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Lean as a Design Approach for Industrial Communication and 5G

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Content

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01 Introduction

The implementation of the Industry 4.0 strategy to secure and develop Germany as an industrial location is closely linked to the use of new information and communication technology (ICT). To a certain extent, ICT forms the **backbone and nerve pathways for networked socio-technical systems**. With the latest development in ICT such as 5G, it is not just a question of improving performance values (latency, throughput, scalability) but also of providing the capacity to make communication services available at any time and anywhere in accordance with needs in a flexible and cost-effective way. These requirements emerge against the background of the increasing networking in companies (vertical digitization) and also beyond company boundaries in the direction of **networked value creation chains** (horizontal digitization). The associated increase in complexity and heterogeneity of ICT presents not only the network operators but also the user industries with major challenges. The question is: how can a suitable communications infrastructure (CIS), including all the systems for data capture/output and transmission and now also data storage and analysis along the communication pathway, and their orchestration (configuration and management) be developed and organized in a way that satisfies requirements and yet remains manageable?

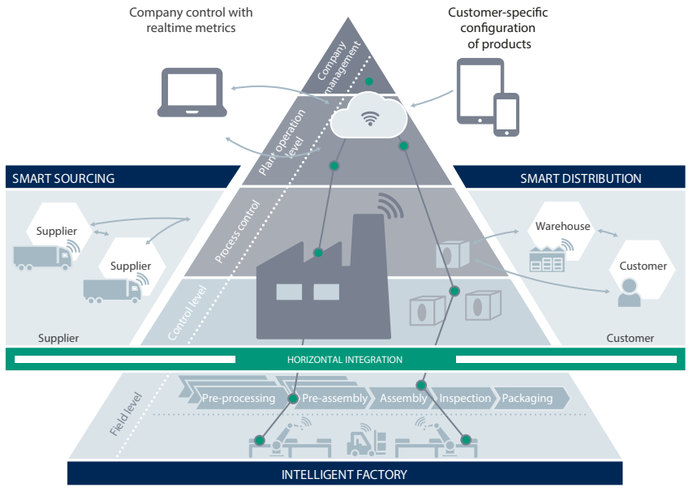

Fig. 1.01: Communication infrastructure as the basis for digital corporate communication

In the past, organizational approaches under the heading “lean” such as lean management or lean production have been pursued successfully to overcome similar challenges, e.g. in the context of automation, with the help of specific principles. Industry 4.0 refers to intelligent networking of people, machines, objects and processes in industry. An extended lean perspective is required in this context. **Communication technology must be included in the lean perspective** to make it possible for companies to organize and develop this highly dynamic area of technology.

An attempt will therefore be made below to apply the principles of lean management to the area of ICT and hence to include consideration of the role of 5G technologies and solutions. **Lean industrial communication (LIC)** can be regarded as a form of application of lean management (LM). As an organizational concept it pursues the objective of optimizing communication along an industrial value creation chain, i.e. designing it efficiently and with a focus on the customer. This should optimize the quality and flexibility of the value creation process (e.g. batch size 1 or changing products) including beyond company boundaries.

In contrast to lean management, in the context of communication both people in their various roles (management, IT/OT managers, employees in production, etc.) and the individual machine are regarded as **customers**. **Efficiency** in this context means providing the person and the machine with the information he/it requires at a specific time or on a specific occasion with as little effort as possible (e.g. with effective use of resources) and making the experience-based knowledge that is gained at the same time available to others.

02 Application of the 10 Principles of Lean Management to Industrial Communication

The aim of lean management as an approach is the efficient organization of value creation processes. This organizational work is regarded as a continuous task that enables a response to changing market requirements and technological developments. Defined principles form the basis for assessment and derivation of measures to be taken. The 10 principles of Graf-Götz and Glatz (Friedrich Graf-Götz, Hans Glatz: Organisation gestalten. Beltz-Verlag, 2001) are used as the basis for what follows.

Starting from the respective definition in lean management, formulation of the principles for lean industrial communication lie at the center of the following explanations. In addition, the principles are applied to the technical level of the communication infrastructure and to the identification of a possible contribution of 5G to the design of that infrastructure.

Principle 1: Alignment of all activities with the customer
In lean management this first principle starts from the idea that minimization of the process costs leads to attractive prices, which can develop strong customer loyalty. In addition, customer requirements such as availability, quality and individuality are taken into consideration.

The translation to lean industrial communication makes communication the central organizational element. It creates an individual information principle for the decisions and actions required at each moment that is optimal for the current process. Decision-making processes are thereby improved and accelerated, and the effectiveness of actions is optimized in terms of quality.

Aspects for implementation of the communication infrastructure (CIS):
- Adaptation to the specific requirements of the applications that the CIS uses by dynamic orchestration and expandability of the network to the running time
- Provision of the necessary information depending on the customer and the process, taking account of the time and volume-related requirements

Principle 2: Concentration on one's own strengths
In lean management, the principle of emphasizing one's own strengths is intended to lead to them becoming better and more efficient in order to consolidate the market position. Here it is a matter of identifying and eliminating superfluous or even bad processes.

The translation to lean industrial communication focuses on effectiveness (doing the right thing) and thus on domain knowledge as the basis for effective, customer-focused communication. The central question is: which data and information are particularly useful at what point and at what time? It is therefore a matter of application-specific expertise and concentration on key information that the communication system should provide. A second important aspect is the optimal architecture and configuration of the communication infrastructure required for this.

Aspects for implementation of the communication infrastructure (CIS):
- Optimal utilization of various technologies by adapting the processes used and locating functions
- Utilization of users' domain knowledge to set up and expand the CIS. For example, information should be used for local topology
- Simple scalability of information processing and storage in the network
- User-friendly configuration and operation of the entire CIS

Principle 3: Optimization of business processes
In lean management, this principle is used to eliminate or revise unnecessary procedures to increase company efficiency. To do so, it must be determined in advance which processes are particularly susceptible to faults and errors and how these can be rectified.

The translation to lean industrial communication puts the value creation process and thus efficiency in ongoing operation at the center. Data and information must be available in the necessary quality and to the necessary extent where they are required or recorded at the point at which they are created. Value creation processes can be improved and accelerated in this way.

Aspects for implementation of the communication infrastructure (CIS):
- Software-based adaptation of the communication infrastructure to dynamically changing requirements and performance parameters (efficiency)
- Possibility of placement of information processing and storage on the basis of knowledge of the application along the network. Processing on site (edge cloud) when, for example, low latencies are required
- Use of machine learning (ML) / artificial intelligence (AI) for self-optimization and dynamic system adaptation with the aim of resource optimization

Principle 4: Continuous improvement of quality
In the sense of lean management, this principle requires processes in the company to develop continuously and to adapt to circumstances, against a background of continuous change in both market demand and customer requirements. Various methods have become established for this, such as the continuous improvement process (CIP).

In the context of lean industrial communication, the principle requires communication to adapt continuously to the requirements of the value creation chain and to remain capable of evolving in order to make a contribution to securing and improving product or performance quality. At its heart is software-based flexibility (orchestration and network function virtualization).

Aspects for implementation of the communication infrastructure (CIS):

- Orchestration of current applications and available network resources
- Monitoring of capacity utilization, throughput rates, quality of service and electricity consumption
- Evaluation of the measurement results and assessment of efficiency by performance indicators
- Analysis of external influences such as interference and identification of the parameters required to compensate for them
- Continuous focus on new technological options and expansion of the functional
- options (new software, for example)

Principle 5: Internal customer focus as corporate mission statement

Lean management defines every employee in a company as both a supplier and a customer. The employee supplies or receives products, services or information with the aim of refining them further or using them optimally for value creation.

Lean industrial communication means maximum transparency regarding one's own performance data, including electromagnetic emissions, data security, and maintenance statuses. The health and protection of employees is of utmost importance. But the fifth principle also means that technical and application-related skills in the company are identified and exploited. This supports the company as effectively as possible and unrestrictedly across the whole range of applications. The company is able to use the communication infrastructure efficiently and for optimal value creation.

Aspects for implementation of the communication infrastructure (CIS):

- Compliance with all safety regulations and regulatory requirements, including health and environmental protection
- Implementation of principles of eco-design, green procurement and socio-economic sustainability
- Establishment of the idea of the life cycle, e.g. by using particularly energy and
- resource-efficient components
- Identification and exploitation of the domain knowledge of specialist employees

Principle 6: Taking responsibility, empowerment and teamwork

In lean management, this principle reflects the idea that complex processes can be mastered and improved only if the management and workforce succeed in anchoring patterns of behavior in the company that promote responsibility and empowerment of the team.

The lean industrial communication approach consolidates this principle in the direction of direct and open communication as a prerequisite for the development of individual responsibility, extension of the scope for responsibility and decision-making and productive and self-determined collaboration in teams. Within limits, communication can therefore be organized as required by everyone. This also means the integration of self-healing mechanisms such as resilience and reliability.

Aspects for implementation of the communication infrastructure (CIS):

- Strategic decisions are shared between various levels of the communication infrastructure
- Independence of components through separate adaptation with simultaneous higher level orchestration/comparison with other system components
- Automatic re-routing in the event of failure of connections (alternatives must be taken into consideration in the planning)
- Reducing complexity through the informatics paradigm: "divide & conquer": The entirety is broken down into smaller, simpler sub-problems that can be mastered and then put back together again for an overall solution
- Object orientation: also division into smaller parts with clear responsibilities

Principle 7: Decentralized, customer-focused structures

Lean management stands primarily for the breakdown of management levels in large companies in the direction of flat hierarchies. Reporting and decision-making pathways between the levels should be shortened in such a way that process times are reduced and ultimately the throughput times for products or the performance of services are optimized.

Decentralized and customer-focused structures as a principle for lean industrial communication means using the separation of the control and data levels that 5G makes possible for highly-effective, customer-focused communication. With this principle, process efficiency can be increased and redundant and useless communication reduced.

Aspects for implementation of the communication infrastructure (CIS):

- Flexible use of central cloud and edge cloud for extension of functions and resource efficiency
- Direct connection to optical networks and the use of optical connections in the fronthaul and backhaul to reduce aggregation levels and operate fewer locations
- AI-based automation of network adaptation and optimization

Principle 8: Management is service to the employee

In lean management it is the task of managers to inspire and motivate their employees to adopt the lean philosophy. This leads to an increase in efficiency and productivity and the employees learn to understand the lean principle and put it into practice.

In the sense of lean industrial communication, management means, in particular, putting employees into a position in which they can complete their tasks optimally and make the right decisions. Management means ensuring that employees can access information that is important to them at any time and share their own information.

Aspects for implementation of the communication infrastructure (CIS):

- Technical basis: Software identification, virtualization, separation of control & data planes
- Distribution of software via app stores for Network Function Virtualization (NFV) for flexible composition of new services
- More useful: opportunities for AI in production – as industrial users can make use of 5G for their needs

Principle 9: Open information and feedback processes
Through open information and feedback processes, lean management pursues the objective of responding to errors and problems at an early stage. This increases both employee motivation and productivity, as errors do not have to be identified by laborious procedures and processes can run more efficiently.

Lean industrial communication is based on secure access to the essential data and information for every employee and every machine. This complete transparency should ensure that processes are optimized, fluctuations can be better responded to, and errors can be avoided from the outset.

Aspects for implementation of the communication infrastructure (CIS):
- Monitoring and awareness of the network and communication between the stakeholders facilitate open processes.
- The network must ensure that everyone can contribute information in a form that is possible and seems expedient for the person involved
- Propagation of errors to support troubleshooting

Principle 10: Change of attitude and culture in the company (kaikaku)
Lean management is a philosophy rather than a collection of methods. Both the employees and the management must understand this and put it into practice. Great importance is attached to identifying and analyzing problems. Errors should be seen as an opportunity and not as problems. Only in this way is it possible to learn from them and grow.

Lean industrial communication is based on the idea that communication in a company not only reflects the internal culture but can also influence and change it significantly. Networked value creation chains require networked communication in and between companies in order to cope with the high requirements of dynamism and process and performance quality in a cost-effective way.

Aspects for implementation of the communication infrastructure (CIS):
- Organizing planning decisions and procurement in large interdepartmental teams to take account of all aspects (technical, economic and ecological) in an integrated way
- Involving customers in the planning of new communication infrastructures and procedures at an early stage in order, for example, to organize security requirements and corresponding measures cost-effectively
- Creating training and staff development courses to allow employees and customers to work effectively

Contribution of 5G to Lean Industrial Communication 03

5G offers a highly flexible platform that can meet many of the requirements of a lean industrial communication approach to the CIS by means, for example, of orchestration and flexibility in the architecture and needs-based provision of performance parameters, taking account of the necessary quality of service (QoS). Virtualization and automation are central components of the 5G architecture. The standardization of NFV and SDN are being pushed forward by 5G. Through this standardization, it is becoming easier for users to place their own functions in the network on hardware from various manufacturers. As a result, communication services in a 5G network not only become more flexible, but are also usable in a dynamic way for applications in accordance with the cloud principle. The hierarchical 5G architecture is the basis for a service structure distributed over the network. Data processing and storage and access to information are facilitated over the whole network. The vision of 5G is to automate configuration of the network and thus to facilitate on-demand self-service in accordance with the cloud definition.

5G is therefore a central key for the development and operation of the CIS in an environment of heterogeneous and changing applications not only from a technological perspective, but also in terms of achieving efficiency gains to reduce the costs of a high-performance CIS and the services based on it.

04 Links to the 5G Research Projects

Within the framework of the BMBF research initiative “Industrial communication of the future”, eight research projects are being implemented with the funding priority “5G – Industrial Internet”. The aim is to develop innovative technologies and management solutions for the industrial Internet. They are providing model technological solutions based on defined application scenarios, using common questions to define the necessary framework conditions and requirements of an efficient and economical industrial Internet as part of the implementation of the I4.0 strategy. Through their research activities, these projects are contributing to achieving the principles of lean industrial communication outlined above.

SHORT TITLE	TITLE	FOCUS
5Gang	5G applied to industry	• Analysis of 5G use cases for business model design • Development of an initial description of architecture • Efficient status monitoring through flexible 5G networks • Flexible production through cross-site networking
FIND	Future Industrial Internet Architecture	• Unified abstraction of industrial quality of service metrics • Analysis of suitable reference architecture • Models taking account of co-existing heterogeneous applications • Adaptation of industrial communication solutions for consistent and dynamic network management
I3	Information-centric networks for the industrial Internet	• Resilient machine-to-machine communication through information-centric networks • Developments of open source software for the industrial Internet • Contributions to Internet standardization
IP45G	Innovation platform for 5G	• System for technological and economic classification of 5G developments • Recording and classification of test beds and description of their role in the introduction of 5G • Success factors in operational integration of new ICT solutions on the basis of 5G • Concept for sustainable assessment • and evaluation of requirements of communication structures in Industry 4.0 environments
FlexSi-Pro	Flexibility and security in the production plant of the future	• TSN configuration for OPC UA via SDN • Level-based security concept for dynamic industrial networks • Communication architecture for flexible plug & manufacture
SESAM	Secure, software-based access networks for the intelligent factory of tomorrow	• Overall concept for a hybrid (optical/radio) wireless communication system developed • EchoRing™, a robust, real-time-compatible wireless technology demonstrated in various applications • Data security concept developed for SDN architecture
SiNSeWa	Secure networks for self-organizing maintenance systems	• Railway technology application replaces aerospace use case • Definition and systemization of reference models, risk assessment • Definition of network architecture and development of security architecture including test specification
SEKOM	Secure real-time communication for industry and retail	• 5G communication concept for smart factory, smart retail • Fokus auf Realtime, Reliability, Embedded Security, Prediction, Massive Access • Technical specification and provision of demonstrators

Table. 4.01
List of projects in the funding priority “5G – Industrial Internet”

05 Conclusion

The development of the user industries that are important to Germany in the direction of the Industry 4.0 vision is bringing communication and the associated technologies into focus in both strategic and operational considerations. The present document describes the application of lean management principles to modern industrial communication and summarizes them under the term ‘lean industrial communication’. On the basis of established organizational principles, the intention is thus to provide a structured aid that allows companies to identify the future requirements that will be made of existing communications and their infrastructure without drowning in technical details and the options 5G offers for meeting those requirements in the context of an integrated, high-performance communication system.

This document is an initial discussion paper designed to focus on and qualify the selected approach in the form of a guide to the discourse. On conclusion of the funding period, the aim is to be able to present a more comprehensive description of the lean industrial communication approach which offers companies guidance in view of the various forms of communication infrastructure for networked value creation chains that include 5G technologies.

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