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Theory and Practice of Implementing a Successful Enterprise IoT Strategy in the Industry 4.0 Era

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Abstract

Since the arrival of the internet and affordable access to technologies, digital technologies have occupied a growing place in industries, propelling us towards a 4th industrial revolution: Industry 4.0. In today's era of digital upheaval, enterprises are increasingly undergoing transformations that are leading to their digitalization. The traditional manufacturing industry is in the throes of a digital transformation that is accelerated by exponentially growing technologies (e.g., intelligent robots, Internet of Things, sensors, 3D printing). Around the world, enterprises are in a frantic race to implement solutions based on IoT to improve their productivity, innovation, and reduce costs and improve their markets on the international scene. Considering the immense transformative potential that IoTs and big data have to bring to the industrial sector, the adoption of IoT in all industrial systems is a challenge to remain competitive and thus transform the industry into a smart factory. This paper presents the description of the innovation and digitalization process, following the Industry 4.0 paradigm to implement a successful enterprise IoT strategy.

Keywords: Industry 4.0; Cloud Computing; Internet of Thigs, IIoT; PLC.

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1. Introduction

The globalization process imposes high requirements on the products and services provided by manufacturing companies. They rely on the notion of value perceived by customers or added value. New digital technologies, the Internet in business, and big data are all ways to generate this value. Germany is one of the flagship countries where this value added by the digitization of companies has been most boosted since 2011 by its new government policy to improve its industrial practices: we are talking about Industry 4.0 or the 4th industrial revolution.

Over the years, the industry has experienced qualitative advances that are sometimes so symptomatic of their time and overwhelming that they have been called "revolutions." The first industrial revolution, 1765, marks the appearance of mechanization, which will erect industry as the foundations of the economic structure of society with massive coal extraction coupled with the invention of the steam engine and the development of rail networks. Other significant innovations such as the loom and metallurgy are emerging. The second industrial revolution, 1870, initiates a technological advance with electricity, gas, and oil, including the development of the combustion engine. The development of the steel industry means communication such as the telegraph and the telephone are emerging.

The third industrial revolution was 1969, the advent of a new energy source, a nuclear power that outclasses its predecessors, and electronics and computers. So many technologies open the doors to programmable logic controllers and robotization after that.

Today's industries tend to connect all of the means of production for real interaction. Industry 4.0 factories make communication possible between actors and connected objects within the production line thanks to the cloud, Big Data, and industrial Internet of Things technologies.

Industry 4.0 is mainly associated with interconnectivity: sensors, social networks, the Internet, and computer software that generate, process, and deliver information with added value in real-time.

When we talk about Industry 4.0, we are mainly talking about the establishment of smart factories. Those new "intelligent" factories will create an ecosystem where all key players participate in the solid collaboration on this platform, procurement, manufacturing, sales and distribution, finance, and accounting work to achieve the company's general objectives [1].

Industry 4.0 aims to be connected. In addition, the large amount of information collected with the different IoTs requires an efficient system for storing these various data. In this context, cloud computing is becoming a mandatory step in 4.0 industries to have almost instant access to the various collected data that has been saved [2]-[5].

Therefore, this study is intended to collate and analyze the current state of research on the pros and cons of Industry 4.0. The research questions guiding this study are:

RQ1: What are the pros of Industry 4.0?

RQ2: What are the cons of Industry 4.0?

RQ3: Why does the organization exist, and what is its product strategy?

RQ4: How does the business plan to achieve long-term sustainable growth?

In this work, we try to answers the above questions. We present the description of the innovation and digitalization process, following the Industry 4.0 paradigm in order to implement a successful Enterprise IoT Strategy. This implementation is achieved by introducing modern technologies in the business processes in both control quality and production planning tasks.

2. Toward Industry 4.0 with IoT

IoT stands for the Internet of Things, which refers to a system where technological objects are all connected to the Internet capable of creating and transmitting data to produce value. This term was used for the first time in 1999 in London during a presentation held by Kevin Ashton to convince - the company for which he worked as a computer scientist - to perfect their security system by integrating the IoT. Harmless at first, this innovation will revolutionize the world of technology. As we can see today, that is to say, twenty years later, the connected objects occupy a large part of our daily life and continue to develop in fields as diverse as they are varied, from industry to biomedical.

International Telecommunication Union (ITU) defines the Internet of Things as *"as a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies"*.

IoT technologies consist of objects to capture data: sensors, a network for transmission, data, information, and operating applications.

The Industrial Internet of Things (IIoT) is a subset of the IoT, explicitly intended for industrial applications. It applies IoT techniques in machine-to-machine connection, data management, and optimization and productivity possible to create "smart factories." Thanks to onboard technology (sensors, actuators, RFID, etc.), the IIoT consists of identifying and interacting with all the elements (machines, products, collaborators, suppliers, customers, infrastructures, etc.) that can be designated as objects.

These objects exchange considerable amounts of data which are then conveyed through a local network or the Internet. Three categories of communicating objects can be distinguished: (1) objects connected directly to the Internet, (2) Machine to Machine (M2M) for which communication between machines, and (3) access to the information system is done without human intervention [6].

The IIoT is the technological foundation of the *Smart Factory*, allowing real-time exchanges within a factory or company in order to facilitate coordination and collaboration between the different operators. Its deployment will ensure productivity and operational efficiency gains for the industry. In addition, it offers the possibility of adapting skills available in real-time to cope with rapid changes or unforeseen events.

The collected data from the IIoT creates knowledge of customers, the environment, business process. All this knowledge will constitute an added value for the company, thus allowing them to make predictions on the evolution of their product in order to strengthen its availability and durability. The IIoT presents a significant challenge behind using the technologies associated with it to successfully collect data and thus transform it into measurable data allowing decision-makers to have a real-time view of what is happening in the plant and make decisions quickly. So, the choice of communication strategies is crucial to guarantee an efficient data exchange.

Better integration of Industry 4.0 consists of determining the type of onboard system adapted to the physical propagation environment to ensure the quality information exchanged and to make it interoperable with the plant environment [7].

The IIoT will authorize businesses to engage in the design and marketing of products and services innovators, which until now could only be considered by certain giants of the industry. Here are some of the benefits of Industry 4.0:

- Optimize energy consumption through the intelligent use of different resources needed by industry. This is achievable by having a global vision of the plant and the equipment used to better manage and optimize their energy consumption.
- Monitor and control machines and equipment in real-time.
- Introduce intelligent processes using machines capable of analyzing their own data to predict when their maintenance should be carried out as an example.
- Optimize the supply chain through product traceability, logistics monitoring, and control stocks.
- Strengthen the value of the existing product by developing new product lines intelligent and thus gain new markets.

Over time, the term has evolved, and it now encompasses the entire ecosystem of connected objects. This ecosystem encompasses sensor manufacturers, software publishers, incumbent or new operators, and integrators. This critical structure can transform a factory into an Industry 4.0 factory, a smart factory! The IoT platform must have the capacity to extract data from sensors and devices, operate and analyze large volumes of data and be able to perform real-time controls at any time.

The interesting aspect of IIoTs is their use in different manufacturing processes. Thousands of smart sensors and tools will be available in a factory and collect data to ensure real-time production and product compliance. To do this, first of all, communications protocols are necessary.

Wireless networks will also be necessary for all these mobile tools that could not be managed by a wired network. A computer system for recording and handling the data collected will be necessary to do compliance control and error detection rather than: Manufacturing Execution System (MES).

MES allows you to have all the factory data in real-time as well as all the production objectives to be able to launch an automatic action and assist the man in his decision-making. Consequently, to obtain real added value from the Internet of Things in the factory, it will be necessary to deploy new communicating tools and deploy MES software.

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3. Steps to Implementing a Successful Enterprise IoT Strategy

Most experts concur that IoT has enormous potential to provide both tangible and intangible benefits across various segments and sectors. IoT is a cornerstone of the technologies that can enable digital transformation across multiple industries. For example, IoT can create a wide array of safety and efficiency benefits for businesses, government agencies, and consumers. However, designing a successful IoT strategy could be very challenging for an enterprise. Unlike other software initiatives, which IT owns and controls, IoT deployments span multiple business units and operational teams. Even for organizations with a successful track record of rolling out complex supply chain solutions or enterprise application integration projects, designing and implementing an IoT strategy can be overwhelming.

To stay competitive, most companies today opt for value creation for process development to increase their bottom line. We have optimized and developed business cases.

"A washing machine factory, which manufactures and installs machines in residence, may, for example, know that one of their machines located in such and such a place vibrates abnormally and that another located 150 m away consumes more energy than the average to be able to send a maintenance agent based on the symptoms that the IoT transmits. This avoids an unscheduled repair, waiting for one of the machines to break down. "

For a traditional industry that is not connected, driving an IoT strategy requires surrounding yourself with a company that helps their customers to implement IoT solutions and start-ups.

For example, Microsoft has already worked with the automotive industry Rolls Royce to develop a predictive maintenance solution. A system that would allow the manufacturer's managers to have a global view in real-time of the planes using this new service.

Some of the factors that negatively impact IoT projects include lack of collaboration among IT teams and OT teams, confusing choice of technologies, lack of interoperability with existing business applications, and lack of alignment with overall business goals. Here is the major step to designing a successful enterprise IoT strategy:

1. Define business goals and the expected outcome.
2. Identify the hardware and devices participating in the connected solution.

3. Prepare the data points and metrics aligned with the outcome.
4. Define the device connectivity and data format.
5. Implement security, governance, and policy across each layer.
6. Identify reference datasets required for transforming sensor data.
7. Factor in machine learning and predictive analytics.
8. Define hot path analytics for near real-time processing.
9. Define cold path analytics for long-term batch processing.
10. Design an intuitive user experience for business decision-makers.

4. Construction of IoT Application Systems for Industry

We have defined what IoTs are and their developments in the industrial sector. We have also introduced the term Smart Factory. However, it should be noted that the establishment of an industry 4.0 involves a multitude of connected systems, IoT, and cloud computing (which consists just through an internet network, the use of servers to store or use data). Therefore, a smart factory must consist of connected equipment equipped with sensors, which generate volumes of information during their operation to provide an overview of factory operations. These installed sensors must support industry-standard protocols such as SECS / GEM (SEMI Equipment Communications Standard / Generic Equipment Model), OPC, and TCP / IP.

SECS and GEM (Generic Model for Communications and Control of Manufacturing Equipment) standard are published and maintained by SEMI.org, an international organization of semiconductor manufacturers, is an organization body that governs the standard for semiconductor manufacturing [8]. It is the main communication protocol used in automation for (initially) the semiconductor/electronics industries. However, today it has been widely adopted in photovoltaic and SMT sectors too. It provides a communication interface between sensors, equipment, and host systems.

These protocols allow all connected equipment to be linked to key manufacturing execution systems (MES), product lifecycle management (PLM), Enterprise resource planning (ERP) applications to guarantee a data collection and information control system in a closed-loop or a whole ecosystem [9].

ERP and MES are essential but not sufficient to make manufacturing organizations competitive; they are must-have solutions to automate the relevant hygiene processes to run more effectively and efficiently. Analyzing this complex data can improve efficiency and achieve optimization while reducing costs. Figure 1 shows the construction of IoT applications for smart factories.

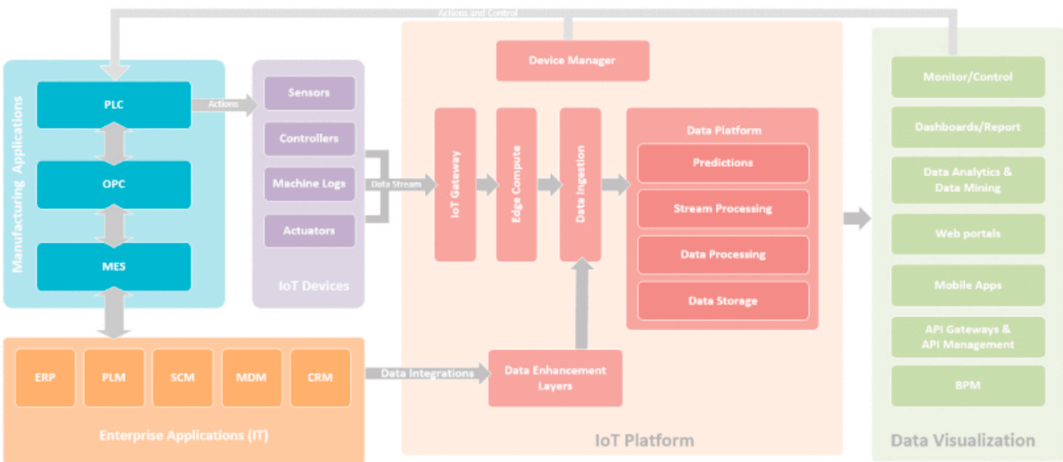

Fig. 1. Construction of IoT application for smart factory.

4.1. Manufacturing Execution System (MES)

These are most of the applications that generate manufacturing operations in factories. The MES, Manufacturing Execution System is an online transaction system that records all factory levels (financial transactions, stock movement, consumption, and sale).

MES are packaged and ready to use in the market, then it is up to the managers of a factory to customize them to meet the needs of the factory. They provide functionalities such as IoTs traceability, their serial numbers but also function test data. However, factories have particular needs; others tend to develop their own MES to assess better what suits them.

4.1.1. Programmed Logic Control (PLC)

An industrial programmable logic controller (or PLC) is a programmable electronic device intended to automate processes such as controlling machines within a factory and controlling industrial robots, for example. PLC is the central unit that manages the programmable logic controller: it receives, stores, and processes the incoming data and determines the state of the outgoing data according to the established program [10].

The programmable logic controller receives data through its inputs. A defined program then processes these. The result obtained being delivered through its outputs. This processing cycle is always the same, whatever the program. However, the time of a PLC cycle varies according to the program's size and its power. When a programmable logic controller performs a safety function, it is then referred to as a safety programmable logic controller or APS.

4.1.2. OLE for Process Control (OPC)

Object Linking & Embedding (OLE) is a technique that appeared in 1995 and is intended for the interoperability of industrial systems. It is not a communication protocol but a technique based on OLE, COM, and DCOM techniques developed by Microsoft for its Windows operating systems. Since 2011, OLE has been renamed Open Platform Communication (OPC) due to its expansion beyond process control [11].

OPC was designed to link Windows applications and process control hardware and software. The standard defines a consistent method for accessing field data from factory devices. This method remains the same regardless of the type and source of the data. OPC servers provide different software methods to access data from process control devices, such as a PLC.

Traditionally, whenever a program required access to data from a device, a custom interface, a driver, had to be written. The objective of the OPC is to define a common interface written once and then reused by any company software, Supervisory Control and Data Acquisition (SCADA), HMI (Human-Machine Interface), etc. Once an OPC server is written for a particular device, it can be reused by any application that can act as an OPC client. An OPC server uses the Microsoft OLE technique (also known as the Component Object Model or COM) to communicate with clients.

Today, OPC is a registered trademark of the OPC Foundation. The techniques developed by the OPC Foundation are based not only on the Component Object Model (COM) and Distributed Component Object Model (DCOM) but also on the work of World Wide Web Consortium (W3C) and Organization for the Advancement of Structured Information Standards (OASIS). The OPC specifications can be separated into two categories: (1) specifications based on COM / DCOM and (2) specifications based on web services. Open Platform Communications (OPC) is the Middle Layer that facilitates communication between MES and PLC.

4.1.3. Supervisory Control and Data Acquisition (SCADA)

SCADA system is a computer application. This system monitors and controls equipment or industrial processes at large remote sites, acquiring real-time data. The implementations of SCADA can be considered as instrumentation frameworks, including a middleware-type layer [12]. The Local SCADA system is a modular system designed to provide communication and/or control of different equipment in an installation that is in the same location. This type of communication is done through a local area network (LAN). The remote SCADA system is a system that has the same tasks as the local SCADA, but it allows to control and supervise an installation in a remote location. This is ensured by a connection over a wide area network (WAN). This is because remote SCADA offers an additional degree of freedom to the local SCADA system. In this thesis, our study focuses on the development of a local SCADA system.

Most applications of SCADA systems use a human-machine interface (HMI). This tool allows the user to view all the processes. Thus, it provides remote control of the equipment.

4.2. Enterprise Application

These include various systems that allow you to run a business:

- *Enterprise Resource Planning (ERP),* integrated management software package is a software package that allows you to manage all of the processes of a company by integrating functions including human resources management, financial management, sales, procurement, and electronic commerce [13].
- *Product Lifecycle Management (PLM).* This is a centralized repository for inventory keeping units. Inventories are created and maintained in PLM applications before being distributed to downstream applications such as ERP and MES.
- *Customer Relationship Management (CRM)* is a system that facilitates the process of ordering a customer's product. It provides a platform for product management and research, management of quotes and customer orders: need to reduce the "time to market."
- *Master Data Management (MDM),* offers a single point of reference for accessing data; This is an application that provides up-to-date information on customer data, product location, etc.
- *Supply Chain Management (SCM)* is a global application that focuses on planning, forecasting, and production planning. These are applications specializing in the development and management of a supply chain [14].

4.3. IIoTs Structure and Platform

IoT Applications are pre-designed software as a service (SaaS) application that can analyze and present the data extracted by IoT sensors to enterprise users through dashboards [15]-[18]. To set up an IoT solution, you have to take into account several important components. At a high level, an IoT platform must have the following abilities. As shown in Fig. 2, each component of the IoT platform is mentioned below:

- *Objects (sensors):* An object is a container of information and mechanisms about a subject. These are active or passive equipment that can generate useful data that creates value for users. The various data retrieved by these objects are processed and transmitted through a network.
- *The network (connectivity):* Wireless connectivity technologies for objects are plentiful. The choice of
- connectivity strategy is based on several criteria and is built as an extension of the choice of sensor. This choice may depend mainly on seven phenomena; location (indoor, outdoor, underground ...), mobility, consumption electrical, remote control, amount of data, frequency of sending, and security. While some connected objects use small networks, either simple machine-to-machine (M2M) connections or LAN-type networks, the vast majority of objects use long-range WANs based directly on the IoT. Today most of these connections are made via existing mobile networks, mainly in 4G and 5G. But new technologies have been developed to set up networks specific IoT based on low-power, wide-area LPWAN networks for low data rate applications with long battery life.
- *Data:* are the different elements collected by objects (i.e., IoT) that have been transmitted through a network. This data will be decoded and processed in order to create added value depending on the field of application for which it is collected. Then they will be stored and backed up. They will be requested for future operations to be carried out. The IoT uses machine learning algorithms to analyze the huge amounts of data generated by connected sensors (objects).
- *Information:* The information is the data after processing. Information is what is going to be conveyed to the user. Information is the simple transcription, the result of collected data that has been processed.
- *Operating applications:* This is the medium on which the user will be able to read the information. These are generally Human-Machine Interfaces (HMI) in which the visualization of information is carried out, which is data collected via an object, transmitted via the network, and processed and saved. Information visualization can be done in various forms: graphs, tables, reports, summary sentences. IoT alerts are set up in some industries to benefit in real-time, visibility on key performance indicators (KPIs), statistics of mean time between failures, and other useful information to define as needed of every industry.

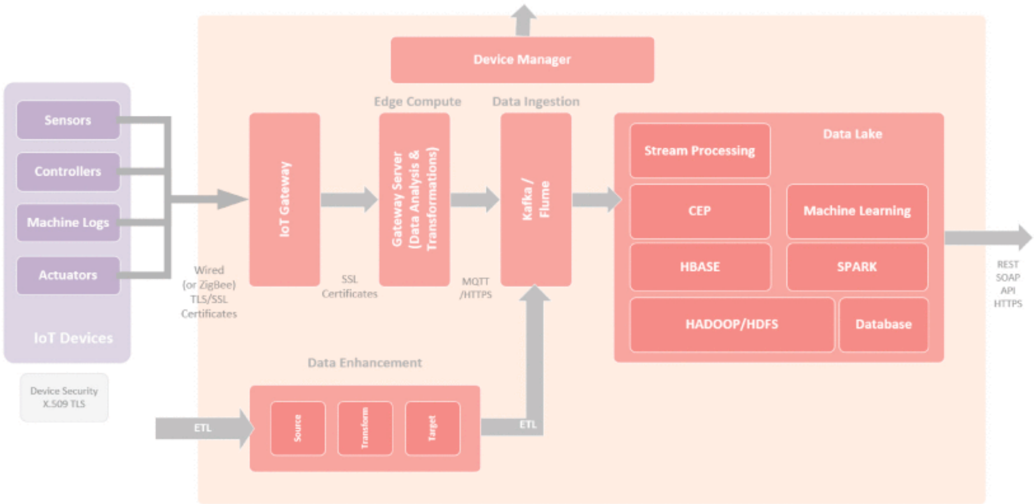

Fig. 2. The main element of an IoT platform.

4.4. Data Visualization, Monitoring, and Control

The dashboard gives us real-time visibility of applicable sensors, devices, and machines. Control and governance: Machines or sensors are controlled from a command center based on real-time Monitoring or detection of anomalies.

- *Data analysis:* All data is analyzed to identify current trends. Predictive and preventive measures are applied through data analysis and learning algorithms.
- *Mobile portal*: Analysis and metrics are provided as a user interface for consumer applications.
- *API Gateway:* The functionalities are exposed through an Application Programming Interface to business applications for forecasting demand, inventory management, traceability but also subject to BPM (Business Process Management) applications.

5. Impacts, Issue and Challenges

The challenges of the fourth revolution are economic, social, and political [19]. We can distinguish between the issues at the company level and the issues at the country level. At the level of a company, the challenges and objectives are:

- Increase productivity.
- Reduce the margin of error.
- Qualitatively improve services.
- Optimize the management of resources and energy.
- Anticipate failures.
- Intervene on a problem more quickly.

Integrating the new technologies of Industry 4.0 to meet its challenges calls into question the current functioning of companies. It is a real paradigm shift for companies, and the transition to Industry 4.0 impacts their entire operation, namely: The production chain, the organization of work, the economy of the company, the management and business logistics, business strategy, but also consumer habits.

The product is designed through a virtual factory. Manufacturing machines become part of a network of machines. The machines communicate with each other in real-time. Equipment and flows are automated, and lines are connected. This allows remote control and management of the company. Supply chains can now be dynamic, putting an end to inventory management and impacting business logistics. All the sensors and data management via the Cloud then make it possible to follow the product in its life cycle; we speak of remote maintenance. This challenges the current product/service divide in product tracking.

New strategies are emerging for companies—interconnections, flexibility, remote control, lead companies towards more global strategies. Making alliances, sharing data and production chains as needed can prove to be very beneficial for SMEs and 4.0-oriented start-ups.

The transformations of Industry 4.0 also impact the organization of work. They lighten the physical labor of workers and lead to more autonomy and responsibility. Interactions with machines occur via human-machine interfaces, cobots, the machine that returns data, and it is no longer the human who goes to the machine. Work teams become learners far from a Taylorist organization. All social strata are affected by the fourth revolution and go beyond the qualified / unskilled divide. New professions will emerge: manual or intellectual professions, skilled or not, which require creativity, artistic sense, social intelligence, and human contact.

The difficulties in implementing 4.0 can be summarized as follows:

- The development of a standard, a reference for companies. A common standard and standards would allow companies to support each other better and assert their competitive superiority if they initiate 4.0 standards.
- Training. It is necessary to train the new generations in the new practices of 4.0 industries and support workers in the 4.0 transition. This transition is complex because it calls into question the added value of a worker, whether qualified or not.
- The investment. The investments are considerable and are not accessible to all companies.
- Data protection. Data protection is a difficulty and a significant challenge when companies are interconnected.
- The difficulties in thinking about 4.0 are formulated in the form of questions:
- How to make 4.0 socially acceptable? Indeed, we have seen that 4.0 changes consumer habits, so consumers must be converted to the new practices of 4.0. There are strong issues of ecology, value for money, and ethics.
- How to define the autonomy of machines? Human responsibility for the autonomy of machines is strongly questioned. The autonomy of questions is a broad question at first glance semantically. It is necessary to reconcile the legal definition of autonomy with the robotic definition.

6. Conclusion and Discussion

Industry 4.0 is at the heart of the technological transformation of enterprises. It represents significant challenges in terms of increasing productivity and therefore standing out from the competition. Originally born in Germany, it spread more and more among large groups in European and American countries. Industry 4.0 is characterized by several technologies that require a significant amount of attention and precision to produce the expected data.

- *What are the pros of Industry 4.0?*

The 4.0 revolution started several years ago and will still be relevant in the following decades. Some technologies are already established and widely used, such as the cloud example. Cybersecurity has been around for the emergence of the internet but will continue to evolve.

The IoT is already well democratized and is starting to be more and more widespread, a lot of research is still on the subject, but the concept is already overall in the digital world. Technologies that seem to be that at their beginning are unhesitatingly augmented reality and artificial intelligence. These two areas are booming today and will continue to evolve in the decades to come. Artificial intelligence, along with deep learning, will become increasingly sophisticated and efficient and become essential in order to use the volumes of data collected, which will continue to increase. Augmented reality is just its prelude and continues for the moment to evoke futuristic technology that is still very "gadget."

This important investment does not yet seem very profitable for small or medium-sized enterprises. According to a study carried out by Schneider Electric on French companies: 95% of business leaders are confident and ready to adapt to change, but 57% of them prefer to expect concrete impacts within two years on their sectors business before launching, 78% are concerned about possible cyberattacks, 68% fear difficulties in recruiting qualified employees in the field.

The most advanced in this transformation are the automotive and electronics sectors. However, even if it is still limited for the moment, the investments are still significant. Indeed, some 840 billion euros/year will be invested from here 2020, with the objectives of 457 billion additional turnover and a reduction costs of 392 billion euros.

- *What are the cons of Industry 4.0?*

Isn't this ideological vision of the factory of the future utopian? Indeed, this vision seems perfect and flawless, a factory functioning perfectly well without any slowdown and disruption. But is it achievable? In the short term, it appears that no, only multinationals are slowly starting this transformation, investing billions. For small businesses, this transformation seems a long way off; for now, not being able to afford such expenses. Part of the current payroll is neither prepared nor trained for this revolution. We would have to wait for at least one new generation more willing to adopt these new technologies.

The question also coming back to each new technology supposed to optimize the work of a worker, who asks if the machine will not simply replace the worker and thus lose jobs for the benefit of the business can also be lifted. Indeed, a factory imagined perfect would not be fully controlled by machines working 24 hours a day without any disturbance or downtime? This situation is not possible in the short term, of course, and will not happen without never doubting. After four industrial revolutions, each bringing new technologies that have changed the world, one can afford to wonder if the fifth will not simply be the replacement for humans in industry.

References

[1] N. Padhi, "Setting up a smart factory (industry 4.0)—A practical approach", pp. 13-17, Oct. 2017.

[2] A. Chehri, A. Zimmerman, « 5G Assisted Smart Manufacturing and Industrial Automation », 12th International Conference on Applied Human Factors and Ergonomics (AHFE 2021), New York, July 25-26, 2021.

[3] A. Chehri and G. Jeon, "The industrial internet of things: examining how the IIoT will improve the predictive maintenance", *Proc. Springer* [1] KES IIMSS 2019, pp. 517-527, June 17-19, 2019.

[4] A. Chehri and G. Jeon, "Routing Protocol in the Industrial Internet of Things for Smart Factory Monitoring" in Innovation in Medicine and Healthcare Systems and Multimedia. Smart Innovation Systems and Technologies, Singapore: Springer, vol. 145, 2019.

[5] P. K. Illa and N. Padhi, "Practical Guide to Smart Factory Transition Using IoT, Big Data and Edge Analytics," in IEEE Access, vol. 6, pp. 55162-55170, 2018.

[6] M. Aazam, S. Zeadally and K. A. Harras, "Deploying Fog Computing in Industrial Internet of Things and Industry 4.0," in *IEEE Transactions* on Industrial Informatics, vol. 14, no. 10, pp. 4674-4682, Oct. 2018, doi: 10.1109/TII.2018.2855198.

[7] Y. Wu, H. -N. Dai and H. Wang, "Convergence of Blockchain and Edge Computing for Secure and Scalable IIoT Critical Infrastructures in Industry 4.0," in IEEE Internet of Things Journal, vol. 8, no. 4, pp. 2300-2317, 15 Feb.15, 2021.

[8] E. F. Terng, S. C. Yeoh, K. C. Tong and K. S. Yeo, "Data Analysis on SMT Reflow Oven with SECS/GEM Communication Protocol," 2020 IEEE 10th Symposium on Computer Applications & Industrial Electronics (ISCAIE), 2020, pp. 118-124

[9] Y. Fan and J. J. Chang, "Equipment communication architecture for smart manufacturing," 2018 IEEE International Conference on Smart Manufacturing, Industrial & Logistics Engineering (SMILE), 2018, pp. 27-32.

[10] O. Ljungkrantz, K. Akesson, M. Fabian and C. Yuan, "Formal Specification and Verification of Industrial Control Logic Components," in IEEE Transactions on Automation Science and Engineering, vol. 7, no. 3, pp. 538-548, July 2010.

[11] Z. Yongsheng et al. "The implementation of PLC monitoring system based on OPC," 2013 IEEE 4th International Conference on Software Engineering and Service Science, 2013, pp. 462-466.

[12] D. Aguirre, S. Gamboa and A. Rodas, "Low-Cost Supervisory Control and Data Acquisition Systems," 2019 IEEE 4th Colombian Conference on Automatic Control (CCAC), 2019, pp. 01-06.

[13] T. T. V. Hau and J. Kuzic, "Change Management Strategies for the Successful Implementation of Enterprise Resource Planning Systems," 2010 Second International Conference on Knowledge and Systems Engineering, 2010, pp. 178-182.

[14] N. C. Suresh, G. L. Sanders and M. J. Braunscheidel, "Business Continuity Management for Supply Chains Facing Catastrophic Events," in IEEE Engineering Management Review, vol. 48, no. 3, pp. 129-138, 1 third quarter, Sept. 2020.

[15] Chehri A., Fortier P., Saadane R. (2021) A Framework for 5G Ultra-Reliable Low Latency for Industrial and Mission-Critical Machine-Type Communication. In: Zimmermann A., Howlett R.J., Jain L.C., Schmidt R. (eds) Human Centred Intelligent Systems. KES-HCIS 2021. Smart Innovation, Systems and Technologies, vol 244. Springer, Singapore. https://doi.org/10.1007/978-981-16-3264-8_10

[16] Chehri A., Saadane R. Zigbee-based remote environmental monitoring for smart industrial mining. ACM Int. Conf. Proc. Ser. 2019:2–7. doi: 10.1145/3368756.3369099.

[17] A. Chehri and H. Mouftah, "An empirical link-quality analysis for wireless sensor networks," *2012 International Conference on Computing, Networking and Communications (ICNC)*, 2012, pp. 164-169, doi: 10.1109/ICCNC.2012.6167403.

[18] A. Chehri, P. Fortier and P. Tardif, "Application of Ad-hoc sensor networks for localization in underground mines," *2006 IEEE Annual Wireless and Microwave Technology Conference*, 2006, pp. 1-4, doi: 10.1109/WAMICON.2006.351901.

[19] Masuda, Y.; Zimmermann, A.; Viswanathan, M.; Bass, M.; Nakamura, O.; Yamamoto, S. Adaptive Enterprise Architecture for the Digital Healthcare Industry: A Digital Platform for Drug Development. *Information* 2021, *12*, 67. https://doi.org/10.3390/info12020067