to structure its range of services in such a way that it can offer highly customized services and at the same time master the great variety and variance of the service modules offered. In the past, customers had the choice of three rigidly priced service levels “Basic”, “Professional” and “Premium”, each of which contains a predefined combination of basic and additional service modules (value services). The service portfolio exclusively comprised service modules that could be provided internally within the company for the customer. Individual queries were recorded either by telephone or in personal sales discussions.

As part of a transformation to a Lean Services 4.0 company, the machine and plant manufacturer decided to offer a modular service catalog online via a service platform. The aim is to pursue a marketplace approach that enables both the integration of third parties and the delivery of data-based services (Smart Services) on the basis of available customer data. Each customer should be able to configure an individual service level according to his requirements.

Pilots for certain types of new plants are initially used to introduce the data-based performance module process optimization. At the same time, dependencies between all offered performance modules are defined at result and process level and stored in an online configurator. For example, process optimization should only be offered if the customer receives at least four days of training. To integrate third-party providers, the machine and plant manufacturer is gradually opening the platform for external service modules such as financing services or energy management. To design the service structure offered as the basis for cross-company cooperation on the service platform, the machine and plant manufacturer as system integrator will successively define standards, logic, rights and obligations.

3.4 Phase III: Designing service delivery

Principle 3: Introduction of the digital shadow

In the first two phases of the Lean Services 4.0 Cycle, approaches were identified to effectively satisfy heterogeneous and rapidly changing customer requirements through specialized market positioning and collaborative value creation, as well as the customer-specific configuration of service bundles. In the following two phases of the cycle, it will be shown how customer requirements can be met internally on the process and resource level both efficiently and flexibly by a digitally transformed service organization. For this purpose, the process and organizational structure is enhanced by the digital representation of processes, resources and information as an additional component.

Potentials: Realtime data availability and process evaluation

Lean Services 4.0 discards holistically predefined services in favor of a customizable module kit. It is imperative that this change is also reflected on the process side. The transformation to a lean and digital service delivery is achieved by shortening the sub-processes and creating encapsulated process modules. By aggregating so-called digital representations of the process modules in a digital shadow, data about service processes and the resources used are available to the companies in real time and in very high resolution.

In the context of the *Internet of Production*, the digital shadow was introduced as a sufficiently accurate representation of optimized service processes and resources used. The pure generation of data from the service process is a primarily technical issue. Nevertheless, a conceptual model of the underlying processes is required to identify meaningful data collection needs. Two basic requirements must be met when selecting data points:

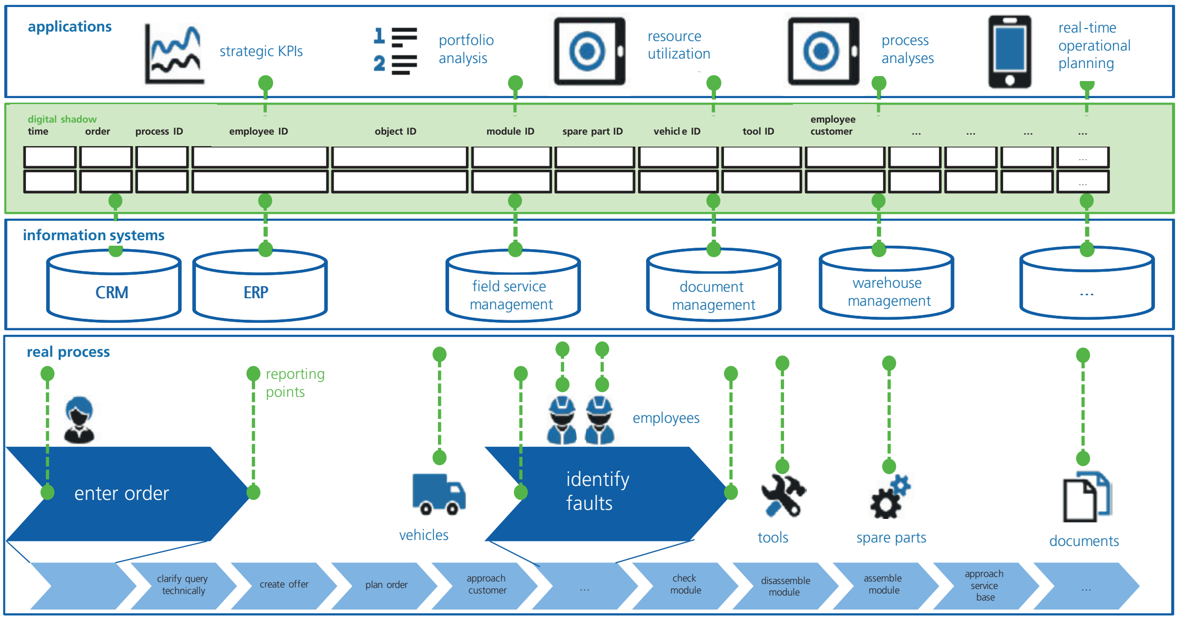


Figure 7: Concept of the digital shadow for services (Harland 2019, p. 7)

Approach: Data model for the entire service organization

- In principle, data has to be collected if they serve to create a complete digital image of the underlying real processes, procedures or conditions.
- Against the background of the demand for economic efficiency, however, the data collection effort should also be kept to a minimum.

By means of dynamic process control, the process modules can be assigned to their corresponding process IDs and all other relevant elements (resources, documents, results) for each individual order. For this purpose, processes must be mapped in the IT systems as rigidly as necessary and as flexibly as possible. The result is a digital process image that places all feedback data from the service process in context and aggregates them in the data structure of the digital shadow. This enables companies to document, account for and analyze flexible processes „at the push of a button".

In order to introduce a digital shadow, the processes in the service department should first be analyzed. The aim of the process analysis is to record a large part of the possible process steps as well as resources in service. It is therefore not necessary to include all processes in the analysis. Rather, the processes should be as complex as possible and cover as many different process steps and resources as possible. The insights gained from this form the basis for a data model that includes all so-called entities that are to be digitally mapped in the service (s. Figure 7).

Such a data model ensures that all recorded data are uniquely assigned to a specific event, regardless of its origin. This, in turn, enables the automated further processing of the data.

Based on the process analysis and the data model, acquisition technologies and data sources for the data to be acquired are selected and implemented. The focus here is on capturing as much data as possible automatically, for example using Auto-ID technologies. The digital shadow is to be understood as a living system that can be continuously supplemented by new data sources or measuring points.

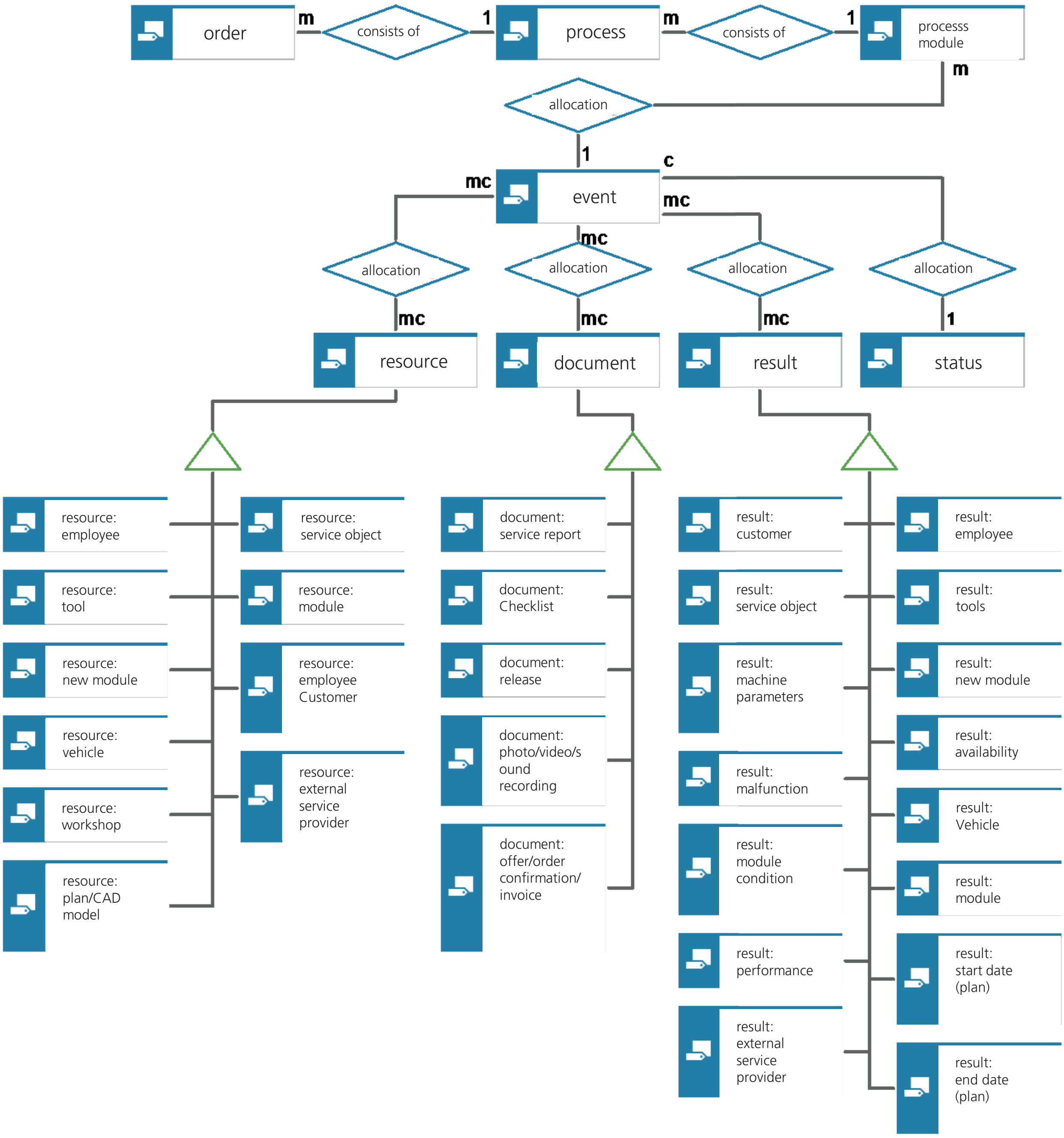


Figure 8: Section of a data model of the digital shadow (Harland 2019, p. 129)

Case study

The machine and plant manufacturer wants to create a digital image of its service processes and transfer the real order processing into the virtual world.

When implementing data recording technologies at feedback points along the service process, the focus is on the widespread use of Auto-ID technologies in order to keep the manual recording effort low on the one hand and to improve the historically poor data quality on the other. Mobile resources of service technicians, such as tools and electronic devices, are equipped with RFID tags. Wear and spare parts are already labeled with matrix codes during storage and recording in the warehouse management system, so that consumption in the field is recorded via mobile devices (e.g. smartphones, tablets) and entered in the warehouse management system in real time.

In the past, the double documentation of service activities in the field and subsequently in the ERP system was a significant waste. The data on times, work content, spare parts and materials that have been recorded automatically or manually in the field are now written directly into the digital shadow and synchronized with the respective application systems.

With this approach, the company realizes an immediate added value, as documentation and accounting processes can be carried out much more efficiently and with a lower error rate. In addition, however, the company has also created the basis for comprehensive, data-based analyses across the entire service organization. For example, it is now possible to optimize spare parts inventories, derive training requirements in a targeted manner or precisely determine the profitability of individual partial services.

3.5 Phase IV: Synchronize processes

Principle 4: Introduction of forecast-based planning and control

In order to effectively manage the complexity of service delivery at the operational level, the Lean Services 4.0 approach requires companies to build the capability of data-based management of their processes and resources. This is not so much about being able to respond quickly to customer requests but rather about proactively identifying and even forecasting customer needs on a data-driven basis. Interfaces between the customer systems and the own service management system additionally facilitate an automated synchronization of the processes for service delivery and lead to shorter throughput times and the smoothing of the provided capacities (e.g. service personnel).

Potentials: Efficient allocation of resources

In the classic Aachen Lean Services Cycle, the synchronization of processes aims to achieve the most efficient service delivery through optimal resource allocation and control. This objective remains fundamentally the same in a transformation to Lean Services 4.0. Increased productivity through more efficient resource planning represents one of the greatest potentials of digitalization in service. Due to the comprehensive real-time availability of data and the transparency generated from it, existing levers are gaining in importance on the one hand, on the other hand new methods can be derived.

By using assistance systems, the allocation of responsibilities and orders to the available service technicians can be carried out without consideration of limiting qualification requirements. The corresponding interface technologies between digital assistance systems and service technicians, such as augmented reality or virtual reality, represent great potential for industrial service.

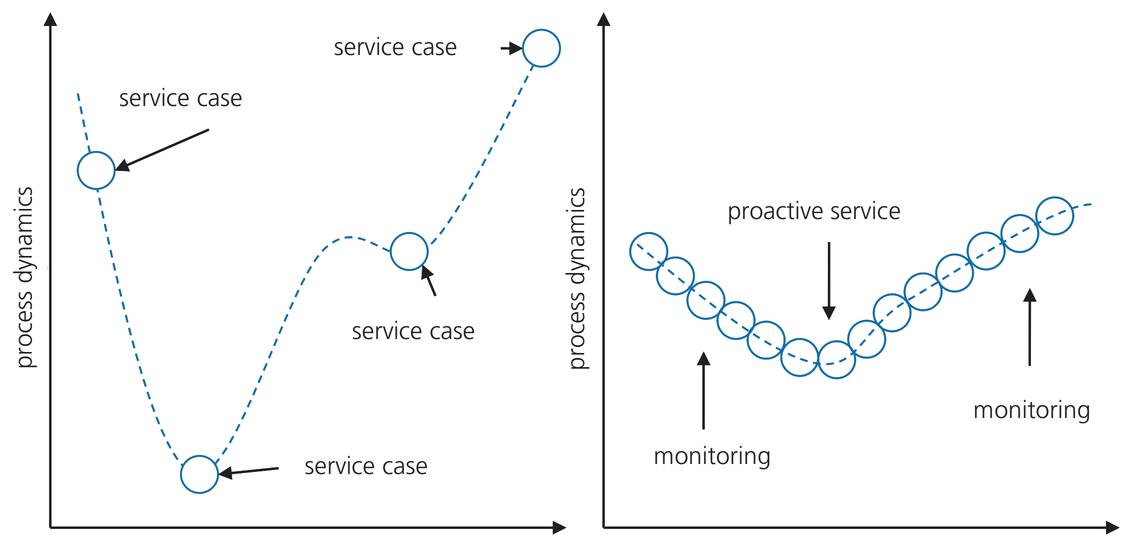


Figure 9: Offering proactive services reduces process dynamics (Stich et al. 2015, p. 109)

Approach: Proactive service control and use of digital assistance systems

By offering proactive services for the assumption of responsibility (output-based business models, s. phase I), the provider has the advantage of reducing his own process dynamics. By means of condition monitoring and downstream analyses (e.g. the use of machine learning methods), service requirements or downtimes of machines and systems can be predicted more accurately (predictive maintenance) and thus better planned. Whereas in the case of a reactive planning paradigm, the service provider must react to customer demand more or less without warning and, if necessary, still meet prescribed reaction times, the offer of proactive services gives the service provider the opportunity to realize the optimal time of service delivery in coordination with his own planning and the entire current order backlog.

While proactive service management focuses on smoothing on the demand side, the more flexibilization of resources on the supply side aims at the ability of a company to react to remaining fluctuations.

In contrast to the cost- and time-intensive qualitative adjustment, such as the multiple qualification of employees in the conventional lean management approach, a "*qualification on demand*" takes place within the framework of Lean Services 4.0. In this process, the ability of untrained personnel to act is enhanced by assistance systems. In a first step, standardized process sequences are completely automated without decision situations and the service technician is relieved. In processes under uncertainty, digital agents support the service technician in a context-sensitive manner by enabling status-based decisions and autonomous actions. The digital shadow of the service processes thereby serves as a database for all assistance systems.

However, the introduction of assistance systems alone does not create added value for companies. Rather, it is essential to create a corporate culture in which employees trust such systems and rely on the advice of digital agents before implementing assistance systems.[4] In addition, existing data must first be converted into a format that is suitable for data glasses, for example. This process must continue to be automated or integrated into the operative processes in order to enable an economic use of the technologies.

[4] s. Schuh et al. 2017b, p. 34

Case study

Already in the context of redefining the strategic benefit, the machine and plant manufacturer decided to design its services according to output-based business models. Within the frame-work of various service levels, the company offers an integrated assumption of responsibility for line output at the customer's site. This requires full integration into customer processes, but also enables a change to condition-oriented maintenance based on continuous condition monitoring.

Dispatching and detailed planning of orders is carried out completely autonomously on the basis of the real-time available position data of the service vehicles and feedback data of the service technicians on the order status. Already during the work preparation of maintenance orders, machine data as well as error patterns are compared with historical data and the spare parts that could solve a similar case in the past are scheduled. In this way, a sufficiently high probability of availability of the necessary spare part on site can be ensured. On this basis, the vehicles are autonomously supplied overnight by a logistics service provider.

After the service technician arrives at the customer's premises, they follow the in-house navigation on their tablet to the place of performance. The quality and efficiency of service delivery is increased by the remote diagnosis carried out in advance and the context-sensitive provision of checklists, service histories and machine structure data via the mobile device. In the event of critical complications on site, the service technician can be guided by colleagues with appropriate expertise via data glasses.

3.6 Phase V: Striving for perfection

The experience gained from the widespread introduction of lean principles in service has shown that a change in culture in the minds of the employees involved is primarily to be seen as a central success factor. This premise is becoming even more important in the course of the digital transformation to a learning, agile company in Industry 4.0. With regard to the striving for perfection within the framework of continuous improvement and a learning organization, there is a large overlap in the goals and methods of “lean” and “Industry 4.0”. Common to both philosophies are the active shaping of change and continuous improvement. The core of Lean Services 4.0 as an integrated approach of both philosophies is data-based learning as a further development of the conventional Plan-Do-Check-Act cycle.[5]

Principle 5:
Continuous, maturity-based monitoring of the organizational development

Companies that base their pursuit of perfection on the principles of Lean Services 4.0 operate a strictly data-driven optimization and adaptation of their business activities in a digitally accelerated PDCA cycle (Plan-Do-Check-Act cycle). Continuous improvement is based on action-guiding maturity models, which allow the design of a structured and defined procedure for a step-by-step transformation to a learning, agile organization. In terms of an integrated approach Lean Services 4.0, the maturity level on the development path towards Industry 4.0 and the Lean Performance maturity level in a company must be recorded and evaluated. Likewise, the effectiveness and efficiency of each transformation decision must be quantified in a data-based manner and aggregated into key figures. This is the only way to ensure that lean methods and approaches are implemented sustainably throughout all phases of the Lean Services 4.0 Cycle, that the necessary skills for Industry 4.0 are learned step by step, coordinated with each other and built up in an economically successful manner. The targeted further development towards a more effective and efficient (service) organization in terms of Lean Services 4.0 thus gains speed and sustainability.

Potentials:
Sustainable and agile further development of the service organization

As described, maturity levels offer the opportunity to transparently map the status of one’s own organizational development and to profitably synchronize further development measures. An example of such a framework is the “acatech Industry 4.0 Maturity Index”, which shows the development path from business organizations to Industry 4.0 on the basis of six maturity levels: **computerization**, **connectivity**, **visibility**, **transparency**, **predictability** and **adaptability** (s. Figure 10). The levels of maturity are collected in a company-specific manner in the four design fields of **organizational structure**, **IT systems**, **resources** and **culture**, which enables a differentiated view and evaluation of the company’s development.

Approach:
Maturity-based further development

The determination of the “gap” between current and targeted maturity level is achieved by a reflected recording of the actual situation for each of the four design fields. The creation of a common basis in all design fields on which to build successively is essential. Along the six maturity levels and within the four design fields, concrete measures can be compiled in a transformation roadmap in such a way that a step-by-step and coordinated further development of the service organization

[5] s. DIN SPEC 77007, S. 49

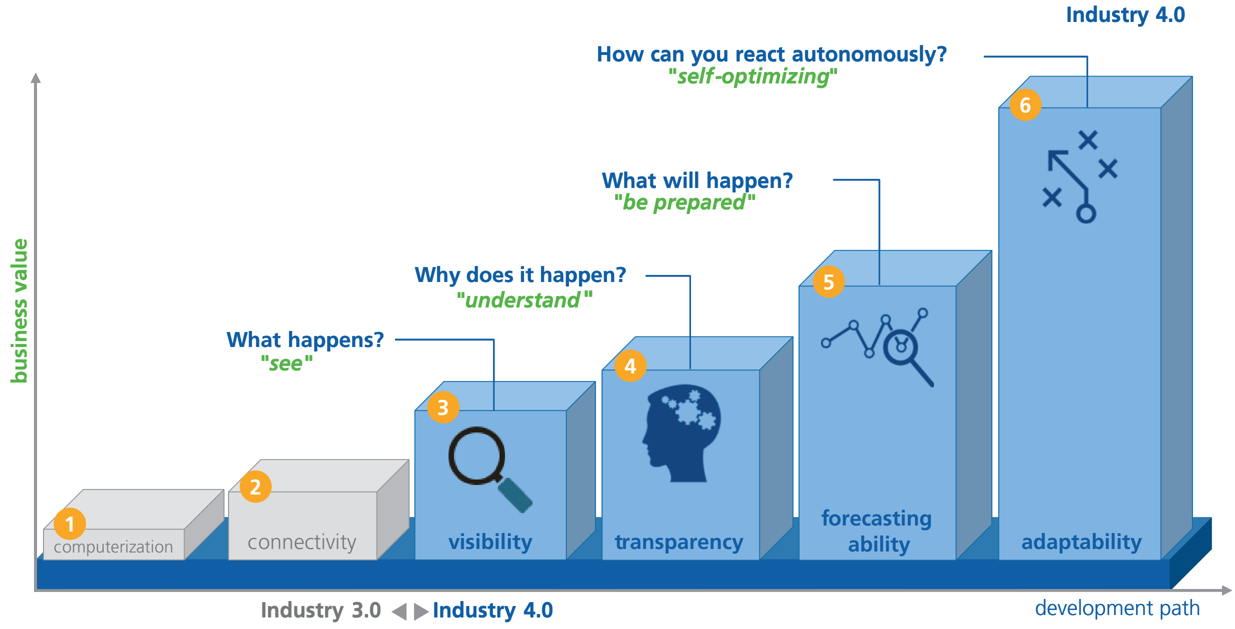


Figure 10: The 6 levels of the "acatech Industry 4.0 Maturity Index" (SCHUH ET AL. 2017b, p. 16)

is guaranteed.[6] The implementation of the measures using classic lean methods[7] must be constantly monitored and checked for their effectiveness. Indicator systems and central KPIs (*Key Performance Indicators*) are regularly discussed for this purpose at shop floor level and expanded as necessary. In this context, too, the digital shadow, as the goal of the third maturity level (visibility), forms the necessary basis for increasing the quality of the key performance indicators/KPIs on the one hand and for automating their calculation on the other.

[6] s. DIN SPEC 77007, p. 21 ff.

[7] s. Whitepaper "Smart Maintenance, einfach machen!" by DEFER ET AL 2019, available via the following link: sm-einfach-machen.fir-whitepaper.de

Case study

The company applies the logic of data-based learning to all four phases described above. The digital shadow over the entire service organization allows well-founded decisions to be made on strategic decisions and decisions affecting the service portfolio as well as on process optimization and alternative control and planning scenarios.

Thus, the company regularly evaluates the profitability of each partial service and adjusts the portfolio accordingly. In a similar way, the company evaluates its customers and uses historical data to check whether, for example, output-based business models are economically viable for certain customers.

During the continuous optimization of processes, the company identifies waste in a targeted manner based on the digital shadow. In a weekly shop floor round, outliers in the key figures (e.g. travel time share, low MTBF in certain areas) are analyzed and measures are derived. The shop floor round is supported by an individually adapted key figure cockpit, which automatically calculates the key figures.

A digital app-based suggestion system will be implemented across departments to enable agile change management in product development and service process design in real time. Employees from assembly and field technicians have the possibility to initiate a digital change workflow via mobile devices. Images and error images are automatically attached to the improvement suggestion. In the digital shadow, synchronization with relevant information on affected resources, documents and current machine status messages takes place. When the improvement suggestion is implemented, direct and indirect effects are tracked out of the digital shadow through the before-and-after comparison of process data (error messages, damage images, process key figures) and communicated to the person making the suggestion as required. In addition to increased agility in development and adaptation of products and processes, transparent communication promotes the constructive handling of errors in the sense of a learning organization.

4 Conclusion

The described procedure enables the integration of existing Lean Services approaches with the digital technologies of Industry 4.0. These technologies serve as technological enablers within the framework of Lean Services 4.0 and make the potential available on the way to a learning and agile service organization. Therefore, it is not a question of rejecting the proven approaches of Lean Services – rather, they form the basis on which the further development of the service organization is driven forward.

The five phases of the Aachen Lean Services 4.0 Cycle provide a way for companies to manage the increasingly individual customer requirements and the complexity resulting from the balancing act between digital and classic service delivery (ambidextry). To achieve this, it is not sufficient to consider and implement individual steps or approaches in isolation, but a holistic assessment of the presented lean principles in combination with the new possibilities of digital interconnection must be carried out. In the form of a maturity-based transformation process, the sustainable implementation of Industry 4.0 with the goal of a learning and agile service organization can be realized and perfected.

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6 The FIR as competent partner in practice

The FIR is a non-profit, cross-sectoral research institution at the RWTH Aachen University in the field of business organization and corporate development with the aim of creating the organizational foundations for the digitally networked industrial company of the future.

The institute accompanies companies, researches, qualifies and teaches in the areas of service management, business transformation, information management and production management. As a member of the German Federation of Industrial Research Associations, the FIR promotes research and development for the benefit of small, medium and large companies. Since 2010 the managing director of the FIR, Professor Volker Stich, has also been heading the Smart Logistics Cluster on the RWTH Aachen Campus. The Smart Logistics Cluster is one of the six start clusters on the Melaten Campus. More than 350 people from science and business research and develop solutions there to optimally network goods and information in a digital world of the future. Oriented towards a completely new form of cooperation between research and industry, the complex interrelationships are made tangible in real production and IT environments.

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