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Efficient tracking for short-term multi-company networks

Mikko Kärkkäinen, Timo Ala-Risku and Kary Främling
Department of Industrial Engineering and Management, Helsinki University of Technology, Helsinki, Finland

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Abstract *Tracking of shipments is an important element of customer service in the transportation industry; and essential for logistics services as merge-in-transit. However, contemporary tracking systems are designed for use within a single company, and are thus invariably inadequate for multi-company environments. The single company focus has led to a reduced span of monitoring and a diluted accessibility of information due to proprietary tracking codes and information architectures centred on the tracking service provider. This paper presents a novel forwarder-independent approach for solving the difficulties of tracking in multi-company supply networks. The research argues that the proposed tracking approach is superior to contemporary approaches for material flow tracking in short-term multi-company distribution networks.*

1. Introduction

Tracking of shipments and conveying the tracking information to customers are perceived to be important customer service components and they are often considered industry norms rather than a potential competitive advantage for logistics service providers (LSPs) (Day, 1991; Janah and Wilder, 1997; Williams and Tao, 1998). Major forwarders and LSPs continuously invest considerable sums in providing tracking services to their customers (Booker, 1999; Coia, 2001; King, 1999; Tausz, 1994). Recently, independent tracking service providers, such as Savi Technologies and EURO-LOG, emerged solely for this purpose (Dierkx, 2000; Lambright, 2002; Loebbecke and Powell, 1998). These developments underline the importance of customers being able to locate shipments in-transit, hence they plan and monitor their operations.

However, traditional tracking approaches do not suit multi-company networks (Huvio *et al.*, 2002; Töyrylä, 1999). Contemporary tracking systems are only useful when goods are handled by one company. Such systems utilise service provider-specific coding for consignments and thus increase the complexity of retrieving tracking information for customers using multiple providers. Generally, the service providers make tracking information available via a Web page, resulting in manual interrogation for customers. The automated alternative is the integrating of the tracking systems to the operating systems of the customer company. However, this is time-consuming and often cumbersome. Moreover, integrating with the tracking systems of the logistics service providers, potentially ties the customers to the providers (Janah and Wilder, 1997). A key failing is also in the lack of LSPs or independent tracking service providers to offer checkpoint networks that are truly

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global in their span of monitoring. Thus, comprehensive tracking is not available for many international businesses.

The aim of this paper is twofold: first, to analyse and present the shortcomings of traditional tracking systems in short-term multi-company networks and, second, to present a new approach for constructing solutions for tracking in multi-company networks.

The remainder of the paper is organised as follows. In Section 2, current literature on shipment tracking is reviewed. The research problem and design are presented in the Section 3. In Section 4, a novel approach for developing tracking systems entitled "forwarder independent tracking", a proof of concept system and its application to an industrial pilot situation, are presented. In Section 5, the implications of the work are discussed, concluding remarks are offered and future research directions are drawn.

2. Literature review

This section begins with the definitions of shipment tracking, the issues making tracking important in logistics and the basic functionality of tracking systems. Then, currently used tracking systems are reviewed, and their most important characteristics, along with the difficulties they impose on multi-company networks, are discussed.

2.1 Definitions of tracking

Regardless of its operational relevance and importance, a clear definition of tracking cannot be found in the logistics literature (van Dorp, 2002; Stefansson and Tilanus, 2001). In particular, tracking has invariably been associated with tracing, to form the commonly adopted concept of *tracking and tracing* (van Hoek, 2002; Huvio *et al.*, 2002). However, the authors argue that it would be more informative to consider tracking and tracing as two different applications. The separation is also presented by van Dorp (2002), where tracking signifies the gathering and management of information related to the current location of products or delivery items, whereas tracing relates to storing and retaining the manufacturing and distribution history of products and components. This segregation is also supported by Jansen (1998) and Töyrylä (1999).

This paper focuses on tracking, its operational significance and the difficulties in utilising current tracking systems in multi-company networks.

2.2 The benefits of tracking systems

Consignment tracking is perceived to be an extremely relevant service in the transportation industry and is thus demanded by most customers (Day, 1991; Janah and Wilder, 1997; Loebbecke and Powell, 1998; Willesdorf, 1991; Williams and Tao, 1998). Also, the accessibility of delivery status at any time and the immediate notification of delays or other delivery problems are regarded as basic information needs in the logistics chain (Loebbecke and Powell, 1998). There are two main reasons for the importance of tracking shipments.

First, tracking systems are needed because they are the link between the information systems and the physical reality (the material flow) in the supply network (Stefansson and Tilanus, 2001). Without tracking systems linking the information systems and the physical material flow, efficient co-ordination of logistic flows would be difficult to achieve (Harris, 1999). Thus, many logistics services; for example, multi-modal transport and merge-in-transit; would be extremely difficult to produce without tracking systems

(Ala-Risku *et al.*, 2003; Giannopoulos, 2003; Kärkkäinen *et al.*, 2003b; McLeod, 1999; Samuelsson *et al.*, 2002). By linking the status of the consignments to other information in the information systems, tracking also enables detecting and reacting to unexpected events, so that they can be resolved before they cause significant problems; or, at the very least, the damage can be minimised (Kärkkäinen *et al.*, 2003c; Stefansson and Tilanus, 2001; Willesdorf, 1991). That is why tracking was seen as a key service component for the transportation industry to meet the requirements of manufacturing when adopting just-in-time operations (Garstone, 1995).

Second, tracking systems can be used for administrative purposes to help in introducing paperless and less paper systems, which improve information accuracy and help to reduce waste. They can, for example, serve as basis for automated payments to haulers. Furthermore, the data collection can provide important and relevant input into a management information system to help find out where costs are incurred as well as where profits are made and to verify if the quality of the process remains acceptable (Florence and Queree, 1993; Stefansson and Tilanus, 2001).

2.3 Basic functionality of tracking systems

The basic functionality of tracking systems is that when a tracked item (i.e. shipment) arrives at a predefined point in the distribution network (a checkpoint) the arrival is registered and a message regarding the arrival is sent to a tracking database (Kärkkäinen *et al.*, 2003c; Loebbecke and Powell, 1998; Stefansson and Tilanus, 2001; Tausz, 1994). The message may contain only three basic attributes: the identity of the entity at the checkpoint, the location of the checkpoint, and the time of the arrival of the entity (Stefansson and Tilanus, 2001). However, additional attributes concerning the consignment may also be recorded, e.g. quality, in the case of perishables.

The most common method of registering the pass of a checkpoint is to use some automatic identification technology to read a code from the tracked consignment, but some tracking systems are based on warehouse transactions or logistics documents related to, for example, customs clearing (Loebbecke and Powell, 1998; Shah, 2001; Stefansson and Tilanus, 2001). In some rare instances, an entity is continuously tracked in the supply network (for example, GPS location of a truck or a marine container). However, since the continuously tracked entity is usually a transport instrument containing several consignments, it can, from a tracking system perspective, be regarded as a moving checkpoint (Anon, 1996; Bodamer, 2002). The last location (and the time of pass) of the tracked item can then be interrogated from the tracking database.

2.4 Tracking in multi-company networks

The functionality and scope of tracking systems need new horizons as the focus of logistics management has turned solely inside from one enterprise to supply chains and networks. Owing to the cross-company nature of supply network processes, different parties of the supply network need to liaise and cooperate in determining the requirements for tracking systems (van Dorp, 2002).

For tracking systems to be applicable in an inter-organisational setting, the parties using the system need to agree on six key issues:

(1) the operational scope of the system;

(2) the goods identification technology used;

(3) the coding of the tracked items;
(4) the content of the exchanged tracking information;
(5) the information architecture used in the tracking application; and
(6) the ways of accessing the tracking information (drawn from van Dorp (2002), Giannopoulos (2003) and Stefansson and Tilanus (2001)).

These will be reviewed in more detail in the following subsection.

2.5 Key features of tracking systems

The most important issue of tracking systems in multi-company networks is the operational scope of the system (van Dorp, 2002). The operational scope refers to the span and range for gathering the tracking information, i.e. the tracking information gathered only from goods handled by a single company (an LSP), or several companies (both LSPs and customers) in the same supply network are able to provide tracking information to the system. The main practices in current systems are:

- the system is operated by one logistics service provider;
- the system is operated by an independent tracking service provider (therefore it can be utilised while the goods are handled by different LSPs); and
- the system can be operated by several different companies that use some specific workstations or software in the checkpoints.

At each checkpoint of the tracking system, equipment is required for reading the identifiers. Therefore, the identification technologies utilised in the tracking system have to be agreed on (van Dorp, 2002; Stefansson and Tilanus, 2001). There may also be an agreement to utilise several technologies (e.g. manually read tracking codes, bar coding, and radio frequency identification) within one tracking system. However, it is imperative that the tracked item can be identified at all checkpoints.

The tracking information of a consignment is gathered using specific identities (i.e. tracking codes) for the tracked items (van Dorp, 2002). The reporting of the tracking information is usually based primarily on these codes. The identities can be service provider specific or delivery numbers/codes, customer order numbers, or other codes specified by the customer.

Tracking systems can also differ in the information content of their tracking messages. As stated earlier, a tracking system may record only the identity of the tracked item, the location of the checkpoint, the arrival time of the item, or combine these pieces of information with additional attributes (Stefansson and Tilanus, 2001). The transmittal of additional information can be a relatively simple and valuable means to gain feedback information from the supply network. For example, if the quality of the consignment has suffered during transportation (observable damage or improper temperature conditions) then appropriate action can be taken.

The information architecture of a tracking system is important, as it greatly influences the ways of building accessibility to the tracking information. There are two basic possibilities for information architecture in tracking systems (applied from Stefansson and Tilanus (2001)):

(1) The tracking system can send the tracking information to each party in the transport chain, which stores the tracking data in its own information system.

Such information systems can contain both tracking information that is received directly from the company's own operations and information brought from a tracking system by another network party.

(2) The tracking information is gathered to a central information system containing all the data. Other network members can obtain tracking information from there by manual information requests (by telephone or over a www-connection), or retrieve the information to their systems by the means of systems integration or system-to-system messaging. This central system is usually operated by the provider of the tracking service, but it could also be operated by a specific third-party IT provider, or a powerful supply network participant.

When considering the accessibility of the information, it is typically most convenient for a company to have the tracking information in its own systems, as it can then be compared to other information (such as planned delivery dates or project construction schedules). Another convenient alternative is to have the information accessible through automatically-performed queries, which demand configuring EDI or XML message interfaces with the central tracking system. Manually performed queries (be they telephone or www-based queries) do not enable automatic follow-up of the deliveries, they are costly and error-prone, yet can be used without any set-up costs. When automated data transfer methods are used, it must be ensured that the system receiving the tracking information understands at least all the basic pieces of tracking information: what the tracked item is, which location the item has reached, and what the time of pass is.

2.6 Review of current tracking systems

A selection of current tracking systems classified with the above criteria, is presented in Table I. The information for systems 1 to 3 was drawn from Stefansson and Tilanus (2001). The information on system 4 is derived from FedEx (2003), Janah and Wilder (1997) and Shah (2001), and system 5 is presented in Loebbecke and Powell (1998). Information on system 6 is gathered from Dierkx (2000), Lambright (2002), and Savi Technology (2002). Finally, information on systems 7 to 9 were gathered in semi-structured interviews with representatives of tracking system operators. For system 7, the director of business development (Kullström, 2003), for system 8 a development manager (Sundelin, 2003), and for system 9 the business development manager and managing director (Mäkinen and Mäkinen, 2003) were interviewed.

Some general characteristics of current tracking systems can be lined out from Table I:

- Most systems operate only within the boundaries of a single company (LSP);
- The predominant choice of identification technology is bar coding;
- The systems utilise mostly proprietary tracking numbers defined by the company operating system, and are based on information architecture where the tracking information is centralised to the provider of the tracking service;
- The basic methods for the customer to access the tracking information are to use manual queries (using a www-site or telephone), or to engage in developing systems interfaces or integrating with the tracking system.

Table I.
Summary of a review of current tracking systems

	Operational scope of system	Identification technology	Item coding	Information content	Information architecture	Accessibility of information
International road haulier (Scansped)	The LSP operates the system	Manual	Proprietary tracking number	Manual data handling, therefore flexible content	Report sheets of specific shipments that are tracked are faxed to central administration	Manually constructed reports from tracked deliveries
International shipping agent (Wilson)	Documents from carriers are used for tracking	This system reacts to documents generated in the delivery chain	Proprietary tracking number	Basic tracking attributes	Centralised at service provider	www-query or EDI link
Express parcel service (DHL)	The LSP operates the system	Bar code	Proprietary tracking number	Basic tracking attributes	Centralised to the LSP	Telephone and www-query, or EDI or systems integration
Express parcel service (FedEx)	The LSP operates the system	Bar code	Proprietary tracking number, alternative references possible	Basic attributes, supplementary information possible	Centralised to the LSP	www-query or systems integration
Tracking service provider (TRANSPO-TRACK)	The system can be operated by different companies if they install a proprietary checkpoint PC in their premises	Bar code	Proprietary tracking number	Basic attributes, supplementary information possible	Centralised to the tracking service provider	Systems workstations at the customers' premises

(*continued*)

	Operational scope of system	Identification technology	Item coding	Information content	Information architecture	Accessibility of information
Tracking service provider (Savi Technologies)	The tracking service provider operates the system	Several different technologies (e.g. bar code and RFID)	Proprietary conveyance tracking numbers	Basic attributes, supplementary information possible	Centralised to the tracking service provider	www-query, systems workstations, XML messages, or systems integration
International road haulier (Schenker)	The LSP operates the system	Bar code	Proprietary delivery number	Basic attributes, supplementary information possible	Centralised to the LSP	www-query
National parcel service (Finnish Postal Service)	The LSP operates the system	Bar code	Proprietary tracking number	Basic tracking attributes	Centralised to the LSP	www-query
National car transport provider (SE-Mäkinen)	The LSP operates the system	The checks are reported manually through on-board computers (large distribution units, i.e. cars)	Manufacturer allocated vehicle serial number, alternative references possible	Basic attributes, supplementary information possible	Centralised to the LSP	www-query or file transfer

Table I.

2.7 Difficulties of utilising current tracking systems in short-term supply networks

As can be seen from the review of current tracking systems, the customer companies of LSPs or tracking service providers, usually have two possibilities for accessing the tracking information: either using manual queries or integrating their information systems with the tracking system. Both approaches present significant problems for companies operating in short-term multi-company networks.

Manual information access provides only limited functionality and is time-consuming. In www-based queries, one can retrieve and interrogate the tracking information of a consignment by giving tracking and authorisation codes on a LSPs Web page. However, it is not a feasible option if there is a significant number of shipments that need to be tracked, owing to the costs and error-prone nature of manual work. Manual queries do not work; for example, in international investment project deliveries, as there are several thousands of project components that need to be monitored (Halmepuro and Nystén, 2003).

Systems integration is also not a viable option in large, short-term supply networks, such as networks delivering mechanical engineering industry investment projects. A great number of suppliers and the global nature of business invariably mean that several LSPs are participating in the delivery of an investment project. The networks are also short-term in project-oriented industries, as the partners change from project to project. Thus, it is usually unfeasible for the customers of the LSPs to engage in business-to-business application integration to get the tracking information automatically. Integrating with all the relevant tracking systems would consume vast amounts of time and IT resources (Linthicum, 2001; Wilde, 1997). Also, it would be difficult to recover a viable payback for the investment during the lifetime of the supply network. Therefore, companies operating in short-term supply-networks are often reluctant to invest in systems integration (Cheng *et al.*, 2001).

Owing to the misfit of manual queries and systems integration as methods for information access, it can be argued that existing solutions are not always directly applicable for tracking in flexible term multi-company networks. For example, the tracking of mechanical engineering industry project deliveries is currently based primarily on manual monitoring and visual inspection at the site, because the existing systems poorly fit the industry (Halmepuro and Nystén, 2003).

3. Research problem and design

Based on observations of the operational problems encountered in companies, the authors undertook a literature review concerning tracking systems for multi-company networks. Consequently, a gap in the body of knowledge was identified, and the following research problem was formulated: "How to construct tracking systems applicable to short-term multi-company networks?".

3.1 Research design

The Council of Logistics Management (2003) has defined logistics as that part of the supply chain process that plans, implements, controls the efficient, effective forward and reverse flow and storage of goods, services, and related information between the point of origin and the point of consumption, in order to meet customers' requirements. Thus, logistics clearly belongs to the field of applied research, which is defined as the pursuit of knowledge with the aim of obtaining a specific goal, i.e. knowledge that has the specific purpose of increasing the effectiveness of some human activity (Niiniluoto, 1993). Therefore, the results of logistics research should be judged not only based on their correctness, informativeness, and truthlikeness, but also on their practical relevance (Benbasat and Zmud, 1999; Kasanen *et al.*, 1993; Niiniluoto, 1993).

The research reported in this paper has aimed at developing new knowledge and a new operating model for shipment tracking following the paradigm of "innovation action research", a research approach presented by Kaplan (1998). Innovation action research aims at giving researchers a structure that can be used to develop a new solution that alters existing practice and tests the feasibility and properties of the innovation (Kaplan, 1998). The flow of research in innovation action research is to initially document major limitations in contemporary practice, identify a new concept to overcome the limitation, and to continually apply and improve the concept through publication, teaching and active intervention in companies. Kaplan (1998) specifically emphasises that installations of the proposed solution model are needed for the researchers to more deeply understand the problem and all the practical issues in it. As case studies are the main method for collecting empirical data in innovation action research, the approach is in line with Dean *et al.* (1992) and Meredith (1998).

Similar research approaches have been also proposed in other fields. The research process of innovation action research resembles closely the "constructive approach" that Kasanen *et al.* (1993) have utilised in management accounting research. On the Information Systems research side, Benbasat and Zmud (1999) are on the same lines with innovation action research in research problem identification. They recommend researchers to look to practice to identify research topics and to look to the literature only after commitment has been made to a specific topic.

This research on tracking systems for short-term multi-company supply networks has followed the guidelines of innovation action research and has proceeded chronologically as follows:

Summer 2001. The authors realized the difficulties of managing project deliveries and the difficulties in tracking shipments in short-term multi-company networks after discussions with a group of project-oriented companies operating in the mechanical engineering industry. These findings were reported in Kärkkäinen *et al.* (2003c).

Fall 2001. The operating principles of current tracking systems were studied in an extensive literature review; and a technical solution for tracking in multi-company networks was developed in co-operation with companies from project-oriented mechanical engineering industry. The first specification of the system was published in Främling (2002).

Spring 2002. Pilot installation of the solution was performed with an original equipment manufacturer (OEM) delivering sub-solutions to heavy industry investment projects, and its subcontractor to validate the tracking approach. The company for the pilot was selected based on two main rationales:

(1) It operates in an industry where the difficulties of current tracking systems are well represented.

(2) It possessed an in-house tracking system that could be extended to process and display tracking information received also from external check-points. The principal information-gathering methods in the pilot implementation were active involvement, observation, and constant contact with key personnel of the OEM company and its subcontractor. Additionally, interviews with

management personnel who were not directly involved in the installation were conducted. Triangulation or other means of data validation were not used, as the aim of the case was to act as a proof-of-concept for the tracking approach, not to provide empirical data on company operations.

Fall 2002-Spring 2003. A conceptual model of a new tracking approach for short-term multi-company networks was developed. The pilot installation greatly increased the authors' knowledge on the most essential factors of building tracking solutions for short-term multi-company supply networks. Thereafter, the "draft approach" was presented to the representatives of different organisations in heavy engineering supply networks to refine it. Representatives of a project co-ordinator company, a logistics service provider, an end customer, and an established business application vendor, were consulted.

Fall 2003. A supplementing review on tracking-related logistics literature and current tracking systems were performed to ground the proposed tracking approach to the current body of knowledge on tracking. The forwarder independent tracking approach in its current, most developed state and its relation to predominant tracking systems is presented in this paper.

4. Forwarder independent tracking: a potential solution

Forwarder independent tracking (FIT) is a tracking approach that can help solve the difficulties of tracking deliveries in multi-company supply networks. In the first part of this section the basic features of FIT are described, a demonstration application complying with the FIT approach is presented in the second part, and an industrial pilot implementation of the system is reviewed in the final part.

4.1 Basic principles of forwarder independent tracking

The aim of FIT is to produce and disseminate reliable tracking data from deliveries that are handled in multi-company distribution networks. FIT systems should enable tracking data to be gathered independent of the company handling the goods, with the resulting location information being readily available to the systems of all those companies requiring it.

During the research process, it was identified that the combination of distributed programming and peer-to-peer information sharing allowed a developing of a new kind of solution to the problems experienced with current tracking systems in a multi-company setting. The problem of acquiring tracking information outside company boundaries could be solved with lean software components by combining these two approaches.

For the solution to have universal application, it was imperative that any given company would be able to receive tracking information concerning their own shipments regardless of the LSPs used. Another pre-requisite for the solution was the possibility of disseminating the tracking information to a project co-ordinator or to a forwarder responsible for the total delivery of the project. This means that any LSP should be able to offer the tracking information automatically to any of its customers, or their customers' customers.

Each shipment should therefore be able to provide two pieces of information:

(1) "which shipment am I?"; and

(2) "who is interested in me?".

So, in the FIT approach, each shipment is given an identification code that reveals both the identity of the shipment, and directly tells where the tracking information should be sent. These pieces of information enable an LSP to gather and spread tracking data. The information system receiving the tracking message also must be able to identify the location the tracked entity has reached, and the time of arrival.

The basic requirements for a FIT system are summarised in Table II.

In FIT, the tracking information can be gathered from both new checkpoints that are installed in the handling locations and the existing tracking systems of the LSP. The conceptual idea of FIT systems is illustrated in Figure 1.

The practical requirements for incorporating a new LSP to the FIT system differ, depending on whether an LSP has an extensive tracking system or not (cf. LSP 2 and LSP 3 in Figure 2) and the life-span of the distribution network.

As new checkpoints are often installed in the distribution network, the checkpoint solutions of FIT systems should be relatively easy to distribute and be quick to install. One solution, fulfilling the distribution requirements, is a file downloadable from the Internet. The installation time for appropriate components should be short even for the less experienced personnel. These kinds of lightweight checkpoints enable a scalable tracking network to be adjusted according to transforming distribution requirements.

LSP currently operating their own tracking systems should not install new checkpoints always. The alternative solution is to re-direct information generated by their tracking systems to the interested party with an integrating middleware component of a FIT system. In such cases, the compatibility of data formats of tracking messages with the recipient's information systems must be ensured, as is always the case when integrating information systems. The integration efforts are justified when continuous high volume business can be expected between the partners.

The aim of the FIT approach is to utilise existing solutions and provide means for efficient tracking in supply networks crossing the boundaries of several traditional tracking systems. Therefore, it is radically different from traditional proprietary approaches.

4.2 The demonstration system

To assess the practical feasibility of the FIT approach, a demonstration system complying with the prescribed guidelines was developed.

As discussed in the previous section, the tracking codes in forwarder independent applications need to incorporate two distinct pieces of information: the identity of the shipment and the identity of the recipient of the tracking information. In the demonstration solution, the notation ID@URI was used. In this notation the ID stands for an identity code of the consignment, and URI stands for the uniform resource identifier (i.e. Internet address) of the computer to which the tracking messages should be sent. Because all URIs are unique by their definition, the ID parts of codes connected to different URIs can be identical without problems of dual codes. This gives the owner of the URI the freedom to define their ID-coding scheme, without the need of co-ordinating the efforts between different parties creating codes. Therefore, ID@URI-coding enables building multi-company applications without the need for standardising and allocating codes for shipments (Kärkkäinen *et al.*, 2003a).

In some situations, the ID@URI may not be used as the only identification code for the tracked product. Existing project management systems usually identify deliveries

Table II.
The basic requirements of a forwarder independent tracking system

	Operational scope of the system	Identification technology	Item coding	Information content	Information architecture	Accessibility of information
Forwarder independent tracking -systems	The system can be easily operable by all LSPs even in short-term networks	Should support several technologies	Identifies the item and the recipient of the information	Basic attributes, preferably possibility for supplementary information	Can in principle be centralised to service provider or distributed to the users of the tracking data	The data should be directly available on the systems of the parties needing the tracking data

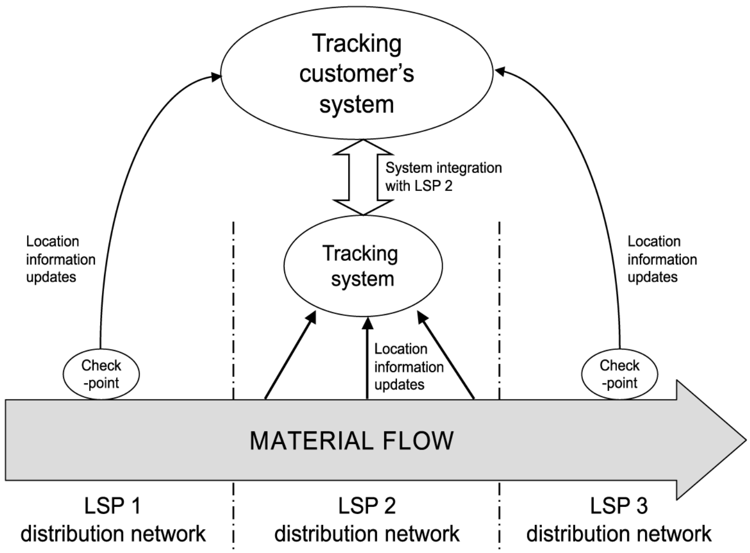

Figure 1. The operating model of forwarder independent tracking systems

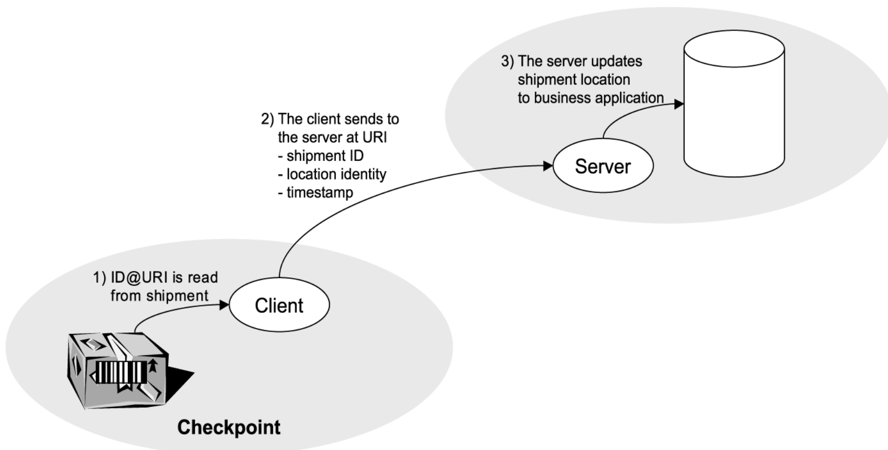

Figure 2. The functionality of the demonstration system

in their own way; for instance, by project and item number. Therefore, to ease the use of the system in the operations of several companies, the system incorporates a functionality of mapping the ID@URI codes to company internal codes. This enables using the system with the current internal coding in a company.

The application was developed around two software components. The first is a client agent, which is needed in each checkpoint where shipments are tracked. The second component is a server agent residing at the computer specified by the URI-part of the identity. It receives tracking messages from the client agents and forwards the tracking information to the in-house tracking system of the company.

The basic operational principle of the system is that when a delivery arrives at a checkpoint, its tracking code is read to the client component. The client then communicates the identity of the checkpoint, the tracking code of the consignment and the time of the reading operation to the server. The server compares the tracking code to the shipment identity used in the in-house tracking system of the case company, and subsequently up-dates the information in the tracking system. Figure 2 illustrates the functionality of the demonstration system.

These client and server components are *lean* (123 and 39 KB, respectively), quick to install, and platform-independent, as they are programmed using Java programming language. Both the leanness and quick installation are important for effective FIT solutions. Leanness is important, as it enables distributing the components efficiently via the Internet. The components can be downloaded via the Internet (even over a GSM-data connection), or distributed as e-mail attachments. The installation of the components typically takes only a few minutes, which enables efficient set-up of the system; and, thus, allows using the system for temporary distribution networks. Platform independence of Java-based components helps to keep the system accessible to all companies in the distribution network.

The recipient's information system can identify the tracked shipment based on its ID@URI code. Separate measures have to be taken to identify the location of the checkpoints. Two different approaches can be used to manage the checkpoint identities:

(1) The recipient of the information manages the identities when it organises the distribution of the checkpoint software. The software can be distributed with the identities via e-mail, or when using www-downloads it can be arranged that the checkpoint personnel have to register the identity and location of the checkpoint when downloading the software. However, this leads to several overlapping proprietary tracking networks when several companies wish to track their shipments in the same location. Although the leanness of the software makes it possible to operate several tracking networks with different software components at a single checkpoint, it demands extra operative effort at the checkpoint.

(2) The checkpoints have globally unique identities based on a standardised notation. The authors propose a notation of the form LocationID@URI for the checkpoint location identities. The location ID is the identity of an individual checkpoint, and the company operating the checkpoint allocates it. The URI is the Internet address of the operator's server containing exact information (e.g. postal address, operating hours, handling equipment) on the individual checkpoints. This enables the system to remain scalable, as all checkpoint identities are globally unique, and companies operating the checkpoints can use the same software components with all their customers.

When using the LocationID@URI notation, the management of information related to checkpoint identities can be implemented with the demonstration system, as the clients can be used also for retrieving information from databases connected to a server component. The practical solution requires that a company operating checkpoints in the tracking network stores the checkpoint identities and the related information on a database table, and installs a server component connected to the database. The companies receiving tracking information can then use a client component to query the database for information regarding specific checkpoint identities (Kärkkäinen *et al.*, 2003a).

The format of the timestamp has been solved in a trivial manner. The server component takes a Java Database (JDBC) connection to the database in which the tracking information is stored, and inserts the information with a standard SQL insert. Therefore, the timestamp generated by the client takes the format used in the tracking database when inserted there.

The demonstration system in itself does not depend on the identification technology used on the tracked consignments. The system can be used with all available techniques for automatic identification if the technology supports the ID@URI notation. In practice, drivers for bar code and radio frequency identification (RFID) readers have been installed, and the system also supports manual data input if no automated means are available.

The key factors of the demonstration system are summarised in Table III.

4.3 The pilot implementation of the system

To further test the practical applicability of the FIT, an industrial pilot installation with the demonstration system was undertaken. The pilot was performed with an OEM delivering sub-solutions to heavy industry investment projects, and its subcontractor. The OEM is one of the leading global suppliers in its product segment.

The company had an in-house tracking system, which was able to track deliveries while they are under its own control. However, it was almost impossible to receive tracking information from subcontractors participating in the delivery, or while the project components were in transportation. FIT was seen as a potential answer to these challenges.

The pilot implementation consisted of two checkpoints in which the delivery was tracked. The first checkpoint was at the packaging department of a subcontractor, located in the same country as the tracking server, but in a town about 200 km away. The second checkpoint was the project construction site. The existing personnel performed the tracking-related activities.

Owing to the risk of dirt and wearing of bar codes present in the mechanical engineering industry supply chain, the case company used RFID technology for identifying the deliveries regardless of the associated costs. In the pilot implementation, the tag's pre-programmed identity was used as the consignment identity owing to the limited amount of programmable memory space in low cost tags, and the URI of the server component was inserted to the programmable information field of the tag.

The pilot installation provided positive feedback. The installation of the components proved efficient, and the system operated to specification. No discrepancies were encountered during the one-month time span of the pilot. Also, the personnel involved had no significant difficulties when using the system.

The case company considered that the system was very efficient, and it decided to use the FIT in the future. The development and maintenance of the system at the case company has since been transferred to a commercial software vendor, and it has since been used in an intercontinental project delivery during 2002 (ISI Industry Software, 2003; Peltonen, 2002).

Table III.
The key factors of the demonstration system

	Operational scope of the system	Identification technology	Item coding	Information content	Information architecture	Accessibility of information
The FIT demonstration system	Any company that downloads the client over the Internet can use the system	Bar code, RFID and manual data input supported currently	ID@URI code specified by the user of information	Basic+free text (condition)	Distributed to the users of the tracking data	Data resides in the systems of the companies requiring the data

5. Conclusions

The aim of this paper was to analyse and present the shortcomings of traditional tracking systems in multi-company environments and to present a new approach for solving the difficulties experienced with predominant systems. To meet these objectives, the authors have undertaken a literature survey, conducted interviews with current tracking service providers and their customers, and built and piloted a tracking system constructed following prescriptions to overcome the shortcomings of current tracking systems in short-term multi-company networks.

The paper makes two distinct contributions to current logistics literature. First, it lines out the issues making predominant, proprietary, tracking approaches unfeasible for short-term multi-company supply networks. Second, it presents an approach that can be used to gather and convey tracking information in these difficult logistics environments.

The design of predominant tracking systems is rather uniform. This might result from the fact that tracking was long perceived as simple in theory, but, surprisingly difficult to implement in practise (Bingham and Perzzini, 1990). Following one company's (FedEx) development of a functioning approach to the implementation of tracking systems, it was more efficient to build similar solutions (Janah and Wilder, 1997; Tausz, 1994). However, the predominant systems force companies to invest in systems integration with the operators of the tracking systems or to rely on manual queries to access the information. Neither approach is feasible when monitoring a magnitude of shipments while operating with several short-term relations.

Based on an industrial pilot implementation and discussions with other supply network participants, the authors conclude that the proposed approach is suitable for tracking shipments in short-term multi-company distribution networks. A new tracking approach is valuable for such environments, as contemporary applications are unfeasible, and significant operational benefits were expected from comprehensive tracking information by representatives of an end-customer and project co-ordinator, as well as subcontractor and OEM companies' personnel (Halmepuro and Nystén, 2003; ISI Industry Software, 2003; Kylliäinen, 2003; Peltonen, 2002). However, the authors acknowledge that the approach still needs further empirical research and application to validate or refute its perceived benefits. Therefore, everyone is kindly urged to test (and challenge) the hypothesised benefits. The software components and their specifications are downloadable at: http://dialog.hut.fi

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