ОБЩЕСТВЕНИ КОМУНИКАЦИИ И ИНФОРМАЦИОННИ НАУКИ
PUBLIC COMMUNICATIONS AND INFORMATION SCIENCES

FROM INDUSTRY 4.0 TO THE SMART FACTORY: INFORMATION MANAGEMENT IN THE GERMAN AUTOMOTIVE INDUSTRY

Ali-Elias, Al-Hamami
University of Library Studies and Information Technologies

Abstract: *This article deals with innovative concepts in the German car industry that range from the Industry 4.0 or IIoT (Industrial internet of Things) approach to all kinds of data generation projects or 360° network solutions. Implementing these initiatives, most manufacturers aim to develop a "smart factory" where an integrated system network is to synchronize the gathering, transmission, evaluation and visualization of data in such a way that decision makers benefit from their instant and convenient availability. Examples of practical applications are given, taken from the factories of leading car manufacturers, particularly from a press shop which is the facility where sheet metal is shaped into components that eventually form the car bodies. In all of the rendered cases, an integrated system network which is the prerequisite for the development of a smart factory safeguards permanent availability of the provided data that ideally are stored in a computer cloud and facilitate both, machine-to-machine and man-machine communication. Lately, the industry has explored ways of how to significantly accelerate data transmission, evaluation and visualization with the help of 5G technology.*
Keywords: *Automotive industry, IoT, network building, information management, 5G*

INTRODUCTION

The concept of Industry 4.0 which represents the current top complexity level of the economic and technological development is also called the "fourth industrial revolution". According to Wikipedia, it is defined as "[…] how the global production and supply network operates through ongoing automation of traditional manufacturing and industrial practices, using modern smart technology, large-scale machine-to-machine communication (M2M), and the Internet of things (IoT). This integration results in […] improving communication and self-monitoring, and the use of smart machines that can analyze and diagnose issues without the need for human intervention" ('Fourth Industrial Revolution' n.d.). So Industry 4.0 is based on CPS (cyber-physical systems) which combine real (physical) objects with information-processing virtual objects and processes that are linked via an open, partly global, always active and "communicating" information network. Industry 4.0 concepts offer great opportunities of organizing and controlling the value-creation chain that encompasses the entire life cycle of products. In turn, every information linked with this life cycle, which extends from the idea, the order, the production, the delivery of the product to the end user on to the final stage, the recycling of the product, can be stored in a well-connected system and

therefore can be fed back into the process at any time. If this happens in real time, facilitated by the introduction of 5G technology, an ideal value creation flow can be realized.

Scientific sources confirm this interdependence. "By connecting people, objects and systems, real-time optimized, self-organizing and cross-company networks are developing, which can be further optimized according to various criteria such as costs, availability and resource consumption" (BITKOM e.V., VDMA e.V., ZVEI e.V. 2015). Within the IoT, the exchange of data is part of the desired automation that leads to higher efficiency, improves the flow of information and allows real-time reactions to change which is important in the case of imminent danger. This system that is based on the wireless connection of individual machines is also known as "smart factory".

For transmitting the generated data, manufacturers today strive to use the latest generation of mobile communications which is the 5G ("Fifth Generation") telecommunication standard. It convinces with a low latency period (only around twelve milliseconds go by before response to any dangerous situation sets in), velocity (download rates of one to ten Gigabytes per second), reliability (only one out of ten million data packages causes transmission problems), and energy efficiency. Thus, 5G technology comes close to the theoretically possible optimum per transmitted Bit and therefore creates perfect conditions for the development of smart factories.

In the German automotive industry, there are many examples of how Industry 4.0 concepts are being upgraded with 5G-backed networks, with the goal of creating a smart factory. These concepts shall be at the center of the following analyses.

RESEARCH METHODOLOGY

This article mainly relies on qualitative evaluation methods based on academic reading, study of sources, logical thinking and descriptive project analyses. In the framework of his research, the author had the opportunity to scientifically accompany Industry 4.0 concepts initiated in the press shop of a renowned German automotive manufacturer. From the professional position that the author currently holds at an international diversified industrial corporation headquartered in Finland, he has moreover gained experience with telecommunication technology and system network building. With these assets in the background, it was easy to him to focus on the two main aspects of his academic aspirations, namely the variety of organizational structures that have proved to be successful in the respective industry branches, and information management with the help of technical solutions.

RESULTS

STATE OF DEVELOPMENT: At the beginning of the new millennium, the German car industry was still underdeveloped in regard to the degree of automation in their facilities, since "… manual work still plays a major role in three quarters of the researched companies and production is either based on it or strongly depends from it in a hybrid system. Less than a quarter of the researched productions are fully or highly automated." (Spath ed. 2013) Certainly the industry now, more than ten years after this eye-opening publication, has made considerable progress in that respect, but the statement shows that the enormous potential of Industry 4.0 concepts has still not been entirely exhausted, although IoT promises to facilitate constant communication between machines, operating equipment and storage sites. And because the industry-related variant "Industrial Internet of Things" (IIoT), in contrast to the more consumer-oriented IoT, requires more sophisticated solutions regarding bandwidths, reliability and latency periods, only the introduction of 5G technology will promote innovation and will take the production process of German car manufacturers to the next level.

EXPECTED BENEFITS: Thanks to the wireless machine-to-machine communication, which will be significantly accelerated with the help of the latest generation of mobile communications,

flexible production chains are created that will eventually lead to the smart factory. In addition, 5G-optimized machine installations allow operators to perform predictive maintenance, for instance with the help of terminal devices on which the evaluated data can effortlessly be visualized. 5G can also significantly improve collaboration between humans and machines. For instance, collaborative machines such as sensitive robots, can assist workers in production, thus combining the advantages of robotics with those of human work. 5G supports this process by transmitting transaction data in real time which allows the parallel processing of a workpiece by man and machine. Last but not least, 5G makes sense in tactile robotics where the new technology not only facilitates the sharing of information, gathered by one robot, with a great number of other robots, but also allows cloud-based collective machine learning on the base of the huge data rates that can be transmitted with the help of 5G. Machine learning enables robots to swiftly adapt to complex motion patterns so that they can be deployed flexibly and independently due to the accelerated installation process.

EXAMPLE OF AN INDIVIDUAL APPLICATION: A typical IoT application is digital material parameter measuring in an automotive press shop. It not only follows the car manufacturers' "big data strategy" and pursues the goals of optimizing the data flow and of creating larger data pools, but also most probably holds the greatest potential for a later upgrade with 5G technology. Currently, particularly roughness measurement is performed inline during a machine stoppage or via sample collection at the front end of the coil (offline measurement). A surface profiler and some static optical systems help the operator to decide which areas are acceptable and which sheet metal parts have to be reworked. In the future, inline measurement via sensor will make the quality of the raw material transparent, as soon as it is inserted into the pressing machine, and at the same time it will facilitate the targeted control of the pressing process. Eventually, the method will even allow consistent enforcement of quality standards on the side of suppliers and will also guarantee complete traceability of the processed material ("coil tracking"), particularly in regard of roughness and basic lubrication. Therefore, the manufactured sheet metal parts are equipped with a data matrix code that runs through the entire coil and is registered on the automotive company's server system, clearly identifying both the components and the original coils.

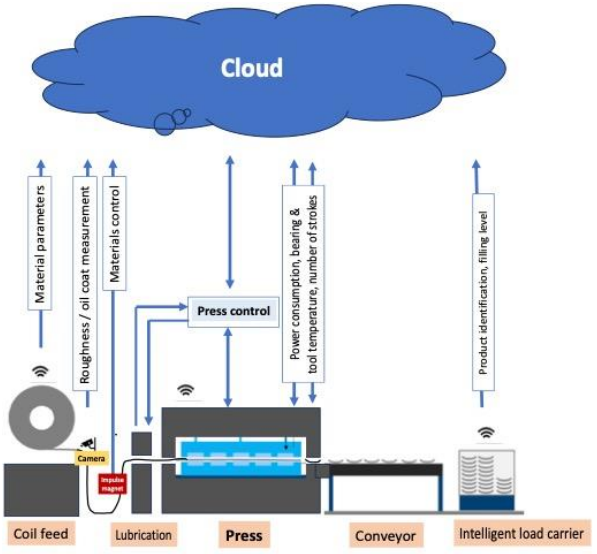

Fig. 1. Schematic illustration of a sheet metal press that delivers data to the data pool in "The Cloud" which in turn will feed the integrated system network with vital information. (Own graphic).

SMART FACTORY LIGHTHOUSE PROJECT: Under the name of "Factory 56", German car manufacturer Mercedes-Benz has developed a digital model factory in which the smart factory concept has turned into reality. "360-degree networking – from the supplier to the customer" (Mercedes-Benz Group AG 2023) is their motto which also reveals that the automotive company's vision of connectivity goes far beyond the conventional IIoT idea: "[…] networking not only happens inside the factory. A significant feature of 'Factory 56' is the all-round networking across the entire value-added chain – from development and design to suppliers, production and customers. In coordination with our suppliers, we use the benefits of tracking and tracing, for example, which allows load carriers to be traced digitally around the world […and] enables early detection of discrepancies in the supply chain and thus a quicker reaction time. For […] production, 360-degree networking means quick and transparent communication across all units. Digital tools are used for development and production, for example, production processes are visualized and optimized by 'Virtual Reality` […] before a real production hall comes into existence. For example, the workstations and processes can be virtually tested and designed ergonomically." (Mercedes-Benz Group AG 2023)

TOTAL CONNECTIVITY: In 2020, Jürgen Prokop, CEO of Trumpf, a leading German manufacturer of machine tools stated in regard to sheet metal manufacturers wanting to promote digitization: "[…] connecting production processes and machines in a network will be the decisive competitive edge." (Mücke 2020) Therefore, the implementation of an integrated system network which comprises the consecutive steps planning, realization, validation is indispensable for the optimization of the information management in large corporations. 5G offers a high data transmission rate and excels with a low latency period and high reliability which make the difference considering the press shop requirements. The installation of 5G base stations and the configuration of the network architecture facilitate wireless communication between various machines, devices and systems in the press shop so that real-time monitoring, control and optimization of production processes will be possible. During the implementation phase, IT experts, network technicians and other relevant specialists should co-operate, painstakingly adhering to security standards and data protection rules, in order not to jeopardize the integrity and confidentiality of the data.

"AI" BOOSTS INNOVATION EVEN MORE: For some time already, artificial intelligence (AI) has been used as the "hidden tool" behind algorithms, which in turn facilitate data evaluation and visualization, both being characteristics of an integrated system network. Therefore, the automotive industry relies on AI as well, since it improves data evaluation and availability and thus provides many opportunities of optimizing production processes. German car manufacturer BMW, for instance, more and more uses AI applications since they, according to Robert Engelhorn, Director of their BMW Group Plant Munich, think that it "[…] is fast, reliable and easy to integrate into the various production processes and, coupled with smart data analytics and cutting-edge measurement technologies, […] opens up new opportunities for more efficient vehicle production." (BMW AG 2020) For BMW, as with any innovation, the key factor is not only effectiveness, the car manufacturer also entrusts to their employees the assessment of the new tools' value, as plant director Engelhorn explains: "At Plant Munich, it takes about 30 hours to manufacture a vehicle. During that time, each car we make generates massive amounts of data. With the help of artificial intelligence […], we can use this data to manage and analyze our production intelligently. AI is helping us to streamline our manufacturing even further and ensure premium quality for every customer. […] It also saves our employees from having to do monotonous, repetitive tasks. Our team

in production are highly experienced specialists, so they are the best judges of whether an AI application can boost quality and efficiency at any given stage of production." (BMW AG 2020)

CONCLUSION

The technology-based concepts of IIoT and 5G, particularly when organized in system networks, can positively impact production processes, value creation, information management, and the world of work in general. The advantages that the German automotive industry can expect from their implementation are obvious, as it will result in significantly improved transmission, evaluation, visualization, and availability of data all of which will make the lives of decision makers easier, especially when the information can be provided in real time. The backbone of this venture is a system network that has to integrate 5G technology which excels with the ability to transmit extremely high data rates and moreover with its low latency period and low failure rate. When planned carefully, such an integrated system network is easily scalable so that it can be extended to become the backbone of a smart factory.

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ОТ ИНДУСТРИЯ 4.0 КЪМ ИНТЕЛИГЕНТНАТА ФАБРИКА: УПРАВЛЕНИЕ НА ИНФОРМАЦИЯТА В ГЕРМАНСКАТА АВТОМОБИЛНА ИНДУСТРИЯ

Резюме: *В тази статия се разглеждат иновативните концепции в германската автомобилна индустрия, които варират от подхода Индустрия 4.0 или IIoT (Индустриален интернет на нещата) до всички видове проекти за генериране на данни или 360° мрежови решения. Прилагайки тези инициативи, повечето производители се стремят да разработят „интелигентна фабрика", в която интегрирана системна мрежа трябва да синхронизира събирането, предаването, оценката и визуализацията на данни по такъв начин, че вземащите решения да се възползват от тяхната незабавна и удобна наличност. Дадени са примери за практически приложения, взети от заводите на водещи производители на автомобили, по-специално от пресовъчен цех, който е съоръжението, където листовият метал се оформя в компоненти, които в крайна сметка формират каросериите на автомобилите. Във всички представени случаи интегрираната системна мрежа, която е предпоставка за разработването на интелигентна фабрика, гарантира постоянна*

наличност на предоставените данни, които в идеалния случай се съхраняват в компютърен облак и улесняват комуникацията между машините и между хората. Напоследък промишлеността проучва начини за значително ускоряване на предаването, оценката и визуализацията на данни с помощта на технологията 5G.
Ключови думи: *автомобилна индустрия, IoT, изграждане на мрежи, управление на информацията, 5G*

Ali-Elias, Al-Hamami, PhD candidate
University of Library Studies and Information Technologies
E-mail: ali_elias.al-hamami@outlook.de