A link between Logistics and Interoperability

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Abstract

The logistic appears as an important role in the growth of organizations, especially in high competitiveness environment. Increasingly, the business environment has become more complex and heterogeneous, so the ability to interact, share, collaborate their assets and information become a significant competitive advantage.

In this sense interoperability is a dynamic interface between their systems and flows and can provide the actors in a supply chain more efficient response regarding cost, quality, and responsiveness.Therefore, this article seeks to map the literature the relationship between logistics and interoperability by building a relevant portfolio of work. This work was characterized as exploratory, descriptive, qualitative and quantitative approaches.

This paper aims to develop the concept of Logistics Interoperability based on information technology, business and logistics activities. From the portfolio of papers resulting from the bibliometric research, an analysis of the contents by using a classification study of the works was applied. The gap found in the literature is concerned with the interoperability and applications directly related to logistics. One of the evidence, after the analysis of bibliometric portfolio contemplating the authors, journals, articles, keywords is the predominance of interoperability the systems area.

Keywords – *interoperability ; logistics; supply chain; bibliometric*

INTRODUCTION

Logistics has a strategic role in organizations. On one side is a cost generator, which in Brazil, according to(Lima, 2006), representing about 13.2% of Gross Domestic Product (GDP). On the other hand, is a way to differentiate a company or at least meet the requirements of the market.The balance between the two extremes involves the appropriation of attributes, such as agility, integration and performance measurement. Because of this, among other things, the logistics need to be fast and flexible, integrate the activities, customers and suppliers and monitor their results, measuring their performance.

However, the differences between companies and between how their own logistics activities are managed, lead to breaks in the flow of materials and information(Fernandez, 2009; Zapata, Toro, & Marín, 2012). Analyzing interoperability, an attribute desired in the area of information systems, it was observed that its principles can also be applied to logistics.

The literature, in general, considers that the ability of an organization to act in an interoperable way, internally and externally, is an important competitive advantage, as it can reduce costs, improve the

response time and allow greater scope of their operations; since interoperability enables the interaction between processes, information sharing, equipment and systems from different organizations(Daclin, Chen, & Vallespir, 2006; Tezza, Bornia, & Vey, 2010).

The advancement of interoperability need occurs from the 90s, with the development and evolution of information systems and an increase in data streams at all organizational levels (Manola, 1995) and between the organizations themselves to obtain greater gains in the production chain.

At the same time, logistics also enables a better relationship between suppliers and customers, by coordinating the material flow and the related information. Thus, logistics acts as a synchronizer element between supply and demand (Ballou, 2009).

It is noted, therefore, that the inclusion of elements in the logistics interoperability studies may be relevant to the development area. That is, if on the one hand, companies realize the need to share information, actions and structures with their customers and suppliers and, therefore, make use of aspects of interoperability, and by the other hand logistics is an important connecting link between companies, with regard to the material flow and related information, it can be concluded that interoperability and logistics, together, offer to important organizations elements for the effectiveness of trade relations. Thus, this research aims to establish the constructs Logistic Interoperability (LI) in order to structure this concept to facilitate the study of logistics and its use in business practice.In what follows are the methodological aspects to attain the goal.

METHODOLOGY

This work is characterized as exploratory, since it has as end the systematization of knowledge about the interoperability logistics. As for the media, is a literature review, having been consulted articles published from 1994 to 2014 in the following databases: OneFile, Emerald, Web of Science, Science Direct, Oxford Journals, SpringerLink, Wiley, DOAJ, Sage, JSTOR.

The research started from the literature, passed to the development and merging with the results. For literature, was used as a keyword the term "Logistics Interoperability" in any article of the field, without temporal cut with the intention to collect the largest possible number of searches. Initially, were identified 112 journal articles (indexed journals). In the next step, the duplicate articles were eliminated, resulting in 82 surveys. Of these, after reading the titles and abstracts and a consequent adherence analysis, 59 articles remained, becoming the Research Portfolio.

For the portfolio management, was used the EndNote software version 6®, allowing a view of the characteristics of the papers, abstract and keywords more effectively. Having defined the Portfolio, it began the classification of articles, which led to the identification of the main areas where interoperability is applied. Based on this information, was studied the historical evolution of the subject matter, presenting the state of the art on interoperability in logistics.

On this basis, the identification of constructs and to propose a concept of interoperability logistics was possible.

Interoperability

In the field of information technology, interoperability allows different organizations to provide data without interfering in their technology choices, production processes, or internal culture, can be defined as the ability of a system or its components to share information and applications regardless of their heterogeneity (Anand, Yang, Van Duin, & Tavasszy, 2012; Bishr, 1998; Blattert, Lemm, Ehrhardt, & Seeling, 2012). Interoperability between components of a distributed system is defined as the ability of these components to exchange information despite language differences and platform (Anand et al., 2012; Chen, Yeh, & Chen, 2010; Ming-yong, 2009).

A broader view is given by (Wang & Wang, 2009): Interoperability is the ability to work together with other companies, acting in the exchange of information and equipment, with minimal impact on them. It is observed that in addition to information, the author also deals with the equipment, perpetuating the concept of the application which was originally restricted to the area of information systems.

Similarly to (Chen et al., 2010) interoperability is the compatibility of skills and assets with other organizations. By addressing skills, approaches the concept of what is proposed in the field of knowledge management.

According to (van Lier & Hardjono, 2011), interoperability is the establishment of mutual connections among two or more systems for sharing information. One aspect to consider is to share the semantics, whose role is to facilitate the understanding of the various stakeholders. And still, to (Buranarach, 2004) semantic interoperability ensures that the data exchanged are correctly interpreted within the context of a given transaction, culture and terminology adopted by each sector of the company. Thus, semantic interoperability is the ability of two or more heterogeneous systems for working together, sharing information between them with a common understanding of its meaning (Lendermann et al., 2003; Paviot, Cheutet, & Lamouri, 2011).

Logistics

Logistics has been recognized as a strategic element to business success. Of all existing settings (many identical), it was used the following:

Logistics is the process of strategic management of the acquisition, handling and storage of materials, parts and final stocks (and the related information flows) through the organization and its marketing channels, such that the current and future returns are maximized through the execution of applications, seeking cost-effectiveness(Christopher, 1999).

It is observed that the fundamental activities such as handling and storage are covered and that its goals are focused on business profitability. That is, it is necessary that the logistics act as an element that can contribute to the business strategy and, in consequence, improve the financial performance of the business.

The customer service is critical to the competitiveness of a company. In this sense, information and resource sharing is required, which supports the need to study the subject interoperability in the context of logistics.

In a survey conducted by (Follmann, 2012), were identified seven attributes that characterize the development of logistics, among which is the integration. In(Pagell, 2004) integration is defined as "the

process of interaction and collaboration in which manufacturing, purchasing and logistics work together cooperatively to reach acceptable results for the organization each other." Nowadays, it adds to the scope of integration the relationship with suppliers and customers. The integration and collaboration are aspects also worked for interoperability.

Logistics Interoperability

From the Portfolio classification was developed to identify the articles that addressed interoperability logistics. It was observed that only 02 of the 59 articles evaluated (Table 1) involved the fact that logistics, which justifiesthe approach taken in this research.

Although there are only 02 studies addressing the interoperability logistics, there are researches that focused on interoperability in some specific aspects of logistics, such as transport (09 searches), storage (02 studies), distribution (03 studies), and management supply chain (15 surveys).

In the field of production, where logistics is an important interface, only from 2005 are papers related to interoperability, dealing with: simulation platforms (Han, Wu, Zhang, & Tang, 2005)or oriented systems orders(Rogers, 2008), or in manufacturing systems(Panetto & Molina, 2008), on construction sites (Briggs et al., 2009; Correa Espinal & Gomez Montoya, 2009), and city logistics (Palacio-León & Adarme-Jaimes, 2014).

Table 1.

Interoperability classification according to their application

Author and year	Application of the classification interoperability		
	Information Technology	Business	Logistics (indirectly)
(Beckstead, 1994)		x	
(Manola, 1995)	x		
(Bishr, 1998)	x		
(Sarjoughian & Zeigler, 1999)	x		
(Cavalieri, Grasso, Redfern, Schiller, & Sillman, 2000)		x	
(Sinex, Basile, Sellers, Kerchner, & Gion, 2000)		x	
(Lendermann et al., 2003)		x	
(Scholz-Reiter & Höhns, 2003)	x		
(Buranarach, 2004; Chaudhuri & Heinrich, 2004; Ducq, Chen, & Vallespir, 2004)	x		
(Bruzzone, Mosca, Revetria, Bocca, & Briano, 2005)		x	
(Han et al., 2005)	x		
(Helo & Szekely, 2005)	x		x
(Talevski, Chang, & Dillon, 2005)		x	
(Lejian & Liehuang, 2006)		x	
(Park, Kwak, Kim, Won, & Kim, 2006)	x		
(Fried, 2006)		x	
(Skinner, 2006)	x		
(Daclin et al., 2006)			

(Brambert, 2006)	x		
(Féniès, Gourgand, & Rodier, 2006)	x		
(Lejian & Liehuang, 2006)		x	
(Leviakangas, Haajanen, & Alaruikka, 2007)		x	
(Rogers, 2008)	x		
(de la Fuente, Ros, & Cardos, 2008)		x	
(Moon, Fewell, & Reynolds, 2008)		x	
(Ye, Yang, Jiang, & Tong, 2008)		x	
(Chituc, Toscano, & Azevedo, 2008)	x		
(Panetto & Molina, 2008)	x		
(Ming-yong, 2009)	x		
(Carson, 2009)		x	x
(Gottschalk, 2009)	x		
(Briggs et al., 2009)		x	
(Wang & Wang, 2009)	x		
(Inkinen, Tapaninen, & Pulli, 2009)	x		
(Ma, 2009)		x	
(Weichhart, Feiner, & Stary, 2010)		x	
(Pan, Zheng, & Yan, 2010)	x		
(Chen et al., 2010)		x	
(Beheshti, Dado, & Van De Ruitenbeek, 2010)	x		
(Smirnov, Pashkin, Levashova, & Chilov, 2005)			
(Smirnov & Shilov, 2010)	x		
	x		
(Kawtrakul, Mulasastra, Khampachua, & Ruengittinun, 2011)	x		
(Khalifa, El Kamel, & Yim, 2011)	x		
(Paviot et al., 2011)	x		
(Scherer & Schapke, 2011)		x	
(Zacharewicz, Deschamps, & Francois, 2011)			
(Mauro, Leimeister, & Krcmar, 2011)	x		
(Johnson et al., 2011)	x	x	
(Buyukozkan, Arsan, Tanyas, & Kagnici, 2011)	x		
(van Lier & Hardjono, 2011)		x	
	x		
(Azevedo & Carvalho, 2012)		x	
(Schilk & Seemann, 2012)	x	x	
(Malhene, Trentini, Marques, & Burlat, 2012)		x	x
(Anand et al., 2012)			
(Blattert et al., 2012)		x	
(Verdecho, Alfaro-Saiz, Rodriguez-Rodriguez, & Ortiz-Bas, 2012)	x		
(Lin, Lin, Roan, & Yeh, 2012)	x		
	x		

Source: the author´s Research

The perception obtained in the literature, combined with the rating of the papers shows the use of interoperability indirectly in logistics, as performance support, demonstrating existing conceptual gapin the studies (Blattert et al., 2012; Daclin et al., 2006; de la Fuente, Ros, & Cardós, 2008; Helo & Szekely, 2005; Lendermann et al., 2003).

Logistic Interoperability – a definition (LI)

From the literature, there has been an approach of interoperability with logistics regarding relations established in certain activities, such Storage and Transport for example. However, there is still no definition that allows a comprehensive look at the LI. Given this gap, we propose the following definition: Logistics Interoperability refers to the logistical capacity that an organization has to share, interact, collaborate, and make its structure compatible with other business functions, and especially with customers and suppliers, without losing the independence of decision and action.

Logistics by its very definition has an interoperable feature, since through integration allows this interaction, collaboration and sharing between the different elements of the organization.

The LI is manifested at various times within the logistics systems, so it results necessary to dismember the general concept of LI defined above. One way would be by Material flow, essence of logistics, which identifies the LI in each of the main logistics subsystems, namely: Supply Logistics, Internal Logistics and Physical Distribution Products.

Supply Logistics in the LI is manifested as the necessary interoperability between the supplier and the client company (the quantities and the time will be provided); between the supplier and the carrier (quantity to be shipped and product mix, in correspondence with the type of vehicle and its capacity); between the carrier and the raw materials warehouse (quantity, timing, frequency of deliveries etc.)

Internal Logistics in the LI is manifested as the necessary interoperability between the raw materials warehouse and production lines (supply lines, frequency, amounts and times); between the different sectors of production that have technological sequence (productive capacities and synchronization of activities); and between the lines / production sectors and finished products warehouse (quantities are delivered in stock and mix thereof, corresponding to the capacity of the warehouse, turning their products etc.).

In Physical Distribution Products, LI manifests itself even more significantly to a lot of companies, the necessary interoperation between some areas of the finished products warehouse (between the storage area itself, and the areas of picking or order picking, between these areas and the shipping docks etc.); between the shipping docks and transport vehicles (capacity and capabilities of these shipping docks, documentation with the information necessary for the delivery of products); between transportation and distribution centers if there are (transport capacity, delivery time, capacity of warehouses or distribution centers), and equally, with the customer warehouses for the finished products.

In figure 1 is illustrated the manifestation of the LI. From it is also possible to observe the constructs of this concept (share, interact, collaborate and compatible).

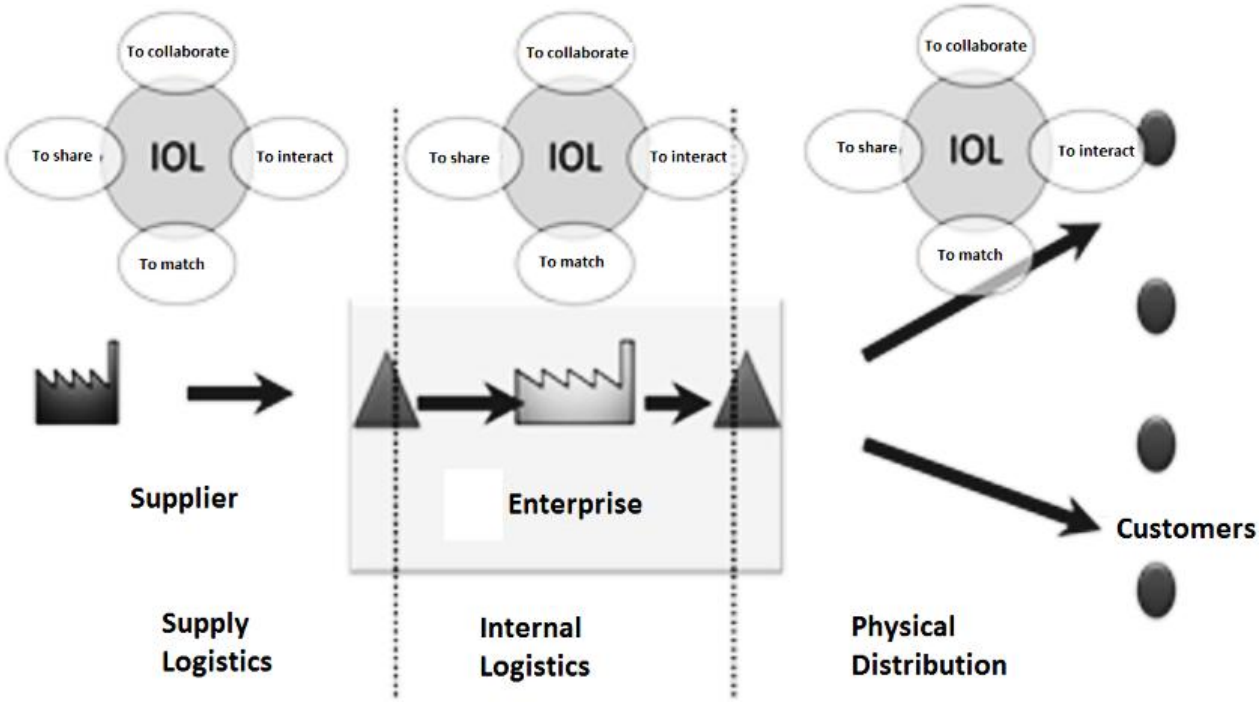

Figure1. The link between interoperability and logistics

Source: The authors

Another way to elaborate the concept of LI in this paper would be based on the main parameters associated with a material flow: space and time. In this way, power would identify a spatial LI (interoperation in places, collection of raw materials and delivery thereof; the specific local delivery of components and parts in production lines and warehouses, delivery of finished products to customers and spatial routes of vehicles etc.) and a temporal LI (interoperation in time between the request for an order to buy raw materials and their arrival in the company, between the time of arrival of the cargo vehicle and the time of completion of preparation of orders, etc.).

CONCLUSIONS

The subject Logistic interoperability is emerging which to fill gaps with respect to a more extensive treatment in logistics area. Its application and treatment is given in a large majority in the area of information systems. Thus, at this study a treatment for the logistics system was given.

The concept of Logistic Interoperability (LI) contributes to reduction of operational work, increased agility and service capacity, reduced logistics costs, improved management and data integrity, promoting greater coherence between the physical flow and information flow, and a greater efficiency for the entire system, since permeates all levels of the organization.

By offering constructs and a concept for LI allows a breakthrough in the discussions on the subject. The quantification of the contribution of the constructs with the effectiveness of LI, the relationship of

the constructs with each other and the measurement of business results on the use of the approach, turn out to be opportunities for future research.

Finally, the structure of the research methods proves to be a logical potential for application in other research on interoperability and logistics, as well as in other areas of knowledge. This is based on the process a solid literature and results consistent with the proposed objective, expanding the field of knowledge.

REFERENCES

Anand, N., Yang, M., Van Duin, J., & Tavasszy, L. (2012). GenCLOn: An ontology for city logistics. *Expert Systems with Applications, 39*(15), 11944-11960

Azevedo, S. G., & Carvalho, H. (2012). Contribution of RFID technology to better management of fashion supply chains. *International Journal of Retail and Distribution Management, 40*(2), 128-156

Ballou, R. H. (2009). *Gerenciamento da Cadeia de Suprimentos-: Logística Empresarial*: Bookman Editora.

Beckstead, R. W. (1994). International Logistics Cooperation: The US-ROK Experience. *The Korean Journal of Defense Analysis, 6*(1), 41-55

Beheshti, R., Dado, E., & Van De Ruitenbeek, M. (2010). The feasibility of developing a new document-oriented concept for BC eWork environments. *International Journal of Design Sciences and Technology, 17*(1), 39-55

Bishr, Y. (1998). Overcoming the semantic and other barriers to GIS interoperability. *International journal of geographical information science, 12*(4), 299-314

Blattert, C., Lemm, R., Ehrhardt, I., & Seeling, U. (2012). Improving the interoperability of forest enterprise resource planning systems with standards. *Schweizerische Zeitschrift fuer Forstwesen (Switzerland)*

Brambert, D. (2006). Swimming in the channel. *Advanced Imaging, 21*(9), 16-18

Briggs, T. L., Gischner, B., Lazo, P., Olson, M., Vicedomine, J., & Wolsey, K. (2009). Enabling interoperability through the ship life cycle. *Journal of Ship Production, 25*(1), 33-44

Bruzzone, A. G., Mosca, R., Revetria, R., Bocca, E., & Briano, E. (2005). Agent directed HLA simulation for complex supply chain modeling. *Simulation, 81*(9), 647-655

Buranarach, M. (2004). *A framework for the organization and discovery of information resources in a www environment using association, classification and deduction.* University of Pittsburgh.

Buyukozkan, G., Arsan, L., Tanyas, M., & Kagnici, A. (2011). *Identifying logistics requirements for enterprise interoperability and collaboration: A European project case.* Paper presented at the Proceedings of the World Congress on Engineering.

Carson, S. (2009). The road to interoperability. *Army logistician, 41*(1), 43

Cavalieri, J., Grasso, S., Redfern, R., Schiller, T. R., & Sillman, J. H. (2000). Material handling issues for the 21st century. *Naval engineers journal, 112*(3), 83-96

Chaudhuri, M., & Heinrich, M. (2004). Exploring virtual network selection algorithms in DSM cache coherence protocols. *IEEE Transactions on Parallel and Distributed Systems, 15*(8), 699-712

Chen, M.-C., Yeh, C.-T., & Chen, K.-Y. (2010). Development of collaborative transportation management framework with Web Services for TFT–LCD supply chains. *International Journal of Computer Integrated Manufacturing, 23*(1), 1-19

Chituc, C.-M., Toscano, C., & Azevedo, A. (2008). Interoperability in Collaborative Networks: Independent and industry-specific initiatives–The case of the footwear industry. *Computers in Industry, 59*(7), 741-757

Christopher, M. (1999). *Logística e gerenciamento da cadeia de suprimentos: estratégias para a redução de custos e melhoria dos serviços*: Pioneira.

Correa Espinal, A., & Gomez Montoya, R. A. (2009). Information technologies in supply chain management. *Dyna, 76*(157), 37-48

Daclin, N., Chen, D., & Vallespir, B. (2006). *Enterprise interoperability measurement-Basic concepts.* Paper presented at the EMOI-INTEROP.

de la Fuente, M. V., Ros, L., & Cardos, M. (2008). Integrating Forward and Reverse Supply Chains: Application to a metal-mechanic company. *International Journal of Production Economics, 111*(2), 782-792

de la Fuente, M. V., Ros, L., & Cardós, M. (2008). Integrating Forward and Reverse Supply Chains: Application to a metal-mechanic company. *International Journal of Production Economics, 111*(2), 782-792

Ducq, Y., Chen, D., & Vallespir, B. (2004). Interoperability in enterprise modelling: requirements and roadmap. *Advanced Engineering Informatics, 18*(4), 193-203

Féniès, P., Gourgand, M., & Rodier, S. (2006). *Interoperable and multi-flow software environment: Application to health care supply chain.* Paper presented at the International Conference on Business Process Management.

Fernandez, J. (2009). Metodología para la construcción de un sistema de flujos de trabajo automatizado (workflow) para empresas de bienes y servicios *Dyna, 76*(159), 227-236

Follmann, N. (2012). *Modelo de maturidade logística para empresas industriais de grande porte.* Universidade Federal de Santa Catarina.

Fried, J. (2006). Bahnen für Europa: Innovationen, Chancen und Risiken aus der Sicht eines integrierten Eisenbahnunternehmens. *ZEV rail Glasers Annalen, 130*(1-2), 8-13

Gottschalk, P. (2009). Maturity levels for interoperability in digital government. *Government Information Quarterly, 26*(1), 75-81

Han, X.-l., Wu, H.-z., Zhang, J.-m., & Tang, S.-c. (2005). Inland Approach of Applying Simulation Based Acquisition to Major Weapon Systems [J]. *Journal of Nanjing University of Science and Technology, 1*, 007

Helo, P., & Szekely, B. (2005). Logistics information systems: an analysis of software solutions for supply chain co-ordination. *Industrial Management & Data Systems, 105*(1), 5-18

Inkinen, T., Tapaninen, U., & Pulli, H. (2009). Electronic information transfer in a transport chain. *Industrial Management and Data Systems, 109*(6), 809-824

Johnson, G. W., Gaylord, A. G., Franco, J. C., Cody, R. P., Brady, J. J., Manley, W., . . . Tweedie, C. E. (2011). Development of the Arctic Research Mapping Application (ARMAP): Interoperability challenges and solutions. *Computers & Geosciences, 37*(11), 1735-1742

Kawtrakul, A., Mulasastra, I., Khampachua, T., & Ruengittinun, S. (2011). Moving Fast Forward to National Data Standardization. *Proceedings of the 11th European Conference on Egovernment*, 643-653

Khalifa, I. H., El Kamel, A., & Yim, P. (2011). Transportation process of containers BPMN-modeling and transformation into ACTIF model. *Romanian Journal of Information Science and Technology, 14*(1), 67-80

Lejian, L., & Liehuang, Z. (2006). *Semantic web modeling for virtual organization: a case study in logistics.* Paper presented at the Asian Semantic Web Conference.

Lendermann, P., Julka, N., Gan, B. P., Chen, D., McGinnis, L. F., & McGinnis, J. P. (2003). Distributed supply chain simulation as a decision support tool for the semiconductor industry. *Simulation, 79*(3), 126-138

Leviakangas, P., Haajanen, J., & Alaruikka, A.-M. (2007). Information service architecture for international multimodal logistic corridor. *IEEE Transactions on Intelligent Transportation Systems, 8*(4), 565-574

Lima, M. P. (2006). Custos logísticos na economia brasileira. *Revista Tecnologística, 11*(122), 64-69

Lin, C.-H., Lin, I.-C., Roan, J.-S., & Yeh, J.-S. (2012). Critical factors influencing hospitals' adoption of HL7 version 2 standards: An empirical investigation. *Journal of medical systems, 36*(3), 1183-1192

Ma, Y.-S. (2009). Towards semantic interoperability of collaborative engineering in oil production industry. *Concurrent Engineering, 17*(2), 111-119

Malhene, N., Trentini, A., Marques, G., & Burlat, P. (2012). Freight consolidation centers for urban logistics solutions: The key role of interoperability. *2012 6th IEEE International Conference on Digital Ecosystems and Technologies: Complex Environment Engineering, DEST 2012*

Manola, F. (1995). Interoperability issues in large-scale distributed object systems. *ACM Computing Surveys (CSUR), 27*(2), 268-270

Mauro, C., Leimeister, J. M., & Krcmar, H. (2011). Service-oriented integration of medical devices - Holistic IT support of clinical processes. *Informatik-Spektrum, 34*(3), 276-285

Ming-yong, L. (2009). 2, XU Di-di1, 2, LIU Zheng-chi1, 2 (1. College of Economics and Trade, Hunan Univ, Changsha, Hunan 410079, China; 2. Hunan Provincial Key Laboratory of Logistic Information and Simulation Technology, Changsha, Hunan 410079, China); Simulation Interoperating Mechanism of Logistic Information System Driven Flexsim [J]. *Journal of Hunan University (Natural Sciences), 11*

Moon, T., Fewell, S., & Reynolds, H. (2008). The what, why, when and how of interoperability. *Defence & Security Analysis, 24*(1), 5-17

Pagell, M. (2004). Understanding the factors that enable and inhibit the integration of operations, purchasing and logistics. *Journal of operations management, 22*(5), 459-487

Palacio-León, O., & Adarme-Jaimes, W. (2014). Coordination of inventory: A case study of city logistics. *Dyna, 81*(186), 295-303

Pan, T., Zheng, L., & Yan, G. (2010). Research of information framework for fourth party logistics. *Journal of Convergence Information Technology, 5*(7), 12

Panetto, H., & Molina, A. (2008). Enterprise integration and interoperability in manufacturing systems: Trends and issues. *Computers in Industry, 59*(7), 641-646

Park, N., Kwak, J., Kim, S., Won, D., & Kim, H. (2006). *WIPI mobile platform with secure service for mobile RFID network environment.* Paper presented at the Asia-Pacific Web Conference.

Paviot, T., Cheutet, V., & Lamouri, S. (2011). A PLCS framework for PDM/ERP interoperabilty. *International Journal of Product Lifecycle Management, 5*(2-4), 295-313

Rogers, D. (2008). Customer driven. *Engineering, 249*(8), 42-44

Sarjoughian, H. S., & Zeigler, B. P. (1999). *Collaborative modeling: The missing piece of distributed simulation.* Paper presented at the AeroSense'99.

Scherer, R. J., & Schapke, S.-E. (2011). A distributed multi-model-based management information system for simulation and decision-making on construction projects. *Advanced Engineering Informatics, 25*(4), 582-599

Schilk, G., & Seemann, L. (2012). Use of ITS technologies for multimodal transport operations–River Information Services (RIS) transport logistics services. *Procedia-Social and Behavioral Sciences, 48*, 622-631

Sinex, C. H., Basile, S. A., Sellers, W. A., Kerchner, D. W., & Gion, T. C. (2000). Linking warfighting and logistics. *Johns Hopkins APL technical digest, 21*(2), 288-298

Skinner, T. (2006). Interoperability exercise tests UK's military communications infrastructure. *Jane's Defence Weekly*(JUNE), 659-661

Smirnov, A., Pashkin, M., Levashova, T., & Chilov, N. (2005). *Ontology-based support for semantic interoperability between SCM and PLM*.

Smirnov, A., & Shilov, N. (2010). Business network modelling: SOA-based approach and dynamic logistics case study. *International Journal of Information System Modeling and Design, 1*(4), 77-91

Talevski, A., Chang, E., & Dillon, T. S. (2005). Reconfigurable web service integration in the extended logistics enterprise. *IEEE Transactions on Industrial Informatics, 1*(2), 74-84

Tezza, R., Bornia, A. C., & Vey, I. H. (2010). Sistemas de medição de desempenho: uma revisão e classificação da literatura. *Gestão & Produção, 17*(1), 75-93

van Lier, B., & Hardjono, T. (2011). A systems theoretical approach to interoperability of information. *Systemic Practice and Action Research, 24*(5), 479-497

Verdecho, M.-J., Alfaro-Saiz, J.-J., Rodriguez-Rodriguez, R., & Ortiz-Bas, A. (2012). A multi-criteria approach for managing inter-enterprise collaborative relationships. *Omega, 40*(3), 249-263

Wang, L., & Wang, G. (2009). RFID-driven global supply chain and management. *International Journal of Computer Applications in Technology, 35*(1), 42-49

Weichhart, G., Feiner, T., & Stary, C. (2010). Implementing organisational interoperability—The SUddEN approach. *Computers in Industry, 61*(2), 152-160

Ye, Y., Yang, D., Jiang, Z., & Tong, L. (2008). Ontology-based semantic models for supply chain management. *The International Journal of Advanced Manufacturing Technology, 37*(11-12), 1250-1260

Zacharewicz, G., Deschamps, J.-C., & Francois, J. (2011). Distributed simulation platform to design advanced RFID based freight transportation systems. *Computers in Industry, 62*(6), 597-612

Zapata, C., Toro, F., & Marín, M. I. (2012). Mapwindow vs. Arcgis: towards featuring the Interoperability between geographic information Systems. *Dyna, 79*(173), 25-33

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