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Smart Systems Integration in Logistics of manufacturing companies

Omar ANBOURI, ***(PhD Student)***
Laboratory of Research in Management and Organizational Sciences - LARSGO
National School of Business and Management - ENCG
Ibn Tofail University, Kenitra, Morocco

Abdelhay BENABDELHADI, ***(PhD, Professor)***
Laboratory of Research in Management and Organizational Sciences - LARSGO
National School of Business and Management - ENCG
Ibn Tofail University, Kenitra, Morocco

Correspondence address :	National School of Business and Management of Kenitra Ibn Tofail University Morocco -Kenitra Postal Code, 14020
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Abstract:

As technologies continue day by day to invade the world, their impact on the logistics field can only expand. Integrating new technologies in the logistics department is not seen anymore as a choice that companies may or may not take, but an obligation that should be taken to follow the competition level of the market, by improving their managerial methods, to reach better results in terms of productivity and efficiency. The inauguration of new technologies of the Industry 4.0 has caused the emergence of a new paradigm on how companies will be able to respond effectively and rapidly to the customers' demands. Industry 4.0 is not just revolutionizing logistics but fundamentally transforming the global economy, and society itself. Nowadays, when we talk logistics, we give more than ever before high importance to the impact of Industry 4.0 new paradigm on logistics operations and internal logistics, which affect almost every single operation within the supply chain process, the fact that logistics encompasses raw materials, movement, final products, and many other operations. Companies have been always searching for new methods and techniques that may help them optimize their logistics operations, especially when it comes to reducing logistics costs and execution times, as well as increasing their supply chain transparency; so, we aimed through this paper to present in a simple and precise way, a theoretical review of the recent works that have been done in the logistics field, to keep the readers updated about the latest trends that are constantly increasing.

Keywords: Logistics, Industry 4.0, Smart system integration
Classification JEL: L60, O32
Paper type: Theoretical Research

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1. Introduction

In recent years, internal logistics, warehouse management, and transportation have grown in importance, as logistics has seen several changes due to the integration of new technologies of Industry 4.0, emerging the development of new managerial methods of the internal part of logistics and transportation. Internal logistics is not seen anymore as a simple storage operation and a shipment starting point, but is considered a fundamental pillar in the strategic planning of companies, as the good optimization of logistics operations allows them to maximize profits and reduce costs; the same as transport field, which has not been seen anymore as a usual operation of getting products from a starting point to an arrival point, but is seen as a key success factor of companies, as it ensures the smoothness of operations, contributes too in reducing costs, time-wasting, and high efficiency of delivery.

The major importance of logistics comes mainly from the fact that it is not limited solely to the operations of a purely logistical nature, or those which take place within the logistics department, but because it is spread over the various operations that take place at the level of the entire company. For example, the logistics department is linked to the department in charge of production, marketing and sales, research and development, and other departments.

The relationship that exists between the logistics department and the other departments means that logistics has become more and more essential within the company, and to which the main resources must be allocated to allow the best conditions to establish a powerful system, which will subsequently allow the achievement of desirable results, and in particular those directly related to logistics, mainly the improvement of quality, the optimization of costs, and the reduction of execution times of operations.

Most of the works that deal with the Industry 4.0 subject are theoretical and conceptual, sharing the basics of the integration of new technologies in logistics departments, showing high insufficiency in logistics 4.0 research, especially with the lack of proof concerning the trends of Industry 4.0 technologies and their potential impact on logistics performance in manufacturing companies.

Traditional studies consider that the success of logistics is always based on four fundamental pillars of logistics: resources, costs, deadlines, and quality of service, without addressing much attention to the managerial methods needed help to reach the expected results.

In opposition to traditional works, new research has given significant importance to the new changes that the field of logistics has been experiencing in recent times, especially the integration of new technologies into the overall logistics effort, by implementing smart systems and smart connected solutions in logistics. Moreover, the integration of smart systems and solutions is not in complete opposition to the traditional works, but rather a positive addition, in a context characterized by more and more changes in the way logistics operations are performed.

To give a contribution to the previous works, this article is a systematic review, that comes with the newest studies and works, dealing with the integration of industrial logistics in manufacturing companies.

For companies, the field of logistics is developing dramatically and daily. Therefore, they always need to be aware of the most important updates related to it.

Recently, discussions are no longer confined to just the logistics 4.0 concept itself, but rather to the levels of development it has reached, especially about the new solutions that have become provided by modern technologies associated with it, such as the smart system integration (SSI), and the smart connected logistics solutions (SCLS).

As for the smart system integration (SSI), it is advisable to present a well-defined and linked structure, which contains the connections that exist between the logistics concepts and the technological implementations, as well as the goals that can result from these connections.

This paper will be divided as follows: we present first a brief overview of the logistics 4.0 concept and smart system integration (SSI), before getting into the smart connected logistics solutions (SCLS); Then, we will summarize the main contributions and works in the discussion section, before ending our paper with a conclusion.

2. Logistics and Smart System Integration (SSI)

2.1.Logistics 4.0: Overview

Nowadays, the logistics field, as well as many other fields, has entirely changed,
due to several technological changes aimed at facilitating and shortening the exchange of information, data, and execution times. (Antoniuk et al., 2021)
During the last decade, internal logistics is not only limited to the movement of raw materials needed for production, or to simply storing goods that have completed the manufacturing process, waiting for the order preparation phase to be shipped, but is seen as one of the essential components of companies' success. (Malindzak et al., 2005)
Logistics 4.0 can be reached by location tracking systems, predictive analytic systems for demand forecasting, and artificial intelligence for warehouse management. (Evtodieva et al., 2019)
Logistics has an immense role to do within a company, as it contributes to the smooth running of the operations, and is always seen as the function in charge of getting the right product to the right customer, in the right quantity, at the right time, at the right place, at the right price, and in the right condition. (Trebuna et al., 2019). It is noticeable that logistics costs are often up to 20% of global costs. The main goal of companies is therefore to establish a process in which they ensure higher profitability and lower expenses. (Sasik, 2014). The non-presence of strong internal logistics processes engenders several issues in the movement of raw materials to feed the production line, as well as the finished products. (Emmett, 2008). In addition, the actual customers' requirements are correctly taken only when a well-determined flaw of goods and materials is established, which comes from efficient internal logistics. (Mikusova et al., 2020)
Generally, logistics 4.0 main objective is to emerge digital manufacturing, involving smart mobility, the flexibility of industrial operations, and their combination with customers and suppliers to adopt innovative methods. (Nasser, 2014). This will help improve intercommunication and collaboration in new and intelligent ways, and make logistics processes more efficient and effective. (Gilchrist, 2016; Baur et al., 2015; Koch et al., 2014)
Logistics 4.0 forces companies to focus on man-machine interaction, information, and communication technology (ICT) as well as the usage of advanced sensors, and the organization's improvement through lean management. (Doh et al., 2016)
Companies aim to respond successfully to customer needs, improve customer relationship management and optimize production processes to save time and costs. (Barreto et al., 2017)
Researchers indicate that Logistics 4.0 can be reached by the integration of horizontal and vertical value chains in terms of digitizing services as well as products and customer relations. (Kovács et al., 2016)
Therefore, process optimization is achieved by properly coordinating and integrating all supply chain components to achieve a high level of transparency and visibility. (McKinsey, 2015).

2.2.Smart Systems Integration (SSI): Literature review

Smart system integration (SSI) has many definitions, we can simply define it as systems that aim to create in an integrated way, a combination between functions and data communication,

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actuation, and sensing. Regarding logistics, the application areas of these systems are divided into four main fields: Transport, factory automation, Internet of Things, and security. (EPoSS, 2017)

The term can also be described as a system based on devices, and technologies, with recognition techniques, and a high ability of management improvement, detecting issues, and anticipating failures. (Ferreira et al., 2019)

The intelligent systems, devices, and technologies mentioned above open up new possibilities for businesses, to reduce their costs, and increase their revenue, by enabling companies to manage devices, inspect data, and organize work processes, to provide a high level of services and increase customer accuracy. (Krithika et al., 2020)

In logistics, better conditions for information sharing can be created through SSI, by coordinating information systems and supply chain processes to ensure better interaction, lower risk of incompatibility, and faster system performance. (Nikolova et al., 2018)

The integration and the implementation of intelligent systems, including real-time location, and augmented reality have been enabled by the Internet of Things, which was primarily used for tracking operations in other fields, it can nowadays easily be repurposed for more industries such as transportation, logistics, and manufacturing, to increase productivity and efficiency. (Ramrez et al., 2019)

Regarding transportation, for example, a design of an intelligent logistics transportation system was described, by setting up a new model that uses software to identify the briefest path to quickly deliver goods. As a result, the shortest paths will be provided between the sources and the destinations with less customer pick-up (CPU) time. (Kumar et al., 2018)

In the same context, smart systems help companies to check the feasibility and evaluate at the same time the performance of the intelligent transportation systems ITS, and aim to improve the customer experience by enabling structured transportation, tracking, and goods delivery. (Cheng et al., 2019)

Based on what precedes, we can make hypotheses regarding the relationship that may exist between the integration of smart systems and logistics performance, which we can answer in our next paper through an empirical study. Starting from the definition of smart systems, which are described as systems based on devices and technologies with a high ability to detect issues and anticipate failures, we assume that there is a significant relationship between smart systems integration and the reduction of execution times. Moreover, since time is directly related to cost, we assume that there is a significant relationship between smart systems integration and cost optimization.

3. Smart system integration framework in logistics (SSI)

Intelligent systems come with several key capabilities that link operational skill levels with materials, equipment, as well as manufacturing, and the involvement in information technology holders such as computers and storage, along with high safety, reliability, connectivity, and interoperability. (EPoSS, 2017)

As one of the main application fields of intelligent systems is the smart factory, the key capabilities of the smart systems align with the key principles of Industry 4.0, and form the basics for its realization, so it can be then categorized as an approach of interconnectivity, digitization, and automation. (Bosch et al., 2017) (Kagermann et al., 2016)

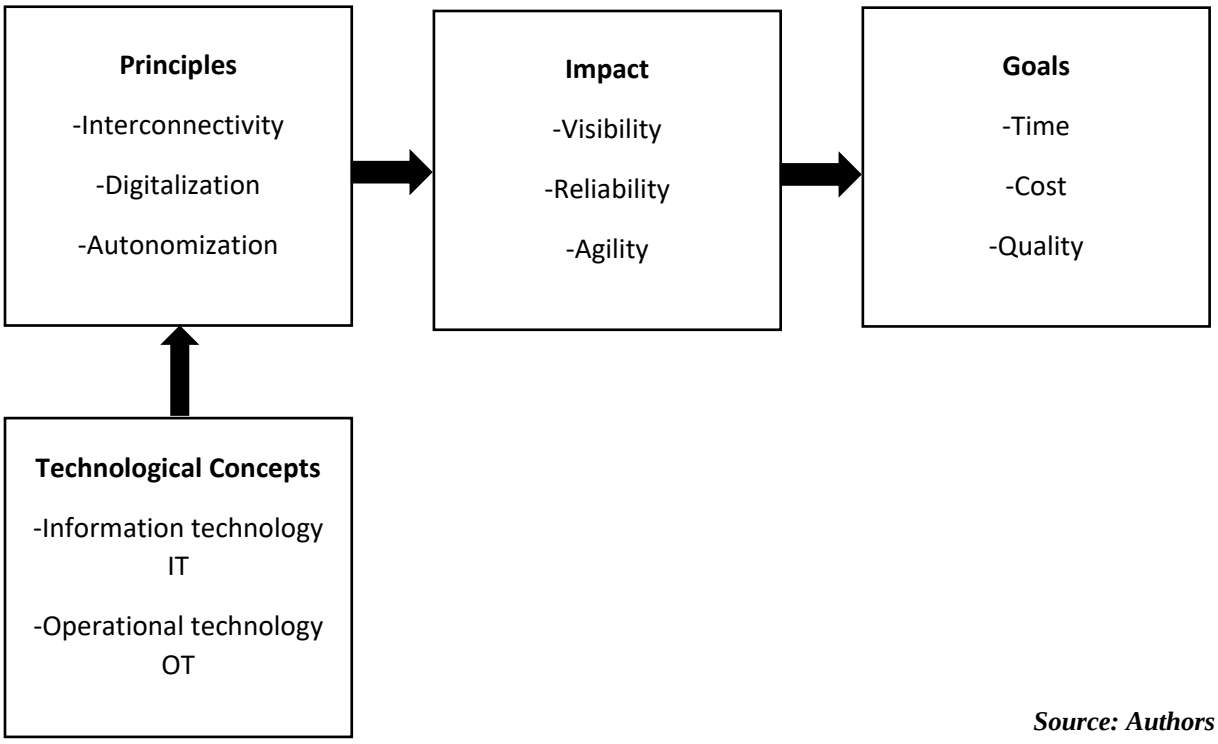
Combining the basic functions of intelligent systems with the technical concept of intelligent logistics enables the implementation of the core principles of Industry 4.0 in the logistics of manufacturing companies (interconnectivity, digitization, and autonomization). Interconnectivity can be ensured through the integration of applications for smart supply

chain, involving all components, while digitization is implemented through the integration of smart logistics, which depends on the information and communication technology ICT. Autonomization can be assured through the intelligent transport system ITS, combined with autonomous vehicles, in addition to the control planning and production systems. These principles aim to unify information technology IT and operational technology OT, permitting manufacturing companies to exploit the potential for optimizing goods' movement, taking into consideration the three main goals of logistics, time, cost, and quality. (Zsifkovits, 2013) (Pan et al., 2017)

Therefore, the most important concrete effects of the principles of Industry 4.0 in logistics are visibility, reliability, and agility. (Bechtold et al., 2021); visibility of any movement permits anticipating failures and any source of inefficiencies, this enables operations more efficient and improves the reliability of forecasts, and because of this, supply chains will be more agile, and reactive, making it easier to adapt to changing requirements.

We present in the next figure the conceptual framework of smart system integration SSI, containing the main concepts we mentioned above, and the important ideas we found in the literature review.

Figure 1: Conceptual Framework



Source: Authors

4. Smart connected logistics solutions

Internal logistics systems are essentially support services that provide material handling and transportation to larger, more critical, complicated manufacturing processes; those systems can realize the changes in the manufacturing environment. Nowadays, smart factories need production systems to flexibly adapt to new products, as well as logistics systems that have to be able to perfectly adjust to the different changes quickly and seamlessly. (Gregor et al., 2017).

Intelligent logistics solutions should be able to follow the high evolution of manufacturing systems, and have to meet several specifications; we quote among others the main

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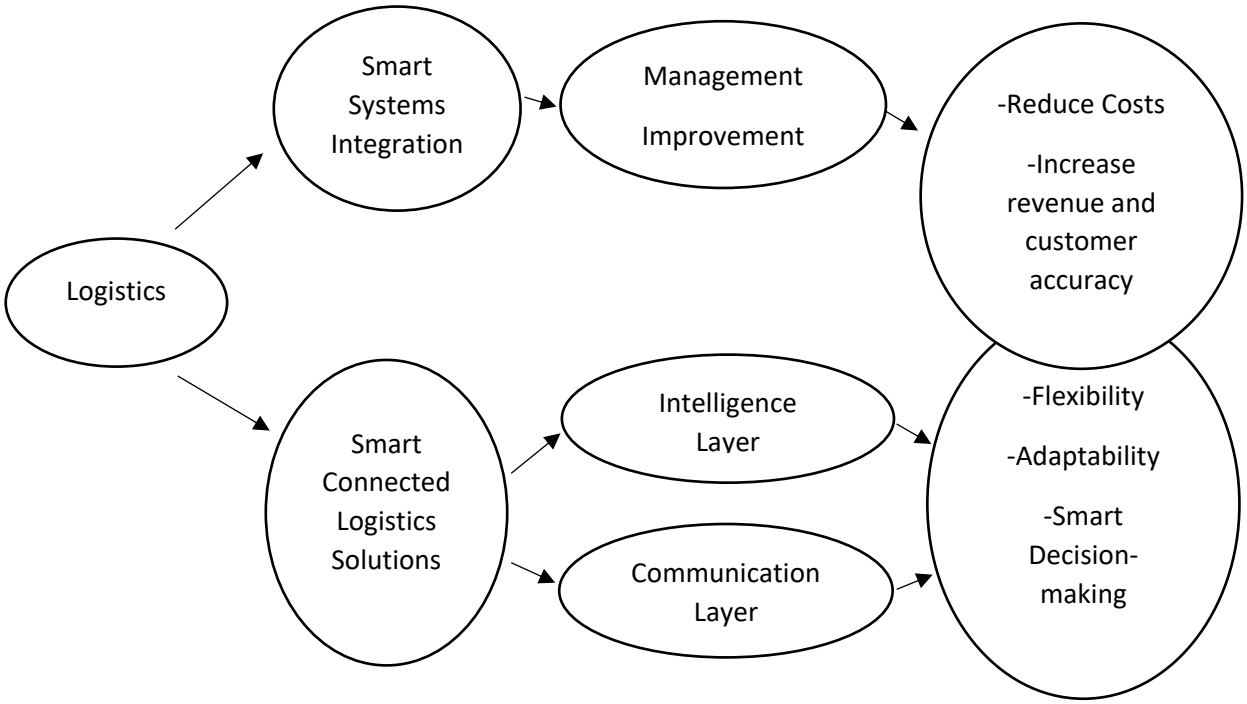
characteristics of intelligent logistics solutions: flexibility, adaptability, self-organization, smart decision-making, and fast reconfigurability. (Rakyta et al., 2016)
To better set up those requirements, several things have to be available; handling robots, mobile robotic systems, technologies of Internet of Things IoT that enable elastic communication and real-time information transfer, as well as cloud computing and cloud infrastructure. (Dulina et al., 2003)
The intelligent connected logistics system is essentially a system of intelligently connected products (such as Automated Guided Vehicles AGVs), that are coordinated through the cloud, which receives on the other hand data from other sources such as production planning and management systems. (Porter et al., 2015)
Connected products are based on a structure in which two important pillars have to be enhanced: the intelligence layer and the communication layer, and they require a variety of features, such as the ability to monitor their conditions and use the information they receive to control their behavior. In addition, connected products need autonomous behavior and characteristics that evolve rapidly and make easy the development of their capacities, which we can call the reconfiguration capability. (Gregor, 2015)
Based on the presence of monitoring systems, a standard electronic control system is set up, realized by the intelligence layer of the product, which gives products the ability to perform their actions such as optimizing route planning, energy consumption, and many other things. In addition, it may automatically start working within that environment, up to a predetermined level.
The intelligence layer can not perform effectively without the communication layer, which lets data transfer, and gives not only an overview of the entire logistics system, but also authorizes automated intelligent devices to communicate with each other and make predictions.

5. Discussion

Logistics has recently become one of the most important departments within manufacturing companies, especially since this department has experienced many changes in its functioning, in terms of strategies, systems, and even at the operational level, following the integration of new technologies into the overall logistics effort.
Logistics has an immense role within a company, as it permits an easy accomplishment of operations, and contributes to optimizing costs, reducing execution times, and increasing quality.
We present in the next figure a theoretical summary that shows the links that exist between different concepts and terms we have evoked in our paper.

Figure 2: Theoretical summary



Source: Authors

We summarize in the next three tables what has been mentioned in the sections above; In table 1, we present what has been found from the authors regarding logistics 4.0 and its importance, then we will come forward the main ideas of smart system integration SSI in the table 2, before getting to smart connected logistics solutions in the table 3.

The first table is a summary of what the authors have said in the literature review about the importance of the integration of new technologies in the logistics field, or what it is called logistics 4.0, and especially how these technologies have contributed to the huge impact, through the improvement of communication and data sharing, prediction and forecasting, as well as making the whole logistics process more efficient and effective.

Table 1 is a summary that includes the main citations of the authors regarding Logistics 4.0. These citations focus mainly on the importance of logistics within companies, as well as the major changes that the field has undergone after the implementation of new technologies, in addition to the impact of these technologies on logistics performance within manufacturing companies.

Table 1. Overview of Logistics 4.0

Author (s)	Year	Logistics 4.0
Antoniuk et al	2021	The logistics field has completely changed, due to several technological changes aimed at facilitating and shortening the exchange of information, data, and executing times
Evtodieva et al	2019	Logistics 4.0 can be reached by location tracking systems, predictive analytic systems for demand forecasting, artificial intelligence for warehouse management
Ramrez et al	2019	The integration and the implementation of intelligent systems, including real-time location, and augmented reality have been enabled by the Internet of Things, which was primarily used for tracking operations in other fields, it can nowadays easily be repurposed for more industries such as transportation, logistics, and manufacturing, to increase productivity and efficiency

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Trebuna et al	2019	Logistics has an immense role to do within a company, as it contributes to the smooth running of the operations, and is always seen as the function in charge of getting the right product to the right customer, in the right quantity, at the right time, at the right place, at the right price, and in the right condition
Gilchrist Baur et al Koch et al	2016 2015 2014	Technologies will help improve intercommunication and collaboration in new and intelligent ways, and make logistics processes more efficient and effective
Nasser	2014	Logistics 4.0 main objective is to emerge digital manufacturing, involving smart mobility, the flexibility of industrial operations, and their combination with customers and suppliers to adopt innovative methods

Source: Authors

The second table presents the definitions of smart systems integration, the impact that SSI has brought for companies and businesses, to reduce logistics costs and increase revenue, and the enormous possibilities they gave, by enabling companies to improve their management, anticipate failures, ensure better interaction, and increasing customer accuracy.

Table 2. Smart Systems Integration

Author (s)	Year	Smart System Integration (SSI)
Krithika et al	2020	Intelligent systems, devices, and technologies open up new possibilities for businesses, to reduce their costs, and increase their revenue, by enabling companies to manage devices, inspect data, organize work processes, provide a high level of services, and increase customer accuracy
Ferreira et al	2019	SSI is a system based on devices and technologies, with recognition techniques, and a high ability for management improvement, detecting issues, and anticipating failures
Nikolova et al	2018	In logistics, better conditions for information sharing can be created through SSI, by coordinating information systems and supply chain processes to ensure better interaction, lower risk of incompatibility, and faster system performance
EPoSS	2017	SSI are systems that aim to create in an integrated way, a combination between functions and data communication, actuation, and sensing. Regarding logistics, the application areas of these systems are divided into four main fields: Transport, factory automation, Internet of Things, and security

Source: Authors

In Table 3, we take a look at the smart connected logistics solutions and the specifications they have to meet to perform adequately, based on a structure that mixes two main layers: the intelligence layer and the communication layer.

Table 3. Smart Connected Logistics Solutions

Author (s)	Year	Smart Connected Logistics Solutions
Gregor et al	2017	Smart factories need production systems to flexibly adapt to new products, as well as logistics systems that have to be able to perfectly adjust to the different changes quickly and seamlessly

Rakyta et al	2016	Intelligent logistics solutions should be able to follow the high evolution of manufacturing systems, and have to meet several specifications; flexibility, adaptability, self-organization, smart decision-making, and fast reconfigurability
Gregor	2015	Connected products are based on a structure in which two important pillars have to be enhanced: the intelligence layer and the communication layer, and they require a variety of features, such as the ability to monitor their conditions and use the information they receive to control their behavior
Porter et al	2015	The intelligent connected logistics system is essentially a system of intelligently connected products (such as Automated Guided Vehicles AGVs), that are coordinated through the cloud, which receives the other hand data from other sources such as production planning and management systems

Source: Authors

6. Conclusion

In this paper, we tried to address the importance of the integration of smart systems in the logistics of manufacturing companies, since logistics is not anymore limited to the simple movement of materials needed for production, or simply storing goods in warehouses, but is considered one of the main pillars within manufacturing companies and an important key success factor.

Our discussion in the first section was around the literature review of logistics 4.0 and smart systems integration, where we presented the main ideas of the authors in their works and papers. We have mentioned that the main goal of companies is to set up a process that permits them to ensure higher profitability, and better quality, with low expenses. Indeed, the field of logistics, like many others, has fundamentally changed, with the inauguration of multiple technological transformations introduced to facilitate data sharing. Moreover, intelligent systems help companies to organize their processes, improve productivity with high precision for their customers, and open up new opportunities to reduce cost, execute time, and increase quality. In addition, better conditions for information sharing can be accomplished through smart systems integration SSI, by coordinating data systems and logistics processes to ensure better interaction, lower risk of incompatibility, and faster system performance.

In the second and third sections, we have shown how the combination between intelligent systems and logistics permits the implementation of the main principles of Industry 4.0 in manufacturing companies; interconnectivity, digitization, and autonomization. Interconnectivity can be established by the implementation of intelligent supply chain applications, as for digitization, it can be achieved through intelligent logistics based on information and communication technology (ICT), while autonomization is ensured by intelligent transportation systems (ITS), combined with autonomous vehicles. Then, we presented a framework of smart systems integration in logistics, which contains the relationship that exists between technological concepts, principles of Industry 4.0, and their impact, as well as the main goals of Logistics 4.0.

Furthermore, Intelligent logistics solutions must be able to keep up with the highly evolving manufacturing systems and meet multiple specifications. Among other things, the main characteristics of intelligent logistics solutions are flexibility, adaptability, self-organization, intelligent decision-making, and rapid reconfigurability. Next, we discussed the structure of

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connected products, which has to contain two layers: an intelligence layer and the communication layer, and they need to have various functions such as the ability to monitor their conditions and use the data obtained to control their operations.

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