iFloW: An Integrated Logistics Software System for Inbound Supply Chain Traceability

Nuno Santos, Diogo Barbosa, Paulo Maia, Fábio A. Fernandes, Márcio P. Rebelo, Pedro V. Silva, M. Sameiro Carvalho, João M. Fernandes and Ricardo J. Machado

Abstract Visibility plays an important role in supply chain management. Such visibility is not only important for better planning, but especially for real-time execution related with the traceability of goods. In inbound supply chain management, logistics planners need to trace raw materials from their requests in order to properly plan a plant's production. The iFloW (Inbound Logistics Tracking System) integrates logistics providers IT applications and Global Positioning System (GPS) technology to track and trace incoming freights. The Estimated Time of Arrival (ETA) is updated in real-time allowing an improved materials planning process. This paper presents the iFloW project and describes how these issues are addressed and validated in a real pilot project.

Keywords Logistics software system · Inbound logistics · Track and trace · Supply chain visibility · Traceability · GPS

N. Santos (✉) · D. Barbosa · P. Maia · F.A. Fernandes · M.P. Rebelo
M. Sameiro Carvalho · J.M. Fernandes · R.J. Machado
School of Engineering, ALGORITMI Research Center, University of Minho, Braga, Portugal
e-mail: nuno.a.santos@algoritmi.uminho.pt

P.V. Silva
Bosch Car Multimedia Portugal S.A., Braga, Portugal

M. Sameiro Carvalho
Department of Production and Systems, University of Minho, Guimarães, Portugal

J.M. Fernandes
Department of Informatics, University of Minho, Braga, Portugal

R.J. Machado
Department of Information Systems, University of Minho, Guimarães, Portugal

K. Mertins et al. (eds.), *Enterprise Interoperability VII*,
Proceedings of the I-ESA Conferences 8, DOI 10.1007/978-3-319-30957-6_15

1 Introduction

As supply chains are more global and interconnected, they are becoming more complex, costly and vulnerable and to deal effectively with risk and meet business objectives they need to be a lot smarter [1]. According to the supply chain leaders, there are five top challenges for supply chain management: visibility, cost containment, customer intimacy, risk and globalization. The supply chain visibility is highlighted as the most important challenge—70 % of those leaders have reported that this challenge impacts their supply chain to a significant or very significant extent and the external integration and visibility as very important or critically important [2].

The supply chain visibility enables to track goods from the manufacturer to the final destination, either in an inbound or outbound logistics perspective. Tracking goods allows one to follow routes of their transportation, so that a visualization software are able to show roadmaps of those routes. The optimization of routes is another common way of using the data from tracking any trade item [3], as well as for planning and management improvement [4].

Tracking routes of shipments in real-time allows one to estimate more accurately the time of arrival of goods in a production network with several locations. The estimation is performed by predicting arrival times at plants based on real-time data from shipments actual position and speed [5]. Thus, production planners get a better information to perform synchronization of material delivery at the plant with the production scheduling. As a result, these tasks may be performed in less time and, if needed, planners have more time to reschedule production. Storage the data of routes also provides additional data for future planning [6].

Issues that may occur within the inbound logistics processes of a manufacturing plant are the time logistics planners spend in freight tracking tasks throughout their activities, and complaints to suppliers caused by transportation process with negative effects in production (like production stoppage and special freight requests—i.e., non-planned freight that occurs, usually, when the freight is in risk of compromising the fulfilment of the supplier delivery plan). Therefore, there is a need to reduce e-mail and phone calls exchange, and any other form of communication. To overcome these issues, some integration and interoperability between the plant's and forwarders' systems is required, originating the Inbound Logistics Tracking System project (hereafter called iFloW project), performed at the plant located in Braga, Portugal of Bosch Car Multimedia (Bosch BrgP).

The main goal of the iFloW project is to develop an integrated tracking platform, which tracks in real-time all the raw materials in transit, from their starting point to the arrival at the Bosch BrgP's facilities, by their part number. This platform currently under development controls and monitors the raw material flow from suppliers to Bosch BrgP's warehouse. Additionally, the iFloW system alerts users in case of any deviation to the Estimated Time of Arrival (ETA), quantities or part number. This project aimed executing a pilot scenario, where the software system was deployed to be able to address a specific scenario (one specific forwarder and in one of their routes). This way, the project assessed: its usage in a tracking task, where it is required improvements, and ultimately its usefulness to the inbound logistics process.

This paper is structured as follows: Sect. 2 addresses related work on solutions for inbound logistics and traceability; Sect. 3 describes the iFloW project, from the problem statement to the specification of the solution; Sect. 4 presents the results obtained in the pilot scenario and Sect. 5 the conclusions.

2 Related Work

Information Technology (IT) has a strong impact on logistics, where in the last years many software solutions have been developed [7]. According to the report from Gartner Group [8], some of these solutions are delivered as (cloud computing-based) services, namely Business-Process-as-a-Service (BPaaS). Many forwarders deliver track and trace services of their freights through BPaaS in complex Supply Chain Management (SCM) environments, like UPS [9], Kuehne + Nagel [10], TNT [11], Panalpina [12], DHL [13], FedEx [14] or Lusocargo [15]. The report from Gartner Group also refers BPaaS SCM solutions as the fourth highest BPaaS-based services market share [8].

A more efficient management of logistics systems is required to allow organizations to be able to obtain the needed materials, at the right time and place [7]. Within logistics systems, Kandel, Klumpp, and Keusgen categorize tracking solutions as discrete and continuous tracking [6]. Barcoding and RFID technologies are categorized as discrete tracking solutions. Alternatively, continuous tracking solutions, like the Global System for Mobile Communications (GSM) and the Global Positioning System (GPS) technologies, allow tracking the position at any time. Yin, Wang, and Zhang propose a topology based in Electronic Business using eXtensible Markup Language (ebXML) for integration of logistics information and e-tag, Radio Frequency Identification (RFID), GPS and General Packet Radio Services (GPRS) technology [16].

The integration of these tracking technologies in a common logistics platform is referred as Integrated logistics information management system (ILIMS) [17]. Platforms like ILIMS allow different parties transmitting, capturing, sharing and gathering the required logistics data via internet. These systems facilitate the processes of both logistics service providers as well as supply chain participants. An approach like a logistics information hub is used for standardizing the definition of third party logistics (3PL) service providers and integrating RFID technology [18, 19], GPS technology [6], and others.

The integration of logistics information obtained with tracking technologies is addressed by many authors. Doukidis et al. propose an integrated web-based RFID-Electronic Product Code (EPC) compliant logistics information system, aiming to discover and share RFID/EPC data [17]. The usage of RFID and GPS technologies, alongside with information models and web-services, is proposed in [20]. In this work, RFID events are integrated with geographical information and associated with the cargo, in order to track and trace that cargo. Cargo transports can also be tracked and traced using logistics solutions for GPS-based track and trace services [20, 21]. Platforms, like Track-Trace.com [22], are able to provide users with track and trace functionalities that are integrated with the forwarders' information systems.

Inbound logistics additionally face product traceability issues. An integrated view on RFID and barcodes is presented in [23, 24], where interoperability for product traceability are addressed. Chen [25] presents issues the handling of large amounts of data on the initial stages of the traceability process using a dedicated RFID middleware. Also the research work in [26] addressed interoperability for customizing products in multi-company operations environments, where also track and trace of shipments and of composite products is addressed.

These proposed solutions focus in defining and developing platforms for receiving information from devices and then allow users to manage the received data as better suits their business. However, the data only flows from suppliers to plants, and afterwards there is not any change to the planning work (which still is performed using phone or e-mail communication, for instance). Additionally, neither of these platforms allow to track and trace products by the part number used within the plant. In comparison, iFloW receives freight information from GPS systems and Electronic Product Code Information Services (EPCIS) events, and integrates with forwarder's systems tracking information for updating ETA values in different scenarios (i.e., iFloW may deal with information of material transported by land, sea or air, and that may be pass in European, African and Asian ports). In addition, allows Bosch BrgP logistic planners to perform tracking searches by part numbers and allows forwarders and Bosch BrgP logistic planners to negotiate special freights requests by directly using iFloW system. The integration of the iFloW system with the forwarder's systems allows logistic planners to be able to track and trace products by using iFloW as a single point of information, where information is available to all users in a standardized format, instead of using the existing BPaaS platforms that only allow to track and trace products from their specific brand. Track-Trace.com platform [22] also integrates the existing BPaaS platforms but only allows to visualize the tracking data, while both Bosch BrgP and the forwarders are able to negotiate freights using iFloW.

3 The iFloW Project

3.1 Problem Statement

Bosch BrgP has a large number of suppliers, which are dispersed all over the world. These suppliers send raw materials to Bosch BrgP's warehouses as a response to requests from the system that controls and manages the stock levels in the plant. However, at a certain point in time, Bosch BrgP does not have access to the exact location of these raw materials. The information related to the inbound flow of logistics is not consolidated and systemized. Bosch BrgP has access to a lot of information from suppliers and 3PL providers, but this information is dispersed over many alternatives, like emails, reports, and physical paper-based documents. Additionally, if any deviation occurs in the transportation process, logistics planners face many difficulties for accessing such information. This problem affects several stakeholders, from operational employees to the top management. This process faces many other concerns, like the fact that people from different areas are involved, information may not be available to users at the same time and in different formats. The planner must control information on all levels, however many times repeated information deviate the process. Also, the dependency from many different partners is a risk that must be managed.

Logistic planners spend at least 10 % of their time in track and trace activities. In the inbound flow of raw materials, the transit time ranges are between four hours for local milkruns and eight days for air transportation, with the exception of the sea transportation that takes five to six weeks. Currently, the tracking of the raw materials is mainly performed by e-mail and phone, in order to communicate with suppliers, carriers and forwarders. The logistic planners have access to a wide set of software applications (e.g., spreadsheets, forwarder's tracking websites, ERP system) to support their decisions.

The plant receives, on a daily basis, a large number of freight shipments from different suppliers dispersed all over the world, and there are many issues that may arise during each process. For instance, ETA of a particular part can be affected by various type of problems associated with the transportation or transshipment processes. Also, the lack of visibility of incoming freights results in larger efforts in the materials planning team that needs to manage dispersed and not normalized information (emails, phone calls, web sites) from their 3PL providers to get the best time of arrival estimation for their materials. Furthermore, delays on the parts´ time of arrival can have a huge impact on the production scheduling, increasing the overall production costs (either by rescheduling production plans whenever a shipment is not on time at the plant or using special air freights to speed up parts delivery at the plant).

Therefore, a new solution is required to integrate freight information from all stakeholders involved in the inbound logistics process providing Bosch's planners with more accurate data and smarter decisions.

3.2 The System Architecture

The software system is a tracking tool that provides its users a global view of the materials in transit, thus fulfilling the following goals:

1. To improve inbound logistics visibility in terms of raw material traceability;
2. To systemize the ordering process and consequently improve its efficiency;

3. To reduce costs related with the occurrence of special freights requests and production downtime occurrences due to failures in the transportation process;
4. To improve the accuracy of inbound logistics indicators, such as time spent by each carrier in a given activity and the degree of participation in the various activities.

Figure 1 illustrates the architecture of the iFloW system, where one can see the integration of the iFloW main server with other systems. It uses information that provide from many technologies, like GPS, Personal Digital Assistant (PDA) devices or SAP-OER (Object Event Repository). The 'middleware server' relates to the enterprise interoperability challenges, aiming to standardize the way information between Bosch BrgP and providers is exchanged. Each supplier or forwarder has their own system, protocol or data structure to integrate. These challenges were overcome with joint development and continuous meetings between iFloW project members and freight providers, by performing mappings and alignment between data formats, used in Bosch BrgP logistics, suppliers and forwarders. The middleware was also developed in order to assure the interaction with GPS systems and EPCIS events aligned with Bosch security policies. EPCIS is a GS1 standard to support information sharing about a (physical) movement between trading partners. The use of this standard also allows visualizing the status of products throughout the supply chain. Finally, the 'iFloW server' executes all business logic, where Bosch BrgP's users, as well as the remaining stakeholders, use these features as a single point of information via a web-based user-interface (web app).

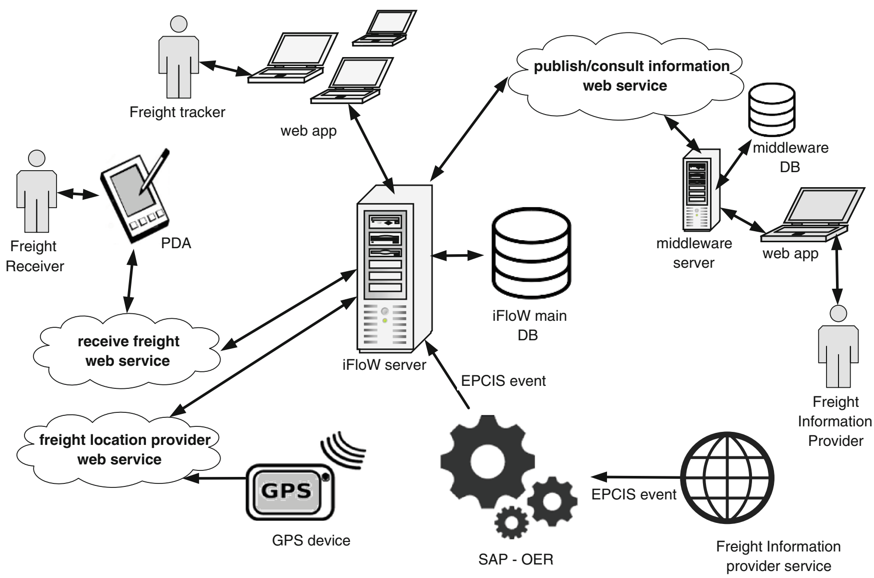

Fig. 1 System architecture

The ‘freight location provider web service’ is the connection to the GPS system. A GPS device is placed in each vehicle and then activated. The location of the freight is provided to the iFloW system by means of a web service that was developed to that specific purpose. The SAP-OER addresses centralized control and visibility requirements, in this case for product tracking and authentication. The information is exchanged by a EPCIS event. The freight information provider service is the system that sends information about freights in transit. Finally, a PDA device inputs the information of the freights that arrive to the Bosch BrgP facilities and sends to the iFloW system (‘receive freight web service’).

4 Current Results

A pilot study (small scale preliminary study) was performed in order to evaluate the solution’s feasibility. The pilot was developed in order to assess the software system’s usage in a tracking task, the need for improvements within the initial design, and ultimately its potential, prior to the development of the full-scale iFloW system. The pilot project characterizes routes performed in the Asian scope, mainly transported by sea and transported by *Forwarder A* (see example in Fig. 2). The route includes land transport between the Asian suppliers and an Asian port, sea transport between the Asian(s) port(s) and a European port and land transport between the European port and Bosch BrgP. The pilot solution allows the real-time tracking of raw material in transit from a departure point to Bosch BrgP facilities, giving additional information to perform the tracking of goods effectively and efficiently. This pilot is able to provide the required insights since: (1) 42 % of suppliers are located in Asia; (2) 95 % of incoming orders are transported by sea and performed by *Forwarder A*; (3) after the first Asian port, the transport is Bosch’s “responsibility”; (4) transit time is 5 to 6 weeks; (5) is related to 79 % of special freights requests that arise from transportation process; (6) in Bosch BrgP is one of the route with more time spent in freight tracking tasks; (7) high risk to production downtime due to extended transit time; (8) *Forwarder A* has Application Programming Interfaces (APIs) that facilitate detailed information to be obtained; and (9) to get detailed information with the GPS technology.

The pilot phase of iFloW project is at this date concluded. The software system provides the location and detailed information of a given part or freight over the route and the respective part details and freight details (Fig. 3). From Fig. 3, we would like to highlight the following aspects: the status (e.g., moving or stopped in an intermediate point—used to intercept a freight if necessary), the ETA to the next intermediate point, the trace of the part along the entire route and respective check points (the user can switch between map view and table view) and very important to the production planning—the ETA to Bosch BrgP facilities.

Fig. 2 Example of a route used in pilot

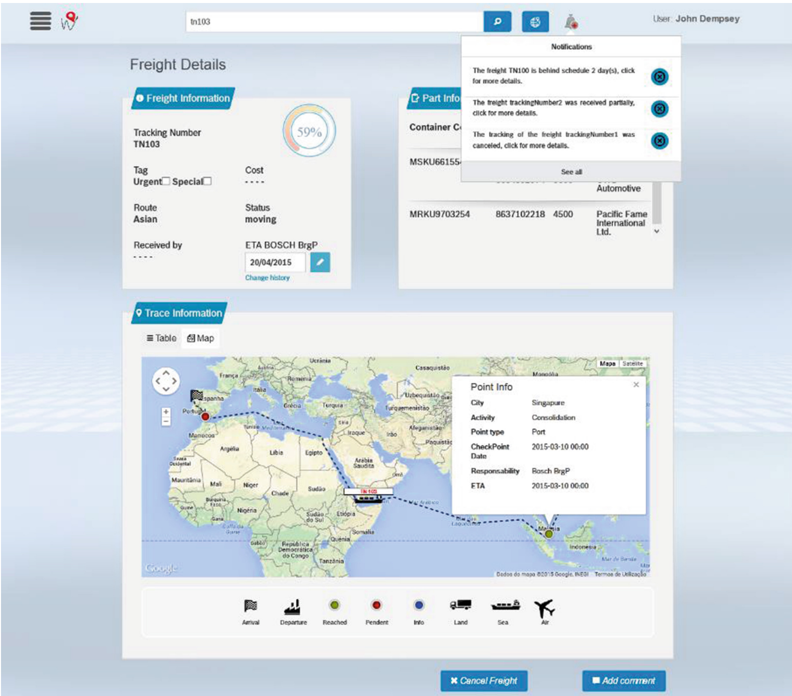

Fig. 3 Freight Details screenshot

Additionally, as can be observed in the top right menu of Fig. 3, the iFloW system alerts ETA changes (e.g., the new ETA and the number of days in that the freight is delayed), or related with freight's cancelation or changes in freight quantities. These notifications add relevant value in freight tracking and production planning tasks. During the pilot phase, the iFloW system was able to successfully:

- Obtain freight information and real-time location from European port and six Asian ports from *Forwarder A*'s system (this task replaces, for instance, e-mail exchanges).
- Search freight location and show its general information, trace freight (shows the events and progress), edit freight information, issue alerts (for ETA changes and for updates in freight quantities).
- Export freight information to Legacy System (including, for instance, Excel files).
- Other features, like: produce statistics information; confirm that the freight has arrived; make freight information available to the Freight Information and Location Provider; consult freight information to prepare, for instance, the delivery plan for a set of freights; and edit and validate the delivery plan for a set of freights for a given day.

These functionalities allowed the iFloW system to optimize in 2 % the flow of transport arrivals, due to the freight negotiation performed in the platform. Freight negotiation relates to cases like, for instance, decide to store materials in one of the intermediate ports when weekly production planning is updated.

Although this phase has ended, it is difficult at this point to measure the project's impact within Bosch BrgP's inbound logistics processes. The pilot allowed perceiving that the iFloW system has indeed potential to improve inbound logistics processes and supply chain management, by providing planners with an improved context for performing the planning. Additionally, allowed depicting risks and obstacles that the prior full-scale development faces, and required encryption efforts in messages' exchange. The pilot faced problems on dependency and communication with third-parties, since the core functionalities rely on inputs from suppliers and forwarders, mitigated with the use of GPS technology from the European port to the freight's arrival at the plant in Braga. Stakeholders were permanently involved so there was common understanding on the approach to use.

5 Conclusions

This paper presents the iFloW project, an integrated logistics software system for inbound supply chain traceability. iFloW is a real-time tracking software system of freights in transit from suppliers to Bosch BrgP facilities, that receives freight information from GPS systems and it integrates with forwarder's systems for retrieving tracking information for update ETA's value and notifications of deviations, as well as enables visibility of the global inbound supply chain traceability process. Visibility and traceability were challenging since the project is executed in a heterogeneous environment, where each supplier or forwarder have their own system, protocol or data structure to integrate. The project required joint efforts between project team, suppliers and forwarders in order to define mappings between data formats, as well as secured interactions with GPS and EPCIS events.

The proposed functionalities were sufficient to successfully enable the tool to perform within the proposed pilot project. Thus, remaining effort will be devoted to implement additional functionalities. The pilot allowed to validate the approach and to depict the risks that the full-scale development faces, namely the dependency form third-parties and security. Since the pilot phase has just been recently concluded, it is not possible to measure its impact within Bosch BrgP facilities. It is expected that its use results in the reduction of track and trace activities, the number of complaints caused by transportation process and of the number of special freight requests due to freight monitoring failures, because Bosch BrgP planners, suppliers and forwarders use the iFloW system as a single point of communication. After the conclusion of the project, we will measure and address these impacts in the plant in future works.

Acknowledgments This research is sponsored by the Portugal Incentive System for Research and Technological Development PEst-UID/CEC/00319/2013 and by project in co-promotion n° 36265/2013 (Project HMIExcel—2013–2015).

References

1. Butner, K. (2010). The smarter supply chain of the future. *Strategy & Leadership, 38*(1), 22–31.
2. IBM. (2010). The smarter supply chain of the future.
3. GS1. (2007). The GS1 Traceability Standard: What you need to know. Retrieved from http://www.gs1.org/docs/traceability/GS1_tracebility_what_you_need_to_know.pdf
4. Martins, J. C., & Machado, R. J. (Eds.) (2012). Ontologies for product and process traceability at manufacturing organizations. In: *Proceedings of the 8th International Conference in A Software Requirements Approach. Quality of Information and Communications Technology (QUATIC)*, IEEE.
5. Brewer, A., Sloan, N., & Landers, T. L. (1999). Intelligent tracking in manufacturing. *Journal of Intelligent Manufacturing, 10*(3–4), 245–250.
6. Kandel, C., Klumpp, M., & Keusgen, T. (Eds.) (2011). GPS based track and trace for transparent and sustainable global supply chains. In: *Proceedings Of The 17th International Conference In Concurrent Enterprising (Ice)*. IEEE.
7. Ghiani, G., Laporte, G., & Musmanno, R. (2004). *Introduction to logistics systems planning and control*. New York: Wiley.
8. Gartner Group. (2012). *Hype cycle for supply chain management*. Stamford: Gartner Group.
9. UPS: Tracking System. Available from http://www.ups.com/WebTracking/track?loc=en_us. Accessed October, 2015.
10. KN Portal. Available from http://www.kn-portal.com/. Accessed October, 2015.
11. TNT Express Tracker. Available from http://www.tnt.com/webtracker/tracker.do?navigation=1&respLang=en&respCountry=US&genericSiteIdent. Accessed October, 2015.
12. Panalpina. Available from http://www.panalpina.com/. Accessed October, 2015.
13. DHL. Available from http://www.dhl.com/en/express/tracking.html. Accessed October, 2015.
14. FedEx Tracking. Available from https://www.fedex.com/Tracking. Accessed October, 2015.
15. Lusocargo. Available from https://www.lusocargo.pt/track.php#!/home. Accessed October, 2015.

16. Yin, M., Wang, X., & Zhang, R. (Eds.) (2008) Standardization and integration of information system in international container logistics wireless communications. In: *Proceedings of the 4th International Conference on Networking and Mobile Computing WiCOM'08* IEEE.
17. Doukidis, G. I., Chow, H. K., Choy, K., Lee, W., & Chan, F. T. (2007). Integration of web-based and RFID technology in visualizing logistics operations-a case study. *Supply Chain Management: An International Journal, 12*(3), 221–234.
18. Choy, K. & Ng, S. W. (Eds.) (2006). Improving supply chain traceability with the integration of logistics information system and RFID technology. *Materials Science Forum*. Switzerland: Trans Tech Publ.
19. Choy, K., So, S. C., Liu, J. J., & Lau, H. (2007). Improving logistics visibility in a supply chain: an integrated approach with radio frequency identification technology. *International Journal of Integrated Supply Management, 3*(2), 135–155.
20. He, W., Tan, E. L., Lee, E., & Li, T. (Eds.) (2009). A solution for integrated track and trace in supply chain based on RFID & GPS. In: *Proceedings of the IEEE Conference on Emerging Technologies & Factory Automation (ETFA 2009)* IEEE.
21. Carlino, M., Confessore, G., & Liotta, G. (Eds.) (2009). Potentials of satellite-based traceability services in logistics. In: *Proceedings of the European Navigation Conference–Global Navigation Satellite Systems*.
22. Track-trace.com. Available from http://www.track-trace.com/. Accessed April, 2015.
23. Terzi, S., Cassina, J., & Panetto, H. (2006). Development of a metamodel to foster interoperability along the product lifecycle traceability. In: D. Konstantas, J. P. Bourrières, M. Léonard & N. Boudjlida (Eds.), *Interoperability of enterprise software and applications*. Germany: Springer.
24. Terzi, S., Panetto, H., Morel, G., & Garetti, M. (2007). A holonic metamodel for product traceability in product lifecycle management. *International Journal of Product Lifecycle Management, 2*(3), 253–289.
25. Chen, X. (2009). RFID middleware design research. Applied computing, computer science, and advanced communication (pp. 50–56). Springer.
26. Holmström, J. & Främling, K. (Eds.) (2005). Design patterns for loosely coupled track, trace, configuration, and check operations in multi-company environments. In: *Proceedings of EUROMA' 2005 conference*.