The Use of Internet of Things (IoT) Applications in the Logistics Outsourcing: Smart RFID Tag as an Example

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Abstract

In a highly competitive and uncertain industry, as is the area of the logistic services, creating new offers, complex, customized and integrated, and their differentiation are the levers of performance and profit to the logistics service providers. Being a specialist, force of proposals and innovation appears to be essential for these third-party actors (noted LSP). Faced with changing their profession, what the added value for the LSP to use information and communication technologies especially Internet of Things (IoT)? What can be the strategies implemented by the logistics service providers to sustain its activity?

This article will lay the theoretical foundation for reflection on the strengths implemented by LSP manifested mainly by the use of radio identification chips (RFID: Radio Frequency IDentification). We will present a novel approach to integrate the RFID smart and legacy Tag in the logistics outsourcing process by using the publish/subscribe pattern with the MQTT (Message Queueing Telemetry Transport) protocol. This approach allows integrating an RFID system continuously to the logistics outsourcing process and reporting event in real time regarding the performance of the LSPs.

Keywords:

The logistic services, LSP, IoT, RFID smart, logistics outsourcing.

1. Introduction

The logistics outsourcing phenomenon has changed the traditional boundaries of companies as well as their managerial and organizational practices within ever larger, global and collaborative supply chains (Jabir and al., 2018).

The reason for this first wave of outsourcing was purely economic (Kedia and Lahiri, 2007), based on cost criteria. Other factors are then built from this phenomenon, including lack of internally capacity references to achieve the benefits of the outsourcing.

It is in this context that the logistics outsourcing phenomenon is then developed and multiplied (Jabir and Jawab, 2015). This reengineering process seems to affect almost everyone involved, from industrial to distributors through Logistic Service Providers (LSP). The point is to reduce costs in a context where the logistical issues become more complex (Bellingkrodt and Wallenburg, 2103). However, under the constraint of the economic environment and looking to be more competitive, companies are developing collaborative relationships increasingly close. Logistics Service Providers follow this path but the strategic dimension constrains the development of their business and their mission.

This article will lay the theoretical foundation for reflection on the strengths implemented by LSP manifested mainly by the use of radio identification chips (RFID: Radio Frequency IDentification). We will present a novel approach to integrate the RFID smart and legacy Tag in the logistics outsourcing process by using the publish/subscribe pattern with the MQTT (Message Queueing Telemetry Transport) protocol. This approach allows integrating an RFID system continuously to the logistics outsourcing process and reporting event in real time regarding the performance of the LSPs.

2. Problem

Getting into a logistics outsourcing process is an important strategic act that its implementation is done in a hurry, especially since it often excludes any possibility of going back (Jabir and Jawab, 2013). This comes to proceed upstream to a comprehensive study. Thus, criteria of human economic characters, organizational, technical, etc ... can be used in the decision to resort or not to logistics outsourcing.

Thus, due to increasing of logistics outsourcing, logistic services appear to be a pertinent field of analysis for the study of inter-organizational relationships (Jabir and al., 2018). On the other hand, companies have realized that they need to cooperate with the LSP, so they can focus on their core activities (Wallenburg, 2009). However, despite the advantages and benefits of logistics outsourcing, many relationships that are not renewed at the end of their contract or does not exist in the period initially planned (Jabir and Jawab, 2015).

The ability of LSPs to stand out against each other results in service qualities ranging from simple freight transportation to implementing integrated and customized service solutions such as after-sales service management and carrying out direct marketing operations (Paché, 2007).

LSPs offer more specialized innovative solutions that can not be realized by companies except at a very high cost. New logistics contracts no longer only consider price, quality of services, lower costs and the performance they generate, but also some ability to manage real-time communication through employment Information and Communication Technologies (ICTs) among all network members. The integration of these different applications within the same system represents an Information Technology (IT) challenge because it assumes an effective interface between the Internet and the information system of each of the companies in the network (Kacioui-Maurin, 2011, p.133). Decision makers also want to benefit from skills that are not available internally and reduce their costs. Therefore, LSPs must be specialists in a technology, in a process, etc. and control their costs (Howard and Squire 2007).

The construction, execution and reconstruction of innovative offers that create value for companies are thus a priori at the heart of the LSP strategies. Especially since technological developments are pushing LSP to innovate (examples: Electronic data interchange, RFID, Internet, WMS, TMS, ERP, etc.) (Saglietto, 2009). We can then conclude that there are real challenges that LSPs should take into account, particularly the use of IoT such as RFID technology. Thus, Figure 1 below shows the overall service provided by the LSPs and the nature of services innovated subject of the article.

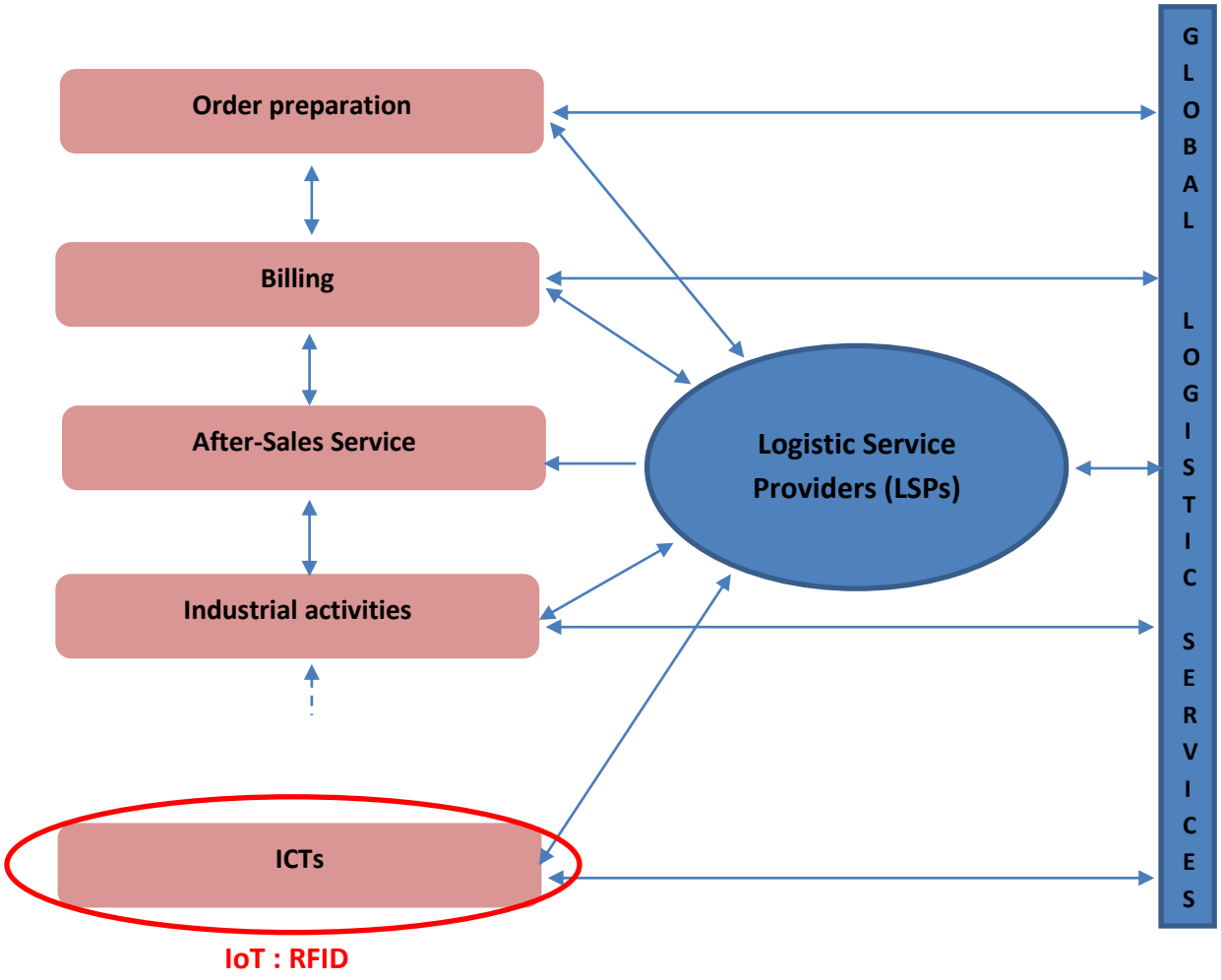

Figure 1. Innovative Logistic Services Proposed by LSPs

3. Logistics outsourcing context

Today, the logistic outsourcing is developing in an industrial environment marked by a strong commercial uncertainty (Wang and al., 2011). Companies have a strong tendency to specialize by refocusing on their core business. In this context, the logistic outsourcing turns out to be a way to improve the closeness with the customers thanks to the density of networks set up by the LSP (Fouad and Jabir, 2012). To be capable of answering quickly the changes and the demands of the market, organization tries to maintain a physical contact with their customers (Wallenburg and al., 2010a). Consequently, companies are not any more directly in competition between them, but rather through the diverse logistic networks to whom they belong (Jabir and Fouad, 2011).

Today, LSP participate actively in the life of the company. They contribute to the value creation and are real levers of improvement, that is why the organization of the control of this actors' dresses multiple stakes (Wallenburg, 2009).

Indeed, the study led by the cabinet Ernst et Young in 2011 demonstrates the strong growth of the number of the providers within the organization. The increase perceives itself both at the level of the number of providers and at the level of the activities which there are confided. The organization is then confronted with problems relative to the management of its various outsourcings.

4. IoT and RFID: State of the Art

Radio Frequency Identification (RFID) technology has experienced a continuous evolution in the last decade, by moving from simple transponders for tracking purposes to sensor-equipped smart Tags, which are able to implement sensing and processing functions [(Donno and al., 2014), (Khan and al., 2014)]. Smart Tags have the potential to substitute or complement existing wireless sensor networks (WSNs) due to their tiny size, low power, and very cost-effective identification mechanisms. They may bring undisputed benefits to various IoT application scenarios, where networked Tags with sensing and computing capabilities create smart environments, such as in enhanced supply chain, factory automation, smart-home, smart-city and personal healthcare scenarios (Khan and al., 2014). However, to fully exploit the potential offered by Smart RFID Tag, it become important to integrate them in the supply chain management to enabling them to be accessible from and to communicate with any other networked devices in the Internet to create a fully smart environment (Jawab and al., 2015).

The Internet Engineering Task Force (IETF) is driving the standardization of IPv6-based protocols for the IoT. The IPv6 over Networks of Resource-constrained Nodes (6lo) working Group (WG) is currently enabling IPv6 connectivity for a variety of link-layer technologies in constrained node networks with limited power, memory and processing resources, such as Bluetooth Low Energy (BLE) and Near Field Communication (NFC) (Nieminen and al., 2014). The 6lo standardization effort has not yet addressed UHF RFID among the link-layer technologies of interest, albeit the potential of modern smart Tags to be included as fully-fledged components in the IoT.

In this article, we design an IPv6-based internetworking solution, which natively enables smart RFID Tags to communicate directly with any other devices connected to the Internet. Kevin Ashton, the co-founder of the MIT´s Auto-ID Center, which developed the global standard for RFID, introduces the term IoT and other sensors,

describing the Internet of Things as a system where the Internet is connected to the physical world through ubiquitous sensors. The Internet of Things can be defined as a dynamically changeable and self-configurable, global network infrastructure having special characteristics based on interpretable communication protocols. In this infrastructure, physical and virtual "things" are intelligent and have unique identities, physical attributes, and are seamlessly integrated into the information network (Nieminen and al., 2014).

With the advent of today's mobile technologies and the IoT, enterprises can accelerate productivity, profitability and operations with solutions designed specifically for their processes. With the right IoT solution in place, enterprises can connect all devices across a centralized cloud network, and capture and share their mission-critical data, allowing them to gain real-time visibility of their operations.

This paper describes an innovative solution based on the publish/subscribe pattern and 6lo-RFID framework to integrate the RFID Tag on the internet of things.

5. Proposed approach

In our approach, we used the publish/subscribe pattern to integrate the RFID Tag in the internet of things. The protocol used is the MQTT (Message Queueing Telemetry Transport). The MQTT is a many-to-many communication protocol, which allows multiple clients to exchange messages using a central broker who is in charge of routing incoming messages based on published services see Figure.2. MQTT is more matured and stable than CoAP. It is best used when a node sends data at irregular intervals of time i.e. event driven system which is good for RFID applications with requirements for continuously reporting events of RFID Tag reads (EPC codes) from many different origins (Valente and Neto, 2017). MQTT is an asynchronous messaging protocol.

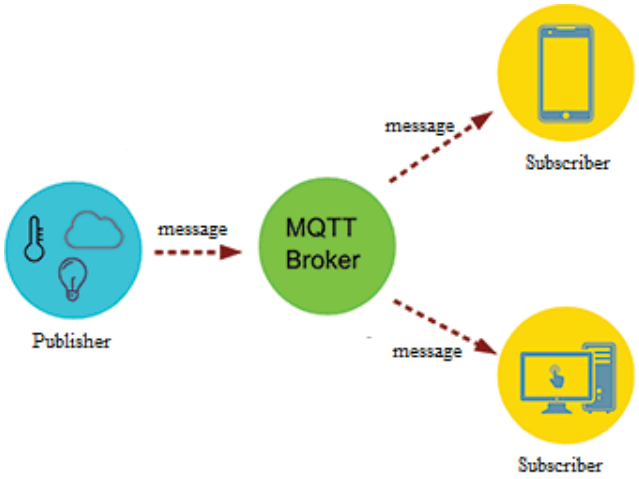

Figure 2. MQTT Protocol

The MQTT protocol is designed for light Machine-to-Machine communications in constrained networks or high latency networks. The MQTT Publisher publishes messages to an MQTT broker, which are subscribed by other clients (Subscriber) or may be retained for future subscriptions. Each message is published at an address, known as Topic (Youngchoon, 2017). Customers can subscribe to several Topics and receive each message posted to each

Topic. MQTT is a binary protocol and normally requires a fixed 2-byte header with a small message payload of up to 256 MB. It uses TCP as transport protocol and hence perfect for scenarios where connectivity is required all through, also it use TLS / SSL for security. Thus, the communication between the client and the broker is a connection oriented. Another great feature of MQTT is its three levels of Quality of Service (QoS) for reliable delivery of messages (Youngchoon, 2017).

The proposed system consists essentially of smart Tag to send their EPC and sensing data to the reader and legacy Tags their EPC to the reader. The reader will send this data to an MQTT broker; this broker can be for example a raspberry pi with a software. Many different brokers already support MQTT, such as ActiveMQ, Apollo, HiveMQ, IBM Message Sight, JoramMQ, RabbitMQ, MosquitoMQ and VerneMQ. The RFID reader will play the role of both a publisher by publishing continuously the data collected from the legacy Tags and smart Tags, and will also play the role of subscriber to receive data form another publisher. The clients or others devices in the network will play the role of the subscriber to read data from the Tags published in the broker in near real time and also the role of a publisher to send data to the Tags as depicted in Figure 3.

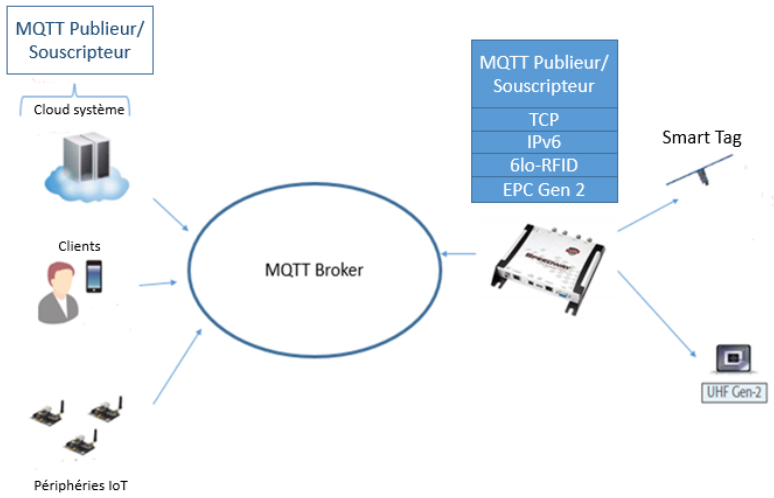

Figure 3. The proposed system based on publish/suscribe pattern

In the proposed system, RFID smart Tag will communicate by using IPv6 Address. For that purpose, we changed the framework presented in (Ivan Farris and al., 2017) by replacing the use of The CoAP protocol by the MQTT protocol. To allow the exchange of IPv6 packets generated by (or directed to) a given Tag, we propose a new organization of the user memory of the RFID Tag (UM), shown in figure 4. According to the EPCglobal Tag Data Standard, the first eight bits of Unified Messaging contain the DSFID (Data Storage Format IDentifier) field, which specifies the format of the rest of the Unified Messaging store. This field includes the data format to indicate which data system predominates in the MU. Clearly, a new data format code must be associated with IPv6-based RFID communications; this maintains compatibility with other RFID data standards. The following bits are reserved for future use (RFU) to manage the protocol version, priority management, or congestion management of the queue.

Since the read and write commands operate on 16-bit word units, we propose to store the 6lo-RFID frame starting with the second 16-bit word of the MU to avoid unnecessary read / write of the field. DSFID when sending / retrieving data packets. The following fields are included in the 6lo-RFID header (2 to 4 bytes) 6lo-RFID header see Figure. 4.

6. Communication Pattern

The proposed approach is a master-slave approach to accessing unified messaging and managing the reader-Tag interaction, where the reader acts as a master and controls the flow of data from / to all variables in its coverage area. The proposed solution is compatible with the Gen-2 protocol because it can easily exploit the already defined Gen-2 commands. The reader initiates the label singulation phase by specifying the EPC code of the desired label in a SELECT command, so that only the label with the specified EPC can participate in the inventory phase and the collisions Tag-to-Tag are avoided until all the Tags are read in their reading area Then, the Write and Read commands respectively allow the transfer of data in the downlink and uplink directions. All these data collected by the reader are published in the broker. This operation is carried out continuously in order to evaluate any event in the RFID system.

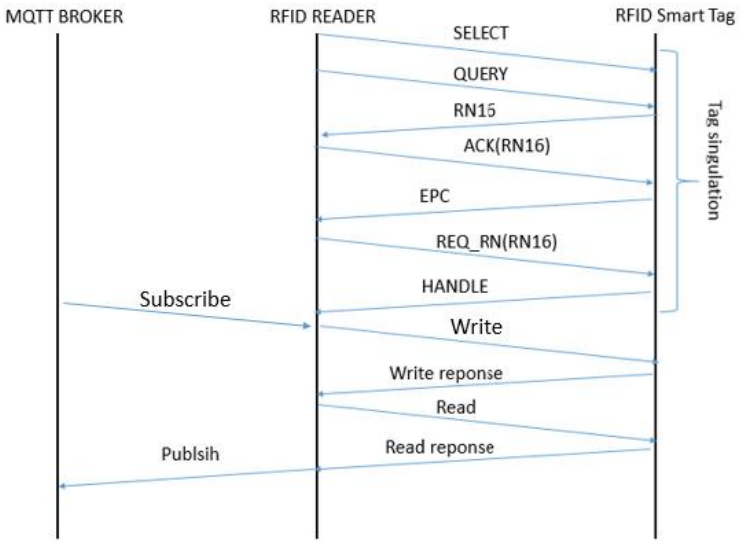

Figure 4. The proposed system based on publish/suscribe pattern

7. Conclusion

In this article, a novel approach based on IPv6 framework and publish/subscribe pattern using MQTT protocol has been designed to transparently integrate RFID systems into the logistics outsourcing domain and enable IPv6 communication and networking over UHF RFID smart Tags. This approach uses a new packet format of data stored in the UM of the RFID Tag called 6lo-RFID this framework includes and IPv6 header, TCP header, MQTT header. This approach is compatible with the standard EPCglobal Gen-2 protocol.

The use of this RFID saves a lot of time and improves the efficiency of supply chain systems and inventory management greatly. In addition, the implementation of RFID reduces the costs that are associated with the movement of goods and information demand. The company is able to see its supply in real time, to compare demand forecasts for accurate and timely order. This complete visibility of the supply chain offers a remarkable insight that allows companies to continuously refine their processes to maximum efficiency at minimal cost. Finally, data collected from RFID technology facilitates high-precision financial reporting and improves management decisions across the organization. For a local company looking to expand its presence globally, the implementation of RFID technology and LSPs could be of great help. Early adoption of RFID technology could simplify supply chain and inventory management systems and provide greater control and accuracy.

However, the market for logistics service providers is still heterogeneous and fragmented and their offer is not stabilized, especially since it is difficult for all stakeholders to face global challenges: control of transport costs, geographic network development, customization of the overall supply and improving service and traceability.

The contribution of the PSL in terms of new technology cannot be ignored, but special attention should be paid to them as they get to develop essential assets to the success of logistics outsourcing process. The evolution of LSP therefore offers interesting research avenues to explore.

Références

Arif, J., Ibn El Farouk, I., Jawab, F, Logistic outsourcing: From the contract's complexity to the logistic services performance, International Conference on Industrial Engineering and Operations Management, 8th IEOM Bandung 2018.

Arif, J., Ibn El Farouk, I., Jawab, F., Risk assessment in the logistics outsourcing process: Decision-making tool, International Conference on Industrial Engineering and Operations Management, 8th IEOM Bandung 2018.

Bellingkrodt, S., and Wallenburg, C. M., The role of external relationships for LSP innovativeness: A contingency approach. Journal of Business Logistics, 34(3), 209-221, 2013.

D. De Donno, L. Catarinucci et L. Tarricone, ".A battery-assisted sensor-enhanced RFID Tag enabling heterogeneous wireless sensor networks," IEEE Sens., pp. 1048-1055, 2014.

F.Valente; A. Neto "Inteligent Steel Inventory Tracking with IoT/RFID" IEEE International Conference on RFID Technology & Application (RFID-TA) ,2017.

Fouad J. and Jabir A., Stratégies d'externalisation logistique, entre risques & opportunités, Rencontres Internationales de la Recherche en Logistique (RIRL) 2012, Montréal Canada.

Fouad JAWAB, Jabir ARIF, Youssef MOUZOUNA, Ahmed MOHSEN, Jamal ELAOUFI « Atouts de l'utilisation des TIC pour les prestataires de services logistiques » Colloque International de la Logistique et le Supply Chain Management LOGISTIQUA, Safi, Mai 2015.

Howard M., Squire B., (2007), Modularization and the impact on supply relationships, International Journal of Operations & Production Management, v27, n°11, pp.1192- 1212.

J. Nieminen ; C. Gomez, "Networking Solutions for Connecting Bluetooth Low Energy Enabled Machines to the Internet of Things," IEEE Network, Vol. 28, No. 16, pp. 83-90, 2014.

Jabir A., and Jawab F., Proposition d'un modèle de gestion des risques de l'externalisation logistique : Cas de Label'Vie. Colloque International de la Logistique et le Supply Chain Management LOGISTIQUA, Tanger, Mai 2013.

Jabir ARIF and Fouad JAWAB, Outsourcing logistics: Strategic Tools for Decision to Outsource Logistic Activities, 4th International Conference on Logistics, Hammamet, Mai-2011, Tunisia.

Jawab F and Jabir A., Risk matrix model applied to the outsourcing of logistics' activities, Journal of Industrial Engineering and Management, 8(4): 1179-1194, 2015.

Kacioui-Maurin, E., (2011), Exploration et exploitation, les formes d'ambidextrie organisationnelle dans l'innovation de services : le cas des prestataires de services logistique, Thèse de doctorat en Sciences de Gestion, Université de la Méditerranée (Aix-Marseille II), Novembre.

Kedia, B. and Lahiri, S., International outsourcing of services: a partnership model. Journal of International Management, 13: 22-37, 2007.

M. Khan, M. Islam et D. Hai, "Design of a reconfigurable RFID sensing Tag as a generic sensing platform toward the future Internet of Things." IEEE Internet Things, pp. 300-310, 2014.

Paché G., (2007), "Les 4PL capitalisent-ils les savoirs issus du pilotage des chaînes logistiques étendues ?" in P.L. Dubois et Y. Dupuy, Connaissance et Management, Economica, 2007, 358 p.

S. P. Ivan Farris, M. Merenda, A. Molinaro, R. Carotenuto et a. A. Iera, "6lo-RFID: A Framework for Full Integration of Smart UHF RFID Tags into the Internet of Things," IEEE Network, 2017.

Saglietto, L., (2009), Conséquences des interactions dynamiques entre les entreprises et leurs 4PL sur l'évolution des canaux de distribution, Logistique & Management, vol 17 n°2, pp. 17-27.

Wallenburg, C. M., Cahill, D. L., Goldsby, T. J., and Knemeyer, A. M., Logistics outsourcing performance and loyalty behavior: Comparisons between Germany and the United States. International Journal of Physical Distribution & Logistics Management, 40(7), 579-602, 2010a.

Wallenburg, C. M., Innovation in logistics outsourcing relationships: Proactive improvement by logistics service providers as a driver of customer loyalty. Journal of Supply Chain Management, 45(2), 75-93, 2009.

Wang Y. et al, (2011), Electronic Marketplaces for Tailored Logistics, Industrial Management and Data Systems, v107, n°8, pp.1170-1187.

Youngchoon Park, Building an effective IoT ecosystem for your business, Milwaukee, Wisconsin, USA: Springer, 2017.

Zeynep, H., and Higgins, M., The effect of contractual complexity on technology sourcing agreements. MPRA Paper No. 4979, Georgia Institute of Technology, 2007.

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