Identification Technologies in Transportation
- In the context of Foliated Transportation Networks

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1 Introduction

As a consequence of the development within information technology and its applications in logistics and transportation, new solutions and combinations of traditional transportation systems become feasible. By using information on the properties and location of the goods, and identification technologies such as radio frequency identification (RFID) in a real-time environment, transportation can be made more effective and efficient (Persson and Waidringer, 2006; Persson and Lumsden, 2006). Thus, finding new ways of organizing the physical flows of goods, transportation networks can be better designed and operated.

A mixed transportation systems concept, called Foliated Transportation Network (FTN), has been developed (Persson and Waidringer, 2006; Persson and Lumsden, 2006). The concept combines the characteristics of a hub-and-spoke network with the flexibility of direct transportation using real-time information and goods identification technologies as enablers. Customer service can be increased while the cost for transportation can be lowered due to better resource utilization and more efficient handling of goods. The environmental impact of transportation can be reduced due to the increased filling rate and that resources are used more efficiently due to better coordination of available resources. In the scenarios describing the concept, RFID is used to provide information about the characteristics of the goods to make the handling operations more efficient.

In previous studies in transportation literature issues such as hub location (Aykin, 1995; (O'Kelly and Bryan, 1998), network optimization (Powell et al., 2002; Crainic, 2000) and mathematical modeling (Crainic and Roy, 1988; Crainic and Laporte, 1997) have been thoroughly analyzed. There is also a growing understanding of RFID and the benefits that can be obtained by using the technology. Thus, the theoretical foundations of the concept can be derived from earlier research and developed to include the real-time scenario discussed here in terms of the use of RFID and information technology in general.

The feasibility and future impact of the concept is discussed by using data from a Scandinavian perspective but should be possible to apply to other settings in other countries and under other circumstances such as intermodal transportation or international freight. To balance the theoretical implications and findings a case study of a major logistics service provider was made to illustrate what the concept would mean in terms of changes to the present transportation networks. For the present and future state of RFID and identification technologies we also refer to a survey that was made during late 2005, depicting the current state of identification technologies among the transportation buyers.

2 Identification technologies and RFID

Demands from leading companies such as Wal-Mart in the US is expected to lead to an increased overall use of identification technologies and RFID in the same way as the bar code was promoted in the 1980s (Smith and Offodile, 2002; Smith, 2005). By demanding that their top suppliers all will use RFID in the future they promote the technology and lead the development. Being important customers, the mandate they have is a strong incentive for companies to start using RFID also in their internal logistics operations. For Wal-Mart and the companies promoting RFID, the reason for implementing the technology the main reasons are availability, cost and better visibility of products in the supply chain (www.walmartstores.com).

The benefits that can be derived from identification technologies such as RFID are several and as the number of applications grows, the advantage of using the technology gets clearer. Without going into to much detail, the fundamental advantage of identification technologies are related to the way information can be stored and transferred. Using radio instead of optical information systems data can be read without visual contact, a large number of products can be identified quickly and if desired, information can be stored on media that can endure very harsh conditions (Wyld, 2006; Lefebvre et al., 2005; Sheffi, 2004; etc.). By being able to scan the goods more frequently, the visibility of goods and products will increase and thus effects caused by lack of information and supply chain visibility can be avoided (Lee and Özer, 2005; Smith, 2005; Twist, 2005).

Another aspect of the technology is the difficulties experiences by early adopters. Various trials and pilots show that the configuration of hardware, placement of readers and tags and different materials influences the success of the presently implemented systems (Lefebvre et al., 2005; Smith, 2005). The limited number of users makes it is difficult to estimate the real value of rfid. A common confusion on what should be attributed to RFID can be noticed. It is sometimes very hard to know whether the accomplished results relate to the technology or the change in the way the processes in focus are organized. In a critical review on previous research, Lee and Özer (2005) claim that the value of RFID can be reduced into two distinct categories: *visibility* and *prevention*, that many of the advantages described as positive effects and consequences of RFID in the literature have other causes and can not be entirely referred to as implications of the technology per se.

There is no doubt that there are rules and restrictions to follow to make it work properly and that there still are many issues to be solved before it can be implemented in large scale. It is up to the user to identify the values that can be created and how the technology will be used. Avoiding a detailed discussion on the value of RFID we will discuss the subject in terms of visibility and prevention as discussed by Lee and Özer.

2.1 Visibility

Visibility relates to upstream and downstream visibility of goods in the supply chain as well as visibility of errors. Warehouse management and inventory control is a key area where RFID and identification technologies have proven to be useful: opportunities for improved inventory management; inventory visibility; enabled operational improvements; reduced inventory shrinkage; and improved asset tracking have been reported (Prater et al., 2005; Smith, 2005; Twist, 2005; Jones et al., 2005).

Several researchers have shown that by identifying the goods when transferred from one process to another, internal efficiency and operational excellence can be increased (Kärkkäinen, 2003; Jones et al., 2004; Autry et al., 2005; Lee and Özer, 2005). In transportation and materials handling there are great possibilities to use the technology. Apart from the transport itself, responsibility, ownership, insurance matters, etc. are important issues in transportation. If RFID tags are used, the product itself will be carrying detailed information of the product, information that can be used both to guide the forwarder during transport and to avoid uncertainties on factors related to responsibility and potential fraud (Angeles, 2005). Information stored on RFID tags attached to the goods can also be used to make the transportation system more apt to handle specific situations, and thus more *intelligent* or *smart* by having the decisions taken at a local level, directly in the handling operation in the terminal (Lumsden and Stefansson, 2006).

When discussing benefits related to visibility some of the most frequently mentioned, such as inventory savings, shrinkage reduction, out of stock reduction and sales increases have to be considered as less certain as proof of the advantages of RFID or other changes in production processes (Lee and Özer, 2005). Thus, opportunities and positive effects must be evaluated based on each specific case individually.

2.2 Prevention and elimination

Prevention is related to the elimination of unnecessary operations such as avoiding shrinkage and having real-time inventory. By adding information on availability, stock levels and the location of the goods in the supply chain to a planning system, stock-outs and obsolescence can be avoided (Lee and Whang, 2001). In the long run, this will lead to more efficient production systems and transportation operations that will be more precise and accurate. It will also reduce the risk of shipping of the wrong products to the wrong place and in the wrong quantities, avoiding the extra handling that might be the consequence thereof.

In transportation networks, the goods identification procedure can be made more reliable and efficient, reducing the time for identification needed at the shipper, in the terminals and at the drop-off point. It also affects traceability and due to the increased readability of the tags and the time and resources required, in a fully developed situation, the goods can be read frequently and thus it can be monitored efficiently all the time. Thus, unnecessary movements and operations on the goods can be avoided. It will also eliminate some of the extra resources needed to track and trace lost goods or equipment, non-value adding operations required today.

Demands from leading companies adopting RFID such as Wal-Mart in the US is expected to lead to an increased overall use of RFID in the same way as the bar code was promoted in the 1980s (Smith and Offodile, 2002; Smith, 2005). The mandate of important customers is a strong incentive for companies to start using RFID also in their internal logistics operations. This means that an increasing number of suppliers will use RFID when delivering products to their major customers and thus the true effects of automatic identification and RFID will show.

2.3 Results from the survey

The survey was made during late 2005 and involved 776 companies out of which 301 responded giving a response rate on 38.8 percent. It focused on issues related to identification technology and the perception of RFID (Persson and Stefansson, 2006). The questions where in most cases statements evaluated by the respondents using a Likert scale. The general trend in the survey showed skepticism towards using identification technologies such as RFID, therefore the results were biased due to the respondents' limited knowledge of the topic. The interest for RFID was to a high degree depending on the influence of major customers, i.e. independently of size, business area and the number of suppliers. Only a small fraction of the respondents claim that they use automatic identification technologies. Surprisingly many of the companies do no use bar codes for identification purposes. Among the responding companies, RFID seems to be a topic that they still lack knowledge on. They are very hesitant towards exploring its possibilities and thus they do not now its full potential. In the few cases where they claim to use the technology, it is often used for other purposes, e.g. in the manufacturing processes.

Demands from leading companies adopting RFID such as Wal-Mart in the US is expected to lead to an increased overall use of RFID in the same way as the bar code was promoted in the 1980s. The mandate of important customers is a strong incentive for companies to start using RFID also in their internal logistics operations. This is to some extent supported by the survey: increased visibility and facilitated information exchange over organizational borders were the two most important motivation factors for implementing RFID. Thus, even if a company lacks incentives of their own to automate the identification process and to implement the technology, they would consider it if there was a demand from the customers to do so.

In the case of prevention and elimination of unnecessary operations and actions, the questions were related to whether the respondents were having problems related to the goods receiving and goods identification processes and if they were considering any measures to take action against it. Surprisingly many of the respondents claimed that there were no problems related to the goods identification and receiving process. Therefore, they were not considering any measures. Neither was the location of goods and resources seen as a major issue among the respondents.

Going from bar codes to RFID means that it will be easier to identify the goods by scanning each pallet or shipment. For the goods identification process this means that the goods have to be easily and quickly identified by both the shipper and the forwarder. Again, the survey shows that most companies do not have this possibility today depending on factors such as the lack of a supporting information system, the absence of customer demands for this type of service or other reasons. The results indicate that there are many companies that are not prepared for this type of information systems yet.

2.4 Future and risk analysis

The survey was an attempt to balance the development described in the literature. It is by no means telling the whole story but will hopefully point out the direction what is to come and when. The subjects addressed in the survey were chosen to depict the underlying demand for traceability and identification from a logistics perspective. Information technology will make future solutions in logistics and transportation increasingly information intense. There is no doubt that future identification technologies will contribute to more efficient transportation and goods handling and that it will mean an efficient handling of resources and goods in terminals and logistics operations

The costs for inefficiency will be higher which will force companies to develop solutions that can benefit from enabling technologies and coordination of activities and resources. This will lead to a situation of increased awareness of the cost for inefficiency in transportation and goods handling operations from the customers. There are already fully developed systems gathering information on potential congestion problems, infrastructure maintenance and road blocks being used to shorten the transportation time. Therefore, similar systems within the goods transportation area should be feasible to accomplish. There is also a great opportunity that future applications will include real-time information such as the present state on the roads, bridges and tunnels, monitoring the traffic situation.

Currently, there are significant problems that have to be solved regarding the international standards and allocation of frequencies as well as standardization of tags and readers. The different suppliers are manufacturing tags according to different standards which means that they can not be read by equipment from other suppliers. Factors like country, technology and frequency have to be considered when deciding on the use of RFID equipment (Jones et al., 2004). This is to some extent also reflected in the survey. For the companies considering RFID for identification of products in a supply chain, the emergence of an international standard is crucial. There are also some technical readability problems that have to be solved before the major breakthrough can be accomplished. So far, tests have shown that the readability is lower than expected. It has proven very hard to obtain full readability on products containing water or metal due to the physical properties of the material (Lefebvre et al., 2005). RFID requires an underlying information infrastructure and support from the involved information systems (Wu et al., 2006).

Whether the result represents the general state of the situation can not be deducted from the results of the survey but from the companies that did have problems with this type of operations, it can be assumed that they have a higher motivation to implement tools identification of goods. However, there is no supporting evidence from the survey that can be related to this issue

3 Introducing the Foliated Transportation Network

There are hardly any pure hub-and-spoke networks operated by less than truckload (LTL) transportation companies today, most transportation networks are mixed so that goods can be moved between terminals according to less fixed routes and schedules. In LTL transportation, terminal networks are developed to suit major high demand or high priority origin-destination pairs (Crainic, 1999), and thus, maximized to serve as many terminals as possible by having direct transport relations where it is possible. In the case where a hub and spoke network is used it is often express goods and mail that is being transported, despite the opportunities for other types of goods.

3.1 Hub and spoke

The main idea behind the hub and spoke concept is to consolidate goods by using one single central hub to decrease the number of direct relations in a network. As the goods to and from the terminal can be consolidated, the filling rate of the trucks will increase (Abdinnour-Helm and Venkataramanan, 1998; Groothedde et al., 2005). The consolidation of goods in the hubs means a buffer which means that the goods can be allocated to vehicle loads despite differences in time and location of manufacturing (Hall, 1987). Due to this collecting and allocation of goods, it also means that customers shipping small amounts of goods can benefit from the same level of service as companies shipping larger quantities (Roy and Crainic, 1992). Terminals where the uptake of goods is low will benefit from this as the goods can be merged with goods from other terminals.

The consolidating operations in the terminals are also the networks major disadvantage, i.e. the loss of time handling the goods in the hubs and the increased distances the goods have to travel. It also means that the terminals have to be large enough to handle all the goods coming in during a certain time-window. If not, there is a large risk of queuing, resulting in waiting times in the system (Shaw, 1993; Roy and Crainic, 1992).

As stated, pure hub and spoke networks are hard to find but some of the express delivery companies, DHL Express, UPS and FedEx, etc. have similar solutions. For LTL carriers, shortcuts in the network are common, having direct shipments between terminals, thus minimizing the handling of the goods cutting the traveled distance.

3.2 Direct shipment

Direct shipment is a way for independent transportation companies to deliver goods for a customer especially when goods are transported directly between two companies as a full truck load (FTL) (Crainic, 2002). This is often the case when no further consolidation or coordination of the goods is required. Customers indirectly decide the amount of goods to be loaded on the truck and the transport will be regarded as a full truck load.

Direct shipments increase in importance when economies of scale can be found (Aykin, 1995). Quite naturally the filling rate of the vehicles has to be sufficiently high. Thus, certain types of goods and products are more likely to be transported by direct shipments. A large part of the direct shipments is represented by the type of goods that either can be mixed with other goods such as liquids and other bulk transports or where large amounts of goods are shipped between two companies. It is common that small niche carriers and carriers offering the lowest cost at that particular moment are chosen based on the personal experience of the transportation manager (Caputo et al., 2005). Flexibility-increasing operations such as repositioning of goods, modification of the trucks or resource reallocation do not normally occur in this type of system.

For LTL transportation companies, direct shipment between terminals in a network is an efficient way to consolidate, coordinate and distribute goods. When using direct shipments in this type of transportation a terminal is needed where incoming goods can be consolidated and allocated to long haul trucks. This is also called direct shipment with milk runs just to emphasize the collecting, coordination and consolidation of goods that take place before the goods are shipped to the distributing terminal.

High filling rate and full utilization of the trucks and resources makes direct shipments the most efficient way to handle goods in a transportation network. This is why most major transportation companies have based their physical networks as combinations between direct shipments and hub and spoke networks.

3.3 Mixed transportation networks

Integrating the principles of hub and spoke with direct shipments means that the service to the customers can be extended. Overnight shipments can be offered due to the fact that goods can be collected and consolidated into large shipments and then sent directly to the distributing terminal following a pre-set schedule, enabling fast services between main cities and major geographical areas can be offered (Persson and Waidringer, 2006).

For a large logistics company using a mixed strategy, the use of direct shipping becomes increasingly complex as the number of customers and direct relations increase (Crainic, 2002). As the number of relations in a network is growing a considerable number of resources is required to maintain a high service level as promised to the customers. This means that the delivery times and the over-night deliveries will cause many trucks to be poorly used. As a consequence of the vast number of relations, the amount of goods to each terminal decreases and thus the resource utilization of the trucks decreases. Demands from customers on high frequency deliveries and short lead times further reduce the possibilities to coordinate the goods for the forwarder.

There is a great potential in mixed networks (Crainic, 1999; Crainic, 2002; Liu et al., 2003). Mixed networks have the potential to be more efficient than both hub-and-spoke networks and direct deliveries used separately. The total cost of the network can be reduced significantly by having links in the network creating interhub links where the amount of goods is large (O'Kelly and Bryan, 1998). Mixed transportation services will imply better equipment utilization, decreasing waiting time at the original terminal and ensuring more rapid service for the customer. On the downside, it also means additional unloading, consolidation and loading operations, heavier delays and higher congestion levels at the intermediary terminals as well as a risk for a decrease in the total reliability of the shipment (Crainic, 1999).

The problems in a mixed transportation network have network-wide impacts and are strongly and complexly interconnected in both their economic aspects and the space-time dimensions of the associated operations. Therefore, decisions should be made globally, network-wide, in an integrated manner involving: service selection, traffic distribution, terminal policies, and general empty balancing strategies. It is also about simultaneously consider the routing of all traffic, the level of service at each route, and the costs and service at each terminal (Crainic and Roy, 1988; Crainic, 2002).

3.4 Foliated transportation networks

The use of identification technologies and real-time information in transportation implies that there will be a more flexible and dynamic way to collect data and using it to organize transportation. Therefore, a concept has been developed for LTL transportation networks, called *Foliated Transportation Networks*, FTN, a name that has been chosen to signify the mutuality of the two underlying concepts (Persson and Waidringer, 2006; Persson and

Lumsden 2006). The concept is a development of the mixed transportation system, combining the positive characteristics of hub-and-spoke networks and the line-based direct shipment networks that many of the major logistics service providers use today.

Practically this means that the foliated transportation network is based on direct shipments coordinated with operations a hub-and-spoke-based terminal network. Similar transportation solutions have previously been referred to as intercity freight transportation (Roy and Crainic, 1992), non-strict hubbing (Aykin, 1995), mixed (Liu et al., 2003), hybrid/extended (Zäpfel and Wasner, 2002) transportation systems or transportation systems with the presence of interhubs (O'Kelly and Bryan, 1998) or shortcuts (Lumsden et al., 1999). By using information on the position and characteristics of the goods, a transportation company will be able to direct goods between the two depending on the amount of goods being sent between terminals in the terminal network. The principle for this is that:

> *As soon as the breakeven point for a full truck load is reached, the goods will be sent directly to the distributing terminal but if the amount of goods does not reach that level it will be sent via the hub-and-spoke system.*

From the collecting terminal, the goods will be transported in full truck load direct to the distributing terminal as long as the amount of goods is sufficient, otherwise an intermediate hub will be used as a consolidation point. In the intermediate hub the goods it will be coordinated with goods from other terminals to form a full truck load before being sent to the distributing terminal.

By combining direct shipments and a hub-and-spoke-network a number of advantages can be realized. A conceptual model of the FTN at a hypothetical logistics service provider is depicted, Figure 1.

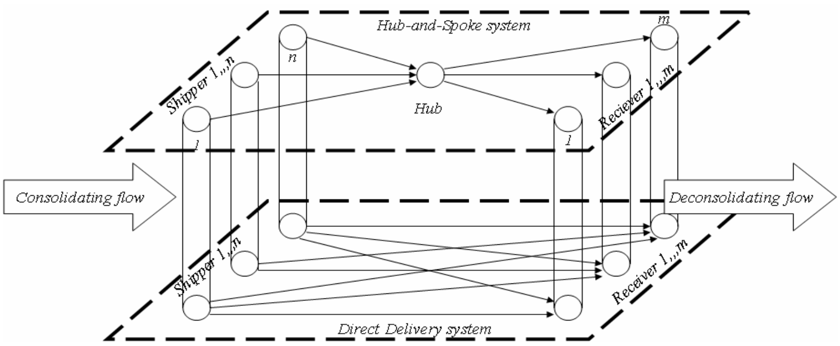


Figure 1 Foliated transportation network of a logistics service provider (Persson and Lumsden, 2006)

By backing up the terminal network using a hub-and-spoke network, goods can be directed between the two using an intermediate hub to consolidate the goods if needed. Similar concepts have been developed in previous research, but then based on other principles for selecting the goods.

One of these models, assisting road hauliers in making decisions about designing the service network, routing freight and balancing empty vehicles, was developed by a group of Canadian researchers (Roy and Delorme, 1989; Roy and Crainic, 1992; Crainic, 2002, etc.). The NETPLAN model is a good example of how a mixed transportation network in use will create benefits for motor carriers and long-haul operators. Other researchers have focused on the collaborative intermodal transportation networks and the economies of scale.

A similar approach was proposed by Groothedde et al. (2005), discussing an approach where consolidated flows will be shifted from road transportation to other modes, better suited to handle large volumes such as rail, barges, coastal shipping etc. The conclusion was that the network being the most efficient in each situation should be chosen regardless of the modality or type of system.

The Foliated Transportation Network (FTN) does not take an intermodal perspective but can be applied to both intermodal and intramodal transportation. The main focus is to make the transportation network more efficient by using real-time information on the goods. By using information systems in general and identification technology in particular, increased efficiency can be obtained while customer service can be maintained on a high level. Using state-of-the-art decision support systems, forwarders will be capable of handling exceedingly complex problems related to the activities in a transportation network. Support systems will help coordinating the activities and resources in the network by integrating goods characteristics, origin and destination information and identification and tracking data that are crucial for the success of the transportation network (Zäpfel and Wasner, 2002). Identification technologies, high speed wireless communication and geographical information systems will facilitate the decision-making process in and between hubs in future transportation systems (Stank and Goldsby, 2000; Caputo et al., 2003; Kärkkäinen and Holmström, 2002). To further illustrate the principal idea of the FTN concept, two scenarios will follow

4 Two scenarios

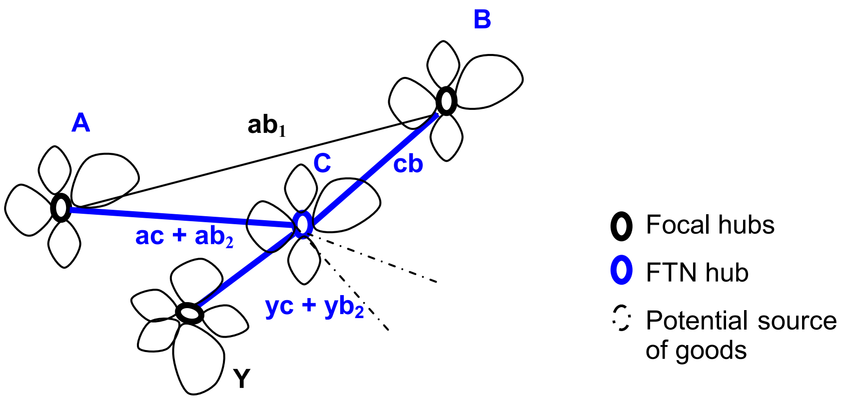
> *Logistics is no longer about simply moving goods from a place to another: it is also responsible for fast and effective services that increasingly include market adaptation, packaging and final delivery* (Lasserre, 2004).

In a situation where the goods do not fill one truck either of two different scenarios is possible: (1) a scenario where the goods in one relation exceed one truck resulting in goods that will not fit on the vehicle, called overhang, or (2) one where the goods in a relation does not provide enough with goods to fill a truck. In both cases it means increased expenses for the forwarder that has to provide the same service fully loaded or not. The two scenarios will be briefly illustrated in the following discussion

4.1 Shipments where the amount of goods between two terminals exceeds one truck in a relation

In order to better use and to fill available resources, the choices have so far been either to let the goods exceeding a full truck to wait for the next shipment for that particular destination or to send the goods by an additional truck and thus generate a low filling rate on that particular truck. Neither of the alternatives is of course ideal for the forwarder, either from a cost or service perspective.

The result of the proposed solution, using the FTN principles is described in Figure 2. In this scenario the amount of goods going between terminal A and B is exceeding one truck. Currently, this means that the forwarder has to either send one full plus a partly filled truck or to prioritize the goods, sending the overhang at a later occasion. According to the proposed solution of an FTN the goods exceeding the first truck, fully loaded, will be sent to an intermediated terminal C. In Terminal C, the goods will be coordinated with goods from other terminals, such as Terminal Y, to be shipped to the final destination, Terminal B. This means that a fully loaded truck will be sent between Terminals A and B plus one truck that transporting goods to an intermediate hub, Terminal C. This means that the amount of goods between the terminals, **ab** in the figure, has to be divided into at least two shipments $\mathbf{ab_1}$ (FTL) and $\mathbf{ab_2}$, and that it will be consolidated with other goods going to the same distributing terminal.



$FTL = EQ < ab = a_1b_1 + ab_2$

$cb = yb_2 + ab_2 + cb_2 + \varepsilon_B$

Where: *ab* is the total amount of goods between two terminals (A and B)

p_iq_i is the i^{th} fraction of goods from a Terminal P to a Terminal Q,

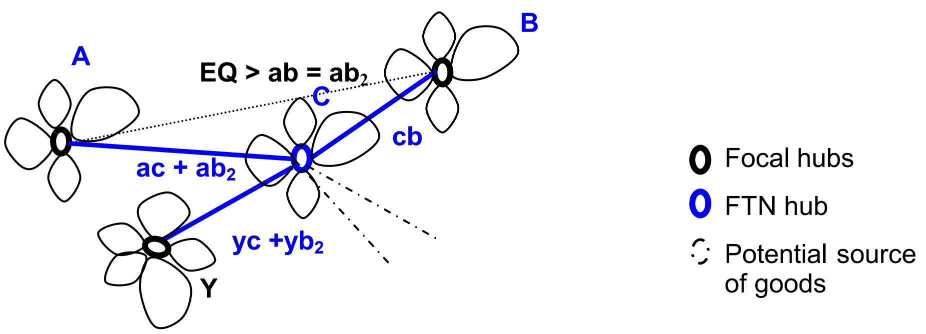
ε_B represents the amount of goods from other terminals in the network shipped to Terminal B

Figure 2 Shipments where the amount of goods between two terminals exceeds one truck in a relation

For the allocation of trucks and other handling resources in the terminals, the availability of information is crucial. When a shipment is sent via an intermediate terminal the lead time is increased both as a consequence of the extra handling process as well as the increased distance the goods have to travel. It also requires that goods to the destination can be merged in the final distributing terminal to be sent as one single shipment to the receivers.

4.2 Shipments where the amount of goods between two terminals is less than one truck in a relation

This is a similar situation to the previous one in the way that the goods have to be coordinated to better be able to fill available resources. As in the previous case where the goods exceeded one truck, the choices have so far been either to let the goods wait for the next shipment or to use the existing truck, resulting in a low filling rate on the truck.



$ab = ab_1$

$cb = cb_2 + ab + yb + \varepsilon_B$

Where: *ab* is the total amount of goods between two terminals (A and B)

piqi is the i^{th} fraction of goods from a Terminal P to a Terminal Q,

ε_B represents the amount of goods from other terminals in the network shipped to Terminal B

Figure 3 Shipments where the amount of goods between two terminals is less than one truck in a relation

Following the same principles as in the previous situation, all the goods will be sent to the intermediate terminal where it will be coordinated with goods sharing the same distributing terminal. Information on the characteristics of the goods has to be available to the forwarder to plan and allocate an appropriate vehicle for the goods. As the goods in the relation between Terminals A and B do not reach an economical transportation quantity, **EQ**, there will be no truck going directly between the terminals, $a_I b_I = 0$. All goods will be sent to Terminal C for coordination with other goods, thus, $cb' = cb + ab + \varepsilon_B$

A significant issue affecting the success of the concept and thus have to be taken into account in both scenarios is the increased distance between terminals. The distance direct between Terminals A and B, using FTL, is shorter than the hub and spoke distance (A to C to B) using LTL. As a consequence, the hub and spoke network (LTL) has to start operate before the direct shipment (FTL) which adds complexity in the filling requirements.

4.3 Problem description

The problem in the traditional solution is that all the goods in a relation have to be transported between the terminals due to service commitments. The consequence thereof is that the utilization of the last truck leaving the terminal often is very low due to late planning and decisions. As the goods have to reach its final destination as scheduled, the transportation company has committed to deliver the service despite sometimes low volumes of goods. Using a FTN some of these problems can be avoided.

The key is that the amount of goods coming in from the shippers is known in beforehand and thus can be used in the planning of trucks, equipment and other resources used to handle the goods in and between the terminals. To coordinate the goods flow information from the customers on the exact amount of goods that will be sent in the network is required. Having access to this information means that there will be an opportunity for the forwarder to plan the use of trucks and other resources in the network. This pro-active planning of goods and resources should be accomplished by using real-time information on the characteristics of the goods to be shipped, enabling quick and reliable sorting and handling of the goods in the terminals

5 A case study of a North European logistics company

In a case study of a North European logistics service provider (LSP), described in Persson and Waidringer (2006) and Persson and Lumsden (2006), a transportation network was studied. In the case study four major factors were identified as important for the success of the concept: *information, time, design of the terminals* and the *properties of the vehicles*. Information and time were considered the most important due to the direct relation to the effects and characteristics of automatic identification and tracing technologies.

Several issues in the studied system were found to deviate from the ideal of the proposed system, mainly the availability of information for planning operations in the transportation network, shortcomings that have to be considered for the success of the FTN approach.

5.1 The booking process

There is currently no standardized booking procedure requiring detailed information describing the goods characteristics in the LTL transport system. In most cases only a minimum of information is entered into the booking system. As described earlier when introducing the FTN concept, early and detailed information is required for the planning of trucks and resources, e.g. to determine when a truck can be filled or not.

It is a necessity that information can be sent efficiently between the shipper and the forwarder. The shippers have to share information on the properties of the goods before entering the transportation network. Thus, it is important for the companies to agree on a standard for information transfer. To avoid lock-in effects between the parties, it is also recommended that an interface requiring a minimum of customization will be used, at least for the shipper.

5.2 The collection and consolidation procedure

The collection and consolidation procedure of a terminal network generally follows the procedures of a hub-and-spoke network with milk runs (Liu et al., 2003). After the pick-up, the goods are sorted at the collecting terminal and then consolidated with similar goods.

Using the FTN concept requires that the goods should be registered continuously during collection that the goods can be coordinated with goods from other shippers. It is important that the increased handling and transportation time is considered when the goods are to be sent via an intermediate terminal. Therefore, the goods exceeding a full truck load, the *overhang*, have to be collected prior to the goods in the direct shipments due to the operations on the goods. The forwarder has to have the information at a very early state to be able to allocate the proper resources and again, information and time are key components.

A problem that arises is deciding when a carrier should be considered full and when there is an overhang, i.e. when the goods exceed one full truck. This is something that can not be changed unless there is information available that will tell more about the characteristics of the goods. In most cases, it is not until the goods are received by the forwarder and sorted on the next link or relation that the true filling rate can be verified.

5.3 Transport, driving times and distances between the terminals

In Sweden and Northern Europe most of the population and manufacturing industry are concentrated to a limited number of regions but still there are large geographical areas that have to be covered. This means that some of the terminals have very large uptake areas where customers are scattered over large geographical areas whereas some have their customers close to the terminal. Therefore, there are big differences in the amount of goods being handled each day between the different terminals.

In most logistics company like the case company, the transportation network is based on the uptake area surrounding each terminal. Depending on the geographical position of the terminals in a network, the intermediate hubs have to be chosen according to their importance for the network as a whole. Terminals not fitting the requirements have to be excluded. Out of the twenty nine terminals of the case company only four were suitable and chosen for the study.

5.4 Operations and handling time in the terminals

An intermediate terminal has to be dimensioned to handle the largest possible overhang if the function is to be secured. The capacity and the goods handling time in the terminals have to be calculated carefully to have a reasonable throughput time of goods passing through the terminal.

To minimize the handling time, the goods have to be easily identifiable and reasonably easy to handle. Therefore, the handling time characteristics of the goods and handling of the goods are also important, goods that are easily identifiable require less effort to be sorted on the next link in the transportation network. Thus, goods specific information is required to speed up the operations in the terminals and to make the sorting operations more efficient.

5.5 Major findings

As a consequence of the generous rules for sending goods in the terminal networks of many of the LSPs, customers have very few restrictions in terms of sharing information about the goods. In most LTL transportation networks time limits and flexibility are preferred in relation to the possibility to further enhance the resource utilization of the transportation network. Thus, the customers demand late pick-up times and flexibility regarding the amount of goods to be sent.

By actively using goods characteristics and information on the goods, resources can be planned and scheduled to better handle the goods in the terminals. Availability and use of information will be crucial to enhance the goods handling and process in transportation networks. The case study shows that the goods handling operations should be fast and reliable in order to make up for the time lost by having the goods go through an intermediate terminal

The more information there is on the amounts of goods to be transported between two destinations and the higher the filling rate that can be tolerated. Previous knowledge has shown that when a truck has a filling rate above 80 percent, the flexibility of the transport and the ability to handle the goods change drastically. This is often why 80 percent is considered the maximum limit and definition of a full truck. If each case can be calculated individually, the forwarder can elaborate on the amount of goods defined as an FTL. Without this information, the transport will become less flexible and the benefit of having a mixed transportation network will decrease.

6 Discussion

In this paper a mixed transportation network called the *Foliated Transportation Network* has been presented as a viable strategy to make transportation networks more efficient and thus more apt to handle future demands and expectation in transportation. What makes it different from other earlier described mixed transportation strategies is the focus on identification technologies and the possibilities to transfer goods specific information that it will bring.

Despite the case study and the survey that has been made on this topic, there are still many issues to prove and questions to answer before it can be verified if this is the way to proceed. RFID is still a dark horse and therefore has a lot to prove before it can be implemented by companies that do not have the financial strength of Wal-Mart or the high-value goods of Airbus or Boeing, actors currently promoting the technology very hard. The survey referred to in this paper is an attempt to balance the picture from the literature. It is by no means telling the whole story but will hopefully point out the direction what is to come and when. The subjects addressed in the survey were chosen to depict the underlying demand for traceability and identification from a logistics perspective. The only ting that can be certain is that the development in information technology will make future solutions in logistics and transportation increasingly information intense.

6.1 Opportunities

Using identification technologies such as RFID has a great potential in making goods handling significantly more efficient than today. Despite the technical problems experienced today the opportunities for the technology are greater that the threats. It will mean that other operations also can be changed and that previously impossible ideas can be realized.

One of these ideas or concepts is the mixed transportation network discussed in this article. Many of the weaknesses of current transportation solutions can be overcome by better planning and utilization of resources. It requires that the shippers are able and willing to share information that can be used by the forwarder to increase filling rates and utilization of goods and resources. In case it will prove possible to accomplish, it might mean a revolution for transportation and goods handling processes in LTL transportation.

6.2 Future

Demands from leading companies adopting RFID such as Wal-Mart in the US is expected to lead to an increased overall use of RFID in the same way as the bar code was promoted in the 1980s. The mandate of important customers is a strong incentive for companies to start using RFID also in their internal logistics operations. Many companies are believed to implement RFID under the influence of powerful suppliers and customers.

Most forecasts indicate that in the future, the costs for inefficiency in transportation will be significantly higher. It will be costly for both forwarders and their customers to waste finite resources due to non-efficient goods transportation. On the other hand, there will likely be more advanced tools that will be able to handle the complex models and optimization problems that might occur. Transportation researchers will be forced to develop solutions that can benefit from enabling technologies and coordination of activities and resources.

6.3 Threats

There are many potential threats to be found, not only regarding the development of RFID but also other identification technologies. Considerable efforts have to be made for companies to find a mutual understanding of how to share information and the way it is to be done. The survey shows that there are many small and medium sized companies that do not share the same visions as the large ones. Even if they are prepared to invest in technologies that might improve their competitive advantage, they do not always have the capacity to do so. Many shippers will probably react negatively to increased demands on information sharing which makes the transition even more difficult to achieve.

There are also many obstacles in the identification technology itself. RFID requires an underlying information infrastructure and support from the involved information systems. It requires global standards and equipment that can be used by companies in various business areas under different environmental conditions to a reasonable cost. Readability of tags is another issue that has to be improved. So far, tests have shown that the readability is lower than expected. It has proven very hard to obtain full readability on products containing water or metal due to the physical properties of the material. There are also significant problems that have to be solved regarding the standards and the standardization of tags and readers, standards that currently differs depending on country, supplier and technology.

7 Conclusions and further research

Using a foliated transportation network requires both the exact amounts and characteristics of the goods to be known in advance, before the pickup is scheduled and carried out. This information must be shared between the shipper, the LSP and preferably also the recipient. To realize the expected efficiency and flexibility in FTL, traceability of goods and resources is necessary. Thus, logistics information and planning systems have a significant role, not only for the optimization of the network but most importantly as a way to handle the goods-specific data needed to make the goods-handling process more efficient.

To facilitate the identification process and to increase the handling efficiency in consolidating and sorting of goods at the terminals, it is necessary for the goods to be easily identifiable.

Using automatic identification systems for identification and traceability, combined with innovative information systems, provides an opportunity to make transportation networks more efficient.

Due to the current development in identification technology, there are still many issues to be solved, of which, some are discussed in the paper and some still to be discovered. Therefore, the intention with this paper is both to attract further attention to the topic as well as an increased understanding of the future possibilities in transportation related information systems. A research project has been

8 References

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