Tracking and Tracing of Global Supply Chain Network: Case Study from a Finnish Company

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Abstract: Supply chain and logistics network tracking and tracing is an essential need in global supply and logistics network. Existing technologies are mostly suitable for single channel supply chain and are not suitable for multi-channel supply network. The objective of this research study is therefore to outline technological knowhow and possibilities related to tracking and tracking items within distributed supply chain and logistics network. This research has focused to implement a novel tracking system applicable for total supply network both inbound and outbound shipments. This study is validated within the boundary of how the available tracking technologies can be useful for a Finnish case company to manage its global supply and delivery network. Both hybrid and cloud enable online-based tracking systems are proposed in this research. The application of the proposed tracking technologies provides the case company with real-time visibility on its current logistics assets.

1 INTRODUCTION

There is growing interest of items tracking and tracing in supply chain and logistics network for the benefit of the end users. It is considered one of the success factors in supply chain management and to achieve competitive business advantage (Day, 1991). Logistics companies are therefore investing substantial amount of their resources in order to offer better services to the potential customers (Toyryla, 1999). Such tracking and tracing service helps customers to identify the location of their ordered items, whether they are in-transit, or already to the way towards the final destinations. This service therefore helps customer to plan in case of delivery delay of their ordered items.

In case of handling goods by one company, contemporary tracking systems might be work well, however, it may not suitable to track global logistics network. In case of tracking and tracing of multi-company supply networks, the tracking system is done by using Internet, where customers can visualize the status of their ordered items (Martinez-Sala et al., 2009). In several situations, multi-company tracking system can be interfaced with the customer company for easier visibility (Giannopoulos, 2003; Kärkkäinen et al. 2004; Benedikt et al., 2012). Although, such interfacing might be challenging and costly too.

The objectives of this research study are too divided into two steps. In the first step, fundamental needs of tracking and tracing within supply and logistics chain are identified along with checking-out various available tracking principles used by the companies for required tracking purpose. In the second part, a real life case study is conducted, where the multi-company tracking solutions are highlighted that is based on World Wide Web.

The rest of the article is organized in the following manner. In Section 2, a theoretical framework is presented, where various aspects of tracking and tracing in supply and logistics chains are elaborated. The fundamental tracking requirements of supply chain and logistics networks are highlighted in the Section 3. In Section 4, various available tracking principles are presented. In Section 5, an online tracking system portal is highlighted, whereas in Section 6 a case example is presented with the objective to demonstrate a pilot project for tracking phenomenon. This research is concluded with future research directions in Section 7.

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2 THEORETICAL FRAMEWORK

Although several researches have highlighted the benefits of tracking system for supply and logistics chain management over decades, companies are still lacking behind to implement such technology (Hinkka, 2012). Supply chain tracking or visibility is nowadays getting much more attention from companies in order to ensure security and minimizing associated risks. According to Musa et al. (2014), supply chain visibility can be defined to mean the capacity of the supply chain to view a product's lifecycle from concept generation to product's end-of-life activities and processes. This tracking system supports manufacturing companies to adopting just in time operations (Hui, 2008).

The tracking of supply network often used to describe a product in the forward direction, whereas tracing is used to infer the product's path and history from downstream to upstream of the supply chain (Dabbene et al., 2014). It is therefore essential to establish an efficient interface between the upstream and downstream of the tracking system. In order to make a tracking system it is required to establish a real time information flow. Such real-time information flow ensure to minimize potential risks and events within the supply network. The supply chain tracking enables companies to support managers in choosing activities, methods and technologies to increase supply chain security without reducing its efficiency (Pero and Sudy, 2014).

The functionality of tracking system concerns with three basic attributes, which can be explained as to identify an item, to locate its current position and current time. At the entry point usually the consignment is tracked by automatic identification technology that reads the code of the consignment and updates its status (Kärkkäinen et al., 2010). In continuous tracking system the assignment position in any time is tracked by interrogating the tracking database. In case of multi-company networks, there need close cooperation and collaboration with each other in order to fulfil the requirements for tracking systems (Shamsuzzoha and Helo, 2012). The information content can be varied between tracking systems (Liwei et al., 2009).

Often a tracking system mainly records the identity of an item, its position and both arrival and departure time. However, there are many occasions that also records other attributes like temperature, humidity, vibration, etc., (Shamsuzzoha et al., 2013). Such additional attributes protect tracked items from unnoticed damage and ensure quality delivery. In general, any company stores its tracking information to its central database, which can be used further if needed. In a network system, the information is stored centrally and retrieves according to the tracking needs (Helo and Szekely, 2005).

3 BASIC REQUIREMENTS OF TRACKING WITHIN SUPPLY CHAIN LOGISTICS

Nowadays different companies are choosing to implement more advanced and intelligent tracking systems. At the same time, there is a significant amount of cost savings for the companies in terms of better overview of flow of goods. However, beforehand several critical questions are needed to be answered by a company such as: what are the tracking requirements, what are the relevant goods and flows, what kind of information is available out there, and what type of technology should be used? This tracking requirement can be for specific product centric and/or inbound outbound tracking.

3.1 Itemized Tracking: Perspectives from Independent Transporters

In today's business, it is nowadays a common trend to outsource in order to meet up companies supply and logistics requirements. From this strategic shift, companies also expect real-time tracking solutions from the logistics providers. However, several issues create complicacy within the companies for both inbound and outbound delivery of items. Both the inbound and outbound transports companies usually have for a relatively take long time and needs to track their items. Some of these transport companies do have sophisticated tracking systems that are used to track their delivery items. None of these are able to (automatically) track shipments once they are on board a truck/vessel.

Furthermore, under logistical strategy choosing a single transport company to monitor the entire supply chain of a company would be complicated if not impossible. In such a case, the monitoring will always be reactive, not proactive - no transport company knows enough about a company's production and business to be able to predict upcoming problems, and correct accordingly.

In order to maintain a steady tracking of delivery items, any companies need to formulate its own tracking system rather than depending on the tracking system provided by individual delivery companies. In such perspective, the company needs to collect and store necessary tracking data from various sources

3.2 Supply Chain Logistics: Inbound and Outbound Tracking

In supply chain and logistics tracking both inbound and outbound tracking of goods are essential. The case of outbound logistics can be considered as the shipments from consolidation warehouse to end customer. This is seen as the most valuable part of the flow of goods and a late delivery is the most costly at this point with reduced customer satisfaction.

In case of inbound logistics tracking following situations are considered as important for any company: a) Lost goods, b) locating a specific product/unit, c) warehouse problems, d) order problems, e) time spent on customer inquiries etc.

From study it is identified that most internal stakeholders said very clearly that the majority of outbound problems are caused by inbound problems - the incoming side of the supply chain would benefit from proactive tracking as much as, if not more, than the outbound side.

Having analysed the current state of the order/delivery/shipment process in a company, several future plans can be assessed to remedy the problems. The best solution can be to form an online tracking portal (based on cloud-ware), to which all stakeholders could supply data for a smooth and efficient delivery process. This portal would tie together the different types of tracking data existing in different databases and ERP's throughout company's supply chain, plus make use of special online tracking services and the data from tracker devices, making it an integrated solution for tracking in the supply chain.

4 VARIOUS TRACKING PRINCIPLES

4.1 Hybrid System (RFID and GPS Tracker)

The hybrid system which is a combination of RFID (Radio Frequency Identification) and GPS (Global Positioning System) can be used to cover different parts of the supply chain network. Rather than focusing on one tracking technology only, it is better to use a mix of two. It is studied that both inbound and outbound transports have different needs. The inbound deliveries are more diverse, come from many places, are worth relatively less money (on an individual basis) and it is not equally important to know exactly (down to a meter), where a goods is. It is more important to know which of a box is not being delivered according to schedule. The outbound shipments on the other hand, move together (most often) are worth a lot of money (usually complete product) and may need to be tracked very exactly. The customer will need to know if a shipment is stuck at a border crossing, very close to final destination, etc.

From this situation, it is necessary to see what technologies can be used to implement a suitable solution for either inbound or outbound logistics. The inbound flow of goods can be monitored well enough by implementing a checkpoint system based on RFID tags – scanned automatically whenever they move past a certain stage or location, while the outbound shipments are better monitored with more precise (but also more expensive) GPS tracking devices attached to especially expensive goods. An example of a checkpoint system for inbound logistics is displayed in Figure 1.

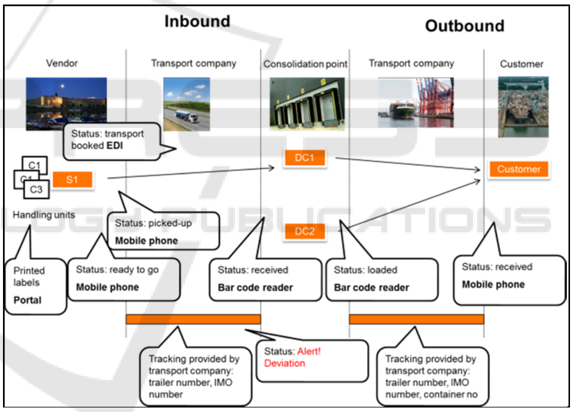

Figure 1: Checkpoint tracking system.

4.2 A Cloud Solution for Logistics Tracking

The basic principle of Cloud solution for logistics tracking uses an online program platform (Cloud-ware) that supports both inbound and outbound logistics easily. This solution generally interfaced with a company's current ERP (SAP) system in order to integrate and store of all the company's data. However, several factors talk against using ERP (SAP) to integrate with the online platform for tracking logistics chain (SAP, 2005).

First of all, security issues of company's internal data. Allowing outside parties such as transport companies and warehouses to automatically add and store data directly in the ERP (SAP) databases should require a certain amount of human supervision - a certain degree of filtering and approval of edits. An independent online platform adds a layer of separation this interaction - nothing more than the purely transport-connected data available in the online tracking portal can ever be accessed by an outsider, lost due to software error, outside attack, etc.

Secondly, cost. The Electronic Data Interface (EDI) service as used by any company to communicate automatically with its ERP's of certain often-used suppliers, charges a certain cost for every update and status message sent. With a tracking system, the amount of such messages might quickly rise to become a significant cost in the system.

Thirdly, ease of modification. With each new module, each new modification, upgrading the ERP (SAP) software site becomes a more expensive and complicated affair. Furthermore, making changes to the ERP (SAP) site requires an extensive approval process by the computer management of any company in order to maintain security. An easily modified online platform could allow more flexibility in making sudden changes and additions, when new tracking solutions and services are added to the mix.

Eventually, an online platform (e.g. Salesforce.com) can provide free online cloud-ware creation and modification within their developer's 'sandbox'; because of ease of programming within this environment; and the way it can easily store and receive data online through a set of standardized interfaces.

4.3 RFID/Barcode Combination System

In order to reduce cost a company often uses single tracking solution such as RFID tags or barcode. However, only using RFID tags or barcode cannot often meet the tracking requirements for a company. The best solution will of course be to use a mix of all possibilities. The uses of barcodes are old and well-known technology already and comparatively easy to use. However, unlike barcodes the RFID tags are a bit more complicated to integrate with the any tracking system since they require a physical component - an actual physical antenna tag that cannot be moved over the Internet.

RFID systems are good because of their automatic scanning capabilities, but if a warehouse worker nevertheless has to manually scan half of the inbound/outbound goods, the benefits are eroded. Since RFID printers are relatively expensive (€2000-€3000) it would be impossible to demand such an investment from small or infrequently used suppliers. Usually large size company uses the combination system for its tracking where RFID tags and barcode are used concurrently for better outcomes.

5 ON-LINE TRACKING SYSTEM PORTAL ARCHITECTURE

Figure 2 displays the overall architecture of an online tracking system. From Figure 2 is seen that the tracking system directly interact with the server which is also interfaced with company's SAP database, supplier e-confirmation, forwarder tracking, warehouse, AIS (Automatic Identification System) tracking and GPS tracking The server that is worked as FTP and message translation also interfaced indirectly with warehouse ERP, AWB tracking and end customer.

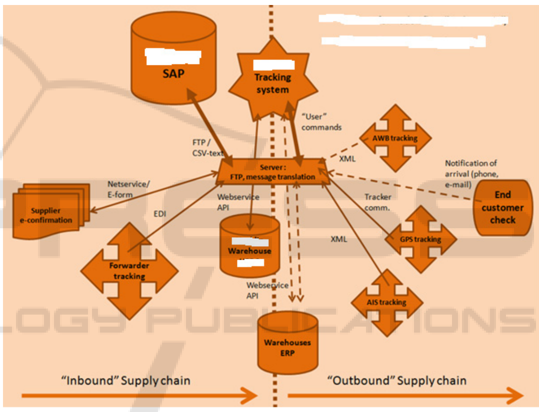

Figure 2: Tracking system program architecture.

This server worked as like as webpage from where customers can visualize the updated information of their logistics items after secured logged in. Both the inbound and outbound supply chain information can be visualized separately. The information is displayed through various formats such as XML, EDI, e-form and web-service API.

6 USE CASE SCENARIO: PILOT PROJECT

In order to demonstrate the overall tracking system this research uses a case company in Finland to track its product from Vaasa (Finland) to Singapore port (Singapore). The tracking route can be seen as in Figure 3. The product started its journey from Vaasa to Mäntyluoto harbour (Finland) by truck I order to store it, which is then transported to Turku harbour (Finland) by truck and eventually towards its final destination to Singapore by vessel.

Figure 3: Snap shot of the tracking route map of the use case company's pilot project (Finland to Singapore).

In this pilot project, different available trackers in the market were analysed with respect to their qualities and most importantly battery life times and TINO (Extended battery life) trackers, GPS trackers and AIS system were selected and used. Both the GPS tracker and the AIS system were interfaced with each other with the objective to get tracking data from both land and sea respectively. The tracking data from the land was received from the GPS tracker, while AIS tracking system receives data from online portal (http://www.marinetraffic.com/; or http://www.vesselfinder.com/). In this pilot study, an option to switch tracking data from one source to another was created. For instance, in case of a location where a delivery item is within a geo-location that is close to a harbour and a radius of 10 km around it, the tracking system will switch from the GPS tracking device to the AIS tracking system to collect any tracking data. However, if the delivery item is at the pre-specified harbour, it will then get its tracking data from the GPS tracker.

In this study, the battery life of the trackers were extended to one month by a customized process which were used considering the travel time from Finland to Singapore. This shows that the extended battery-life TINO trackers are viable options for the international tracking of the case company's goods. The basic difference of using our proposed system is that AIS only be used to find the location of the shipment, but not the condition of the shipment's contents. Our proposed system would enable not only to track the shipment accurately through the existing AIS system but also send the conditional data (humidity, temperature, dew point temperature, vibration, etc.) of the goods in the shipment, which is often considered as very important criteria of product quality and customer satisfaction.

When a GPS-tracker is trapped inside a cargo, it cannot transmit its tracking data. In that situation, the AIS ship-tracking system is used to receive tracking information. Of course, as can be seen from the route map, certain areas of coastline are less actively monitored by AIS hub-connected stations than others - just before the coast of Portugal, the tracking system did not pick up any transmissions for a few days.

The range of a normal AIS antenna is estimated to about 70 kilometres, and if the data-sharing stations on the coast are too far away and no data-sharing vessels are nearby, the tracking system will not show up-to-date tracking data. Certain areas are not monitored at all (by law); such as the coast of Somalia - the recent pirate activity there means that it would be unwise for the tracking hubs to provide data for anyone to access. Other areas are simply not being monitored and/or shared with the tracking system. More and more stations are joining every day, though.

In general, the swap of tracking data is automatically conducted between the GPS tracking device and AIS system. However, in case of AIS tracking system, it is necessary to enter the IMO-number (identification) of the ship manually in order to work properly. In the future, the transport managers of the case company will be able to monitor and correct such cases in the online tracking system directly.

6.1 Integration of Tracking Data/Information over the Online Portal

With more integrated data communication between parties and better tracking coverage, finding logistics items should become easier. The tracking system will use the transport company and consolidation warehouses (and possibly the suppliers) as sources of checkpoint data and the system is notified whenever an item is loaded / offloaded. If a delivery is missing because of several reasons such as inappropriate markings, error during transportation, warehouse relocation, etc., then the search of the item is focused to a specific certain area, at least. In the future, better RFID tag systems may even allow the warehouse personnel to go "hunting" for a lost item, with a strong, directional RFID scanner.

In this research work an online portal was developed using the salesforce (www.salesforce.com) platform. Figure 4 displays the online portal with overall information display that is needed to track an item. This portal consists of various tabs such as customers, purchase orders, projects, shipments, handling units etc., that are required for specific tracking information.

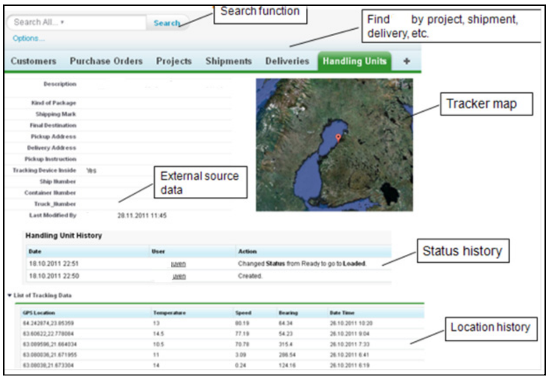

Figure 4: Tracking portal interface.

If the delivery/project manager wishes to know the status of any missing item, he/she could go to the handling unit tab of the portal and insert the handling unit number if known, otherwise can use the search button to find the item. In the portal, usually all the relevant tracking data of an item is stored. In addition, delivery/project manager could also be able to know the travel route of an item by using Google map as interfaced with the tracking portal.

In case of absence of the handling unit number of a missing item, it is also possible to know its status by using the search tab of the tracking portal, where all the items handling units are stored. From that tracking portal, all the relevant information of an item such as shipment/delivery date, its status, supplier's name, etc., are possible to retrieve. By this way, a delivery/project manager would be able to know the status of a delayed item too.

A customer demand to update frequently can be easily met by using this online-based tracking portal. If a tracker device is on board the shipment, or the AIS number of the shipment vessel is known, a delivery/project manager can see (down to the meter) where the shipment is. They can see whether a shipment is stuck at a border crossing or waiting off the coast because of difficult harbour conditions. The manager can easily take a screenshot of the route map and show this to the customer. In the future, it is even be possible to make this a feature of the portal - automatically generating and sending an info mail or a one-time-link to the customer's mail, at the press of a button. This should provide a good amount of customer good-will and reduce the human search time considerably.

6.2 Combining Data from Sources

The function of the portal is to act as an integrator of data. The HU screen shows (Figure 4) this principle: the main data is taken from case company's ERP (SAP) and transport company's but case data could also be added by suppliers. Literature shows that a higher degree of data integration in a supply chain also leads to better data reliability because of fewer manual data entries into different systems.

During the pilot project, two the most simple forms of data communication have been used to establish contact with warehouse and transport: text files communicated via FTP server (in the UN EDIFACT standard) and communication directly via Salesforce's own web interface/application interface.

6.3 Connecting Trackers to the Correct Handling Unit of the Logistics Item

One important feature of the prototype tracking portal is providing a simple system for "electronically" attaching a tracker to a certain handing unit number of an item needs to be tracked. While it is very easy to physically attach a tracker device to an item, the coupling of a tracker's identification number (its IMEI number, much like a mobile phone) and a handling unit would require logging in into the portal and manually writing in numbers.

In an attempt to simplify this process for factory and warehouse personnel, an easy-to-use smartphone application was created. By scanning the tracker's identification number bar code (already present on the trackers) and the handling unit's bar code, the mobile app will provide the portal with the information that these two units have now been coupled. Using this mobile app elaborate the tracking facility outside the warehouse, which is often needed by the manager remotely to track the status of delivery items within the warehouse. Even knowing the handling unit number of a shipment, managers would be able to track the items already loaded on a vessel which is integrated with mobile SIM card. This SIM card transfers the necessary information of the items to the mobile phones of the managers remotely through the assistance of AIS portal system.

Figure 6 displays the snap shot of coupling tracker/handling unit function with mobile app, while Figure 7 visualizes the handling unit update function with mobile app for tracking system of logistics items.

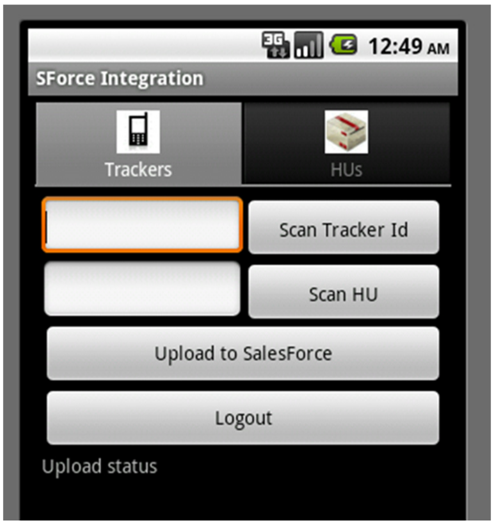

Figure 6: Tracking system mobile app – coupling tracker/HU function.

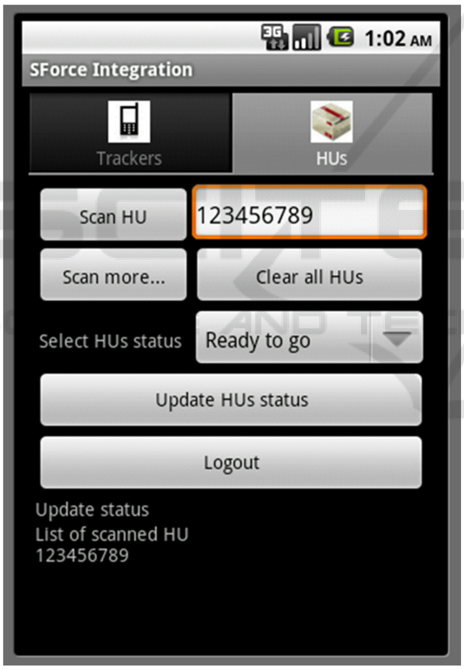

Figure 7: Tracking system mobile app – HU status update function.

7 CONCLUSIONS AND FUTURE RESEARCH

The importance of shipment tracking is getting more and more attraction within supply and delivery network. At the same time, delivery companies are concern in today's supply chain risk management and like to minimize it by implementing appropriate and cost effective tracking devices or tools. In order to develop the predominant tracking systems, companies are often forced to invest deploying various available tracking devices for their tracking needs.

The objective of this study was to investigate and analyze various available tracking technologies with their functionalities or principles as we all as the requirements of supply chain and logistics networks tracking. In order to fulfill such aim, this study presented a theoretical framework after critically investigate and analyze past and present literature on supply chain tracking and tracing systems. In addition, this study also piloted a real-life multi-company tracking system that might supports companies to deploy their supply chain tracking solutions successfully. The presented case example as highlighted within this research scope will encourage supply chain and logistics providers to implement an effective and efficient tracking system of their delivery networks.

In future research more case examples will be conducted based on online tracking system in order to generalize the presented approach. More available technologies and tools on supply chain tracking and tracing can be investigated to get optimum performance. Additionally, an in-house tracking device will be designed; developed and tested that can be used for goods tracking purpose.

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