Tracking based material flow transparency for small and medium sized enterprises

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Abstract: Efficient supply chain management demands transparency for inventory and deliveries along the whole supply network. However, the information technology solutions enabling transparency are expensive and intricate to install and few small and medium sized enterprises have adopted their use. This paper identifies the distinct difficulties small and medium sized enterprises experience with the prevalent solutions for material flow transparency. A lean, tracking based approach is proposed that enables integration of small and medium sized enterprises within multi-company supply networks. The technical feasibility and applicability of the proposed approach are discussed on the basis of data gathered in two pilot installations and three case studies.

Keywords: Logistics, Supply chain, Small and medium sized companies (SMEs), Transparency, Visibility, Tracking

1 Introduction

In the present day business landscape, companies should not be considered independent entities, but as parts of multi–company, multi-echelon networks, i.e. supply chains, delivering goods and services to the final customer (Christopher, 1992; Lambert and Cooper, 2000). Supply chain management theory claims that controlling these multi-company networks integrally can provide significant benefits (Cooper et al., 1997; Burgess, 1998; Magretta, 1998; de Leeuw et al., 1999; Mason-Jones and Towill, 1999; Mentzer et al., 2001; Norek and Pohlen, 2001). Material flow transparency, specifically the visibility to inventories and deliveries in the whole supply network, is considered an imperative requirement for successful supply chain management, and has been associated with significant supply chain

efficiency improvements (Ballard, 1996; Clarke, 1998; Gunasekaran and Ngai, 2004; Lee and Billington, 1992; White and Pearson, 2001).

However, small and medium sized companies (SMEs) have, for the most part, remained outside these advanced, integrated supply networks. This is because the information technology (IT) solutions enabling transparency in supply chains are expensive and intricate to install, and the available off-the-shelf solutions demand sophisticated internal systems (Stefansson, 2002). Thus, often SMEs do not have the necessary resources for their implementation, and as they usually operate with lean systems they can not in most cases wholly benefit from efficiency improvements (Eagan et al., 2003; Morrell and Ezingeard, 2002; Stefansson, 2002). Therefore, it is not surprising that SMEs have implemented these solutions only on a very limited scale (Jackson and Sloane, 2003; Levy et al., 2002; Patterson et al., 2003; Stefansson, 2002).

The lack of investment can be detrimental for SMEs' competitiveness. For example, Closs and Savitskie (2003) state that firm success is strongly dependant on effective information sharing; and Kemppainen and Vepsäläinen (2003) regard inter-enterprise systems as prerequisites for success in the next decade. Consequently, by holding back investment in supply chain IT solutions, SMEs face the risk of permanently falling behind in the developments in supply network management (Stefansson, 2002). This is a notable threat even on the level of the European economy, since SMEs represent 99 per cent of all enterprises in the EU; and provide approximately 65 million jobs (EU, 2004).

The aim of this paper is to identify the difficulties small and medium sized enterprises experience with the currently prevalent solutions for building transparent multi-company supply networks. Furthermore, the paper presents a lean, tracking-based approach that can aid SMEs join multi-company supply networks without considerable investments.

The paper is organised as follows: in the second section we review previous literature on SME requirements for supply chain information technology adoption, and introduce the proposed tracking-based material flow transparency approach. In the third section the research design and data collection methods are explained. Based on material gathered in pilot installations and case studies, the fourth section presents results related to the technical

feasibility of the proposed approach and its suitability SMEs, and discusses its area of applicability. Conclusions are presented in the final section of the paper.

2 Literature review

2.1 The criteria for SME compatible transparency solutions

Few SMEs, regardless of their desire for supply chain efficiency, have implemented supply chain transparency solutions. The body of literature discussing the implementation of supply chain information technology in SMEs is limited. However, the recognised importance of the topic is illustrated by the recent dates of the publications.

Four distinct reasons for the low adoption of current transparency solutions by the SMEs can be identified from the literature: the available options mostly involve high investments, presuppose sophisticated internal systems, require IT expertise, and are applicable for communicating only with a single partner. These reasons will be reviewed next in more detail.

Most current information technology solutions for enabling material flow transparency in multi-echelon supply chains require considerable investments. The motivation for the solutions is that the potential long-term savings offered by the solution will outweigh the investment needed for a tighter integration of the supply networks. However, the volume of business transactions between an SME and its business partner often falls short of justifying the IT investments aimed at facilitating that relationship (Morrell and Ezingeard, 2002; Stefansson, 2002). Also, the cost of the solutions is simply too high for many SMEs' investment capability (Stefansson, 2002). Therefore, transparency solutions suited for SME needs should not demand significant initial investment.

The current supply chain transparency solutions are mainly designed to appeal to significant market segments, without the need for extensive tailoring of the solution, and therefore only acknowledge mainstream enterprise software packages (Stefansson, 2002). However, SMEs mainly operate with legacy systems or low-end standard software packages (Morrell and Ezingeard, 2002), since the more advanced systems are most often too expensive and unnecessarily sophisticated for the needs of SMEs. Therefore, in order to use existing supply chain transparency solutions, SMEs have to abandon the efficiency benefits of integrated

systems by operating the solution manually (Morrell and Ezingeard, 2002); or face an additional investment of an internal information system that would support the data sharing system (Stefansson, 2002). The need for investment on internal systems invariably makes the total cost prohibitive (Stefansson, 2002). Thus, SME compliance should not demand sophisticated internal systems in order to function.

SMEs usually only have limited technical expertise and IT resources. In contrast, most transparency approaches demand significant expertise and resources for installation and maintenance. This misfit in the required and actual resources is widely stated as a significant root cause for SMEs lack of investment in supply chain transparency solutions (Eagan et al., 2003; Morrell and Ezingeard, 2002; Patterson et al., 2003; Stefansson, 2002). From an SME-viewpoint transparency solutions should consume as little as possible information technology oriented resources, both in implementation and maintenance, enabling the companies to cope without recruiting expensive specialist staff.

SMEs also usually invest in supply chain data sharing systems due to pressure of their large business partners (Eagan et al., 2003; Levy et al., 2002; Morrell and Ezingeard, 2002). Investing to a *specific* data sharing system with one business partner limits the systems flexibility of the SME; and other important partners may have incompatible integration requirements (Levy et al., 2002). This leads to potential additional integration investments, and also ties the company to the specific partners and increases the partnership opportunity costs of the company (McLaren et al., 2002). Thus, a typical SME with several important business partners would require solutions that could be utilized in several relationships.

Taking these challenges together, supply chain transparency solutions that are intended to reach SMEs should include the following characteristics:

- Low initial systems investment
- Applicability with legacy and low-end standard systems
- Lean implementation and maintenance, to minimise the requirements for IT specialist staff
- Scalability of the solution, to maximise the applicability of the investment

2.2 A tracking-based approach for supply chain transparency

Forwarder independent tracking

The proposed transparency approach is based on collecting shipment information with a forwarder independent tracking (FIT) system (Kärkkäinen et al., 2004). FIT is an approach for building tracking systems that was designed for use in short-term multi-company networks. A pilot system built according to the FIT guidelines is available at http://dialog.hut.fi. It consists of two types of easily installable software components: check-point clients and server components. The check-point clients are used to register the movements of material and inventory statuses in a supply network, and the server components receive information from the clients and pass it to business applications. (Kärkkäinen et al., 2004).

An important feature of the approach is the coding it uses for shipments. The coding must encompass two pieces of information: the identity of the shipment, and the address of the recipient of the information (Kärkkäinen et al., 2004). Främling (2002) has proposed the notation ID@URI for satisfying these requirements. In this notation the ID stands for an identity code of the consignment, and URI stands for the Internet address of the computer to which the information should be sent. This ensures that the system can be used with several partners and, also, that the uniqueness of tracking codes can be managed.

The basic guidelines of forwarder independent tracking are illustrated in Figure 1 (adapted from Kärkkäinen et al., 2004).

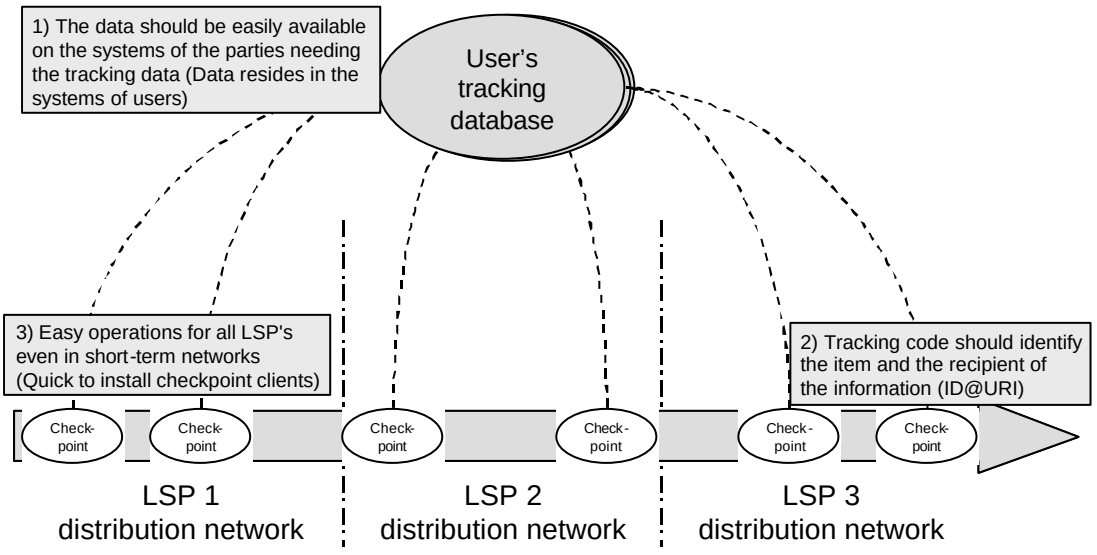

Figure 1 The basic guidelines of forwarder independent tracking

Establishing visibility to goods in transit

Since their development, shipment tracking systems have been utilised to generate transparency to consignments in transit (see e.g. Day, 1991; Loebbecke and Powell, 1998; Stefansson and Tilanus, 2001; Willesdorf, 1991). These systems traditionally gather information from shipments on the move by registering the arrival of shipments on predefined checkpoints of the system. The FIT approach is aimed at building a wide and scalable tracking network, as its checkpoints are quickly and easily installable on new locations without a need for any specific hardware, additional software, or systems integration in the checkpoint location (Kärkkäinen et al., 2004).

The proposed approach in building supply chain inventory transparency

When building inventory transparency with tracking systems, checkpoints that track all in- and out-going material of a warehouse or a specific inventory area need to be established. By interrogating the tracking database it is then possible to find out what shipments are currently in the inventory location (Ala-Risku and Kärkkäinen, 2004).

For establishing stock keeping unit (SKU) –level inventory transparency, information of the content of the shipments is also needed (Ala-Risku and Kärkkäinen, 2004). The inventory levels for each SKU can be calculated by counting the number of the SKU in each shipment in that storage location. Correspondingly, the inventory value for that location can be calculated by summing up the values of shipments residing in that location.

3 Research design and methods

While reviewing the difficulties SMEs experience with supply chain transparency solutions, we recognised a previously developed tracking-based transparency approach as a potential solution for overcoming the challenges SMEs had previously experienced. Therefore we set out to address the following research question: "How does the tracking based transparency approach meet the criteria for SME friendly IT solutions?" Furthermore, as with all solutions, the proposed approach is unlikely to be the most suitable solution for SMEs in all business environments. Therefore we posed a second research question: "How does operational environment affect the applicability of the proposed approach?"

The research reported in this paper was conducted following the paradigm of "Innovation Action Research (IAR)", which aims at giving researchers a structure that can be used to

develop new solutions that alter existing practice and to test the feasibility and properties of the innovations (Kaplan, 1998). The flow of research in innovation action research is to initially document major limitations in contemporary practices, identify a new concept to overcome the limitations, 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 deeply understand the problem and all the practical issues in it.

As suggested by the IAR framework, the technical feasibility of the proposed transparency approach has been validated in pilot implementations. The implementations of the approach were conducted with a tracking system constructed by Främling (for a more detailed description of the software see Främling, 2002; Kärkkäinen et al., 2003), which can be freely downloaded at http://dialog.hut.fi. The proposed approach was first tested for generating transparency for goods in transit in the mechanical engineering industry (see Kärkkäinen et al. (2004) for a detailed description of the pilot). Consequently, the functionality of creating supply chain inventory transparency with the tracking approach was tested in an additional pilot implementation. In this pilot, Främling's tracking system was used to create inventory transparency to six installation warehouses in a telecommunication network installation project. The warehouses did not previously have any warehouse or inventory management system. The pilot established proof that the approach can be used to establish inventory transparency, even to supply chain locations entirely lacking warehouse and inventory management systems.

To assess the applicability of the proposed transparency approach and its impacts on SMEs in different industries, we performed three case studies in different industries. The first case was conducted alongside the second pilot implementation. Case study data was collected from the pilot supply chain with active participation of the researchers in planning and executing the pilot, as well as several interviews with the participant organisations. This case is referred to later in the paper as the "telecom case".

To establish the implications of the proposed approach in different industries, two additional case studies were conducted: one in a furniture industry supply network including a large retailer and three SME suppliers (furniture case), and one in the mechanical engineering industry, including an equipment manufacturer, its SME supplier and a project contractor

(machinery case). These cases were selected in order to collect primary data from the consumer goods as well as industrial investment sector. As all case supply chains included both small and large companies they were ideal for the purposes of this research. The research steps and their motivation are illustrated in Figure 3.

The interviews used for data collection were semi-structured; in a typical interview session we first discussed the perception that the respondent's organisation had on material flow transparency, and the current pressures, possibilities and plans for building transparency. After this, we presented the proposed transparency approach, and the respondents were asked to describe their perception on its implications on their organisation and the supply chain, and compare it with their prevalent or planned transparency solutions.

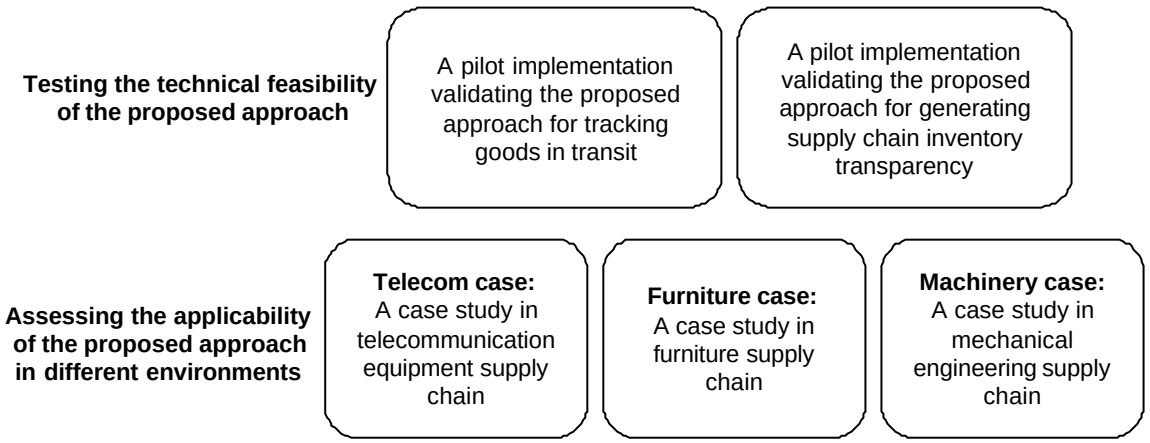

Figure 2 The research steps and their motivation

4 Results

In this section, we will first address the applicability of the proposed approach for SME companies, and then discuss the business environment characteristics affecting the applicability of the proposed approach. Both case study findings and pilot experiences are referred to in the discussion.

4.1 The suitability of the proposed approach for SMEs

We discuss the suitability of the proposed approach for SMEs by reviewing our research results with reference to the identified challenges of contemporary solutions: the investment requirements, demands for internal systems, installation and maintenance requirements, and scalability of the solution approach.

Investment requirement

The pilot installations revealed that the approach offers inventory transparency at a very low investment. At the lowest investment, only a computer with an Internet access is required for any location where transparency information is gathered. Additionally, a bar code reader can be used to automate the input of shipment tracking codes.

The low investment requirement was considered very important in the telecom case, as the distribution warehouses are temporary, i.e. they are utilised only for the duration of the installation project. This was also identified in the furniture case. Due to the low investment requirements, it was suggested that the approach could be utilised with selected suppliers in situations demanding increased inventory transparency, e.g. in product introduction, ramp-down, and promotion situations.

The SME interviewee in the machinery case considered low investment cost a beneficial aspect of the system, but noted that there were also other costs to be expected from the installation and subsequent use of any transparency system. He was also very sceptical of the possibility of gathering the generated customer value through higher price or direct charges, although the company has already been pressured to increase material flow transparency by one of its major suppliers.

Applicability with legacy systems and low end systems

The second pilot proved that the proposed approach can be utilised to generate inventory transparency also to locations without any previous systems, and can thus act as an inventory management system for the companies operating it. This was considered essential in the telecom case study as the projects are delivered through several locations, currently without any inventory or warehouse management systems, and by the contractor in the machinery case as project sites currently lack inventory management systems.

However, the pilot system's lack of integration to business applications can also be considered a potential downside of the system. As one interviewee in the furniture case reminded, without extra integration tasks the approach demands additional, potentially manual reading of labels from all packages entering and leaving inventory locations. In normal circumstances it does not usually take more than a few seconds to read a bar code label, but it certainly presents an extra step in the process. Linking the code reading to receipt

or dispatch functions in the enterprise system in use would ease the effort but also demand separate integration tasks.

Installation and maintenance effort

Transparency can be generated with the system with little maintenance and installation effort. This was well illustrated in the inventory transparency pilot, where the regular warehouse personnel after only two hours of training were able to install the checkpoints in minutes and operate them successfully as a part of their normal installation project processes through the ten month span of the pilot.

The low requirement for technical expertise was greatly appreciated in the telecom case, as the storage locations are dispersed geographically and the people operating the systems in practice have limited or no technical background.

In the furniture and machinery cases, low technical requirements were considered less of an issue. Personnel are trained to manage the existing internal systems, and personnel changeover is considerably lower than in the telecom case.

Scalability

When utilising FIT type tracking systems, the SME can utilise the same checkpoints for providing transparency to different supply networks that are co-ordinated by possibly competing companies. The recipient of the information can be decided by changing the URI part of the package code. The scalability was demonstrated in the pilot installations, although there was no need for additional recipients in the actual operations of the pilots due to their restricted nature.

4.2 Environmental characteristics affecting the applicability of the proposed approach

The pilot installations and case studies revealed several environmental factors contributing to the applicability of the proposed transparency approach, which will be analysed in this section. We first review the factors in the business environment that make the approach attractive, and then move to the factors that undermine its practicability. The applicability factors of the proposed approach are summarised in Table 1.

Environmental factors with positive contribution to applicability

Based on the case studies, supply chain environments that profit the most of the tracking approach are characterised by short periods demanding additional transparency, supply chain locations with no existing inventory management systems, and situations where delivery items are already assigned to end user orders.

The first issue concerning the applicability of the approach was the time-span of the transparency requirement, which was brought up in all the three case studies. The features making the approach attractive for short-term need are low investment cost and speedy implementation. The case results revealed two distinct categories of temporary transparency need. In the telecom and machinery cases the need can be described as developing transparency to storage locations that exist or are included in the supply chain only temporarily. In the furniture case, temporary transparency was seen desirable in infrequent and complex situations demanding increased supply chain visibility, such as promotions, product introductions, product ramp-down, or when incorporating a new partner to the supply chain.

The second aspect, which was very clearly present in the telecom case and machinery cases, was the suitability of the transparency approach for supply chain locations without existing inventory management applications. The approach does not require any inventory applications; instead, it can actually provide a simple inventory control system for the storage operator in addition to the transparency for the supply chain. The cases showed, that there are a surprising number of storage locations that are operated completely without inventory control applications. This study suggests that such storages might especially exist in project oriented supply chains.

Third, the case results suggest that the tracking based transparency approach is well suited for supply chains were delivery items are designated for a specific end use or end user, and thus require delivery item level control in the supply chain. This notion first surfaced in the telecom case, where the delivery items as a rule are pre-assembled installation packages for a single project task. An interviewee from project management operations regarded the dwell times of individual items as a far more important metric for controlling and developing operations than inventory levels of SKUs or inventory value. He argued that as the project operations are carried out with installation packages, not SKUs, the distribution process

should also be controlled and measured on delivery item level to ensure effective support to the installation project.

Environmental factors with negative contribution to applicability

The following environmental factors were identified to limit the applicability of the approach: strict requirements for efficient processes and possession of adequate internal systems, long-term partnerships with large partners that support integration efforts, and high volume warehouse operations with dismantling receipt delivery packages and re-packaging items for dispatch.

As identified in the furniture case, the proposed transparency approach if it is not integrated to internal systems can introduce a new manual work phase to the material handling processes. If the company already has sufficient internal material control systems, the costs of using the approach may in the long run exceed the costs of integrating current systems with the partners. Therefore, in cases of high operational efficiency requirements and existing inventory systems, the applicability of the approach needs to be studied individually.

Building transparency by integrating current systems may also be appealing, if more wide-ranging solutions are desired. For example, during the furniture case study, the retailer organisation started to offer a flexible integration module to its suppliers. All three case SMEs accepted the offer, as the retailer IT organisation had agreed to deal with all data conversions. The investment to the retailer's transparency solution can be considered natural for the supplier companies, as the retailer is a major customer for each of the suppliers and the companies have agreed on building a long-term partnership with each other. Therefore, even the supplier companies expect the systems investment to be beneficial in the long run. In this instance, the investment is rather to the mutual relationship, not mere data exchange, which may in some situations be strategically desirable.

One supplier in the furniture case currently uses a tracking-based internal inventory control application. However, it is clear that the tracking based approach is most useful when the contents of the transport packages are not unpacked or repacked to form other entities in the supply chain. The unpacking and re-packing of goods can be managed with the tracking-based system, by using composite container methodology applied from object-oriented programming as presented by Främling et al., (2004). However, the recording of all

unpacking and packing operations individually can sacrifice the efficiency of warehouse operations. Therefore, the proposed approach cannot be considered feasible for traditional large volume distribution warehouses. The furniture suppliers system is feasible, as they always packages only one product per package.

Table 1 Environmental factors contributing to the applicability of the proposed transparency approach

Environmental factors with positive contribution to applicability	**Environmental factors with negative contribution to applicability**
+ Short time transparency requirements are addressed: o Transparency to a temporary storage location or distribution partner o Temporarily increased need for transparency (e.g. promotions and product introductions)	- Well working current internal systems and high efficiency requirements in the supply chain
+ Supply chain locations or distribution partners currently lacking internal solutions	- The integration of current systems can be seen as an investment to long-term relationship and potential support from the larger party
+ Delivery item level measurement and control desirable in the supply chain	- High volume operations where packages are dismantled and repacked

5 Conclusions

SME's have had severe difficulties in utilising supply chain transparency solutions, and implementations have therefore been scarce.. A fundamental problem with the solutions is that they are often built to maximise business efficiency, not to minimise expenses, and thus are too sophisticated for SMEs. However, the functionality needed for building supply network transparency is minimal and, thus, leaner solutions can provide sufficient support for successful supply network management. Based on the pilot and case study results we can conclude that the proposed tracking based approach is feasible for generating material flow transparency in supply chains including SMEs.

The results indicate that the approach can provide rapid payback in supply chains with temporary transparency needs, limited information systems, and need for delivery item level logistics control. We consider this an important implication for management pursuing supply chain transparency, as well as research on supply chain information technology. The results also suggest that the suitability of tracking based approach is questionable in environments with strict efficiency requirements and adequate internal control systems, long term relationships, and large scale SKU-level warehouse operations.

The results of this research contribute to the literature of material flow transparency and supply chain information systems, by presenting a new systems approach for developing transparency to supply chains. The research clearly identified the relation between the length of the transparency requirement and the characteristics of the suitable transparency application, which is missing from extant literature. Based on the research, temporary transparency requirements can be further classified to two categories: temporary supply chain configurations and temporarily elevated need for transparency caused by a situation with increased uncertainty.

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