

## **Increased transparency within and beyond organizational borders by novel identifier-based services for enterprises of different size**

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### **Abstract**

Recent trends in production call for efficient means of tracking and tracing within and beyond company borders. The pioneering track-and-trace solutions introduced by large companies can, due to their expenses as well as their lack of flexibility, hardly be the preferred choice for networks of smaller enterprises, and the mainstream of today's new off-the-shelf business integration platforms is not targeting the small business sector either. The paper highlights the key problems to be overcome for the successful introduction of lean but extensible entry-level track-and-trace solutions, and presents the concept and first pilot application results of the ongoing, EU-funded R&D project, TraSer.

### **Keywords:**

Production; Information; Auto identification

## **1. INTRODUCTION**

The ultimate goal of manufacturing is the general transformation of resources to meet human needs. Nowadays, customer needs are becoming increasingly critical, production and delivery processes are exposed to fast changes, and additional complexity is introduced by the emergence of production networks, as well as a higher degree of customization or product variability. All these challenges have to be met in a sustainable way, as addressed by the ManuFuture initiative which identifies four main directions of progress: adaptive, digital, knowledge-based, and networked manufacturing [1]. In addition, an increasing emphasis is laid on the real-time properties of an entire production system [2], as production and market challenges have to be answered in a finite—and decreasing—time frame. Also, the decomposition of large 'monolithic' production structures into autonomous but collaborating entities is gaining importance, directing the focus of manufacturing theory and practice towards cooperativeness [3].

The concept of the digital enterprise [4], i.e., the mapping of the key processes of an enterprise to digital structures by means of information and communication technologies (ICT) offers one of the prerequisites of managing the above problems. However, in order to master the high dynamics in the processes and demand, real-time feedback from the production is required [5].

Agent-based [6] or holonic [7] approaches are attractive in all main domains of manufacturing because they offer help in realizing important properties such as autonomy, responsiveness, modularity and openness. Multi-agent systems working in a decentralized way are able to use distributed and incomplete sources of information and knowledge. Uncertainties and possible conflicts arising from the system's distributed nature can be resolved via communication, collaboration and cooperation [6].

While the above approaches to production modelling and control are all promising, their practical feasibility always boils down to providing sufficient information about the processes and entities in question [8]. For real-time control actions, information about the state of the controlled system must be provided without large time lags. While information flow is easier to manage within and between IT components, it may become critical to maintain links between physical products and the related software agents, as the product is continually changing and moving without a permanent network connection being guaranteed [9]. Better information flow and transparency may also contribute to further improvement, such as real event-driven control [10], as well as 'plug and produce' performance [11] based on autonomous resources and intelligent products.

The paper addresses the transparency problem in a specific scope: keeping track of individual entities across company borders. After summarizing the key issues and the unsolved problems of the domain, an open-source solution platform is presented in a summary of main features, benefits and pilot implementation examples.

## **2. TECHNOLOGICAL BACKGROUNDS OF ITEM TRACKING**

The practical introduction of information transparency requires the elaborate, clearly defined system and architectural improvements listed below (see also corresponding hierarchical layers in Fig. 1):

- Relevant materials, resources etc. need to be identifiable in order to generate accurate and specific information (layer 1 in Fig. 1). Recent trends of customization, or improved customer services often require unambiguous identification of individual instances [12], which is taken into account in current and upcoming identifier allocation standards (such as sGTIN [13] including both the item class and unique serial number).
- Proper interfaces must be present between the information processing architecture and the identifiers. Most application areas require the identification technology to work without human intervention (layer 2 in Fig. 1). These needs are, in part, already answered by today's AutoID (automatic identification) technologies [13], however, the coming years will certainly witness numerous further achievements and, possibly, quick technological obsolescence in this field.
- Reading an identifier under specific conditions has a further interpretation, i.e., it implies the presence of the identified object at the given place and time. The processing architecture has to interpret this relation correctly and must be able to store the occurrence for subsequent retrieval and processing (layer 3 in Fig. 1). In this context the terms tracking (keeping track of the specific states of the object) and tracing (keeping track of the relations of the individual with other uniquely distinguished entities as tools, sub-assemblies etc.) are widely used and appear in practical enterprise IT solutions, especially at larger companies.
- More and more production and delivery processes reach across company borders. In order to make these long-term operations observable to all relevant participants of the value chain, tracking and tracing information locally present at various companies must be shared across organizational borders (layer 4 in Fig. 1). This calls for a common ground of standards and ontologies allowing interoperability of transactions, as well as reliable and configurable access control and security measures.

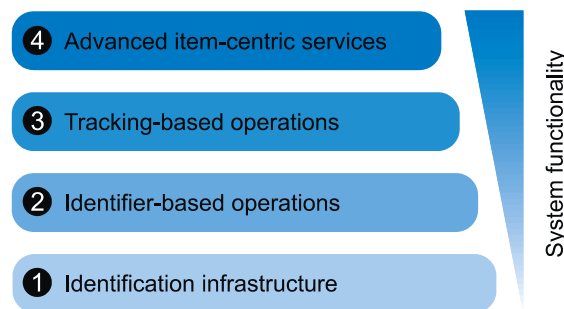


Fig. 1. Hierarchy of functionalities based on unique identification.

Fulfilling the above requirements, especially in pioneering solutions, requires considerable technical and financial efforts, as well as a paradigm change with decision makers and operating personnel. Still, the past decades have already witnessed the penetration of automatic identification and track-and-trace in the industry. Nowadays, the ripeness of the underlying technologies—as well as the industrial demands for process transparency—have resulted in identifier-based solutions and track-and-trace becoming an integral part of off-the-shelf business integration packages.

However, assurance of multiple-tier transparency in value chains is, nowadays, by no means complete. Here, three major burdens are yet to be overcome:

- Even though technologies enabling massive inter-organizational transparency are present as components, they were, until now, rarely combined to serve this specific purpose. Their adequate integration is a demanding process with challenges such as the standardization, negotiation of acceptable solutions etc. to be tackled.
- The majority of enterprises within a value chain is still reluctant to provide the cross-company transparency of data or tracking services, as the motivation of envisaged benefits is still outweighed by concerns of potential data security threats related to information sharing.
- Today's track-and-trace solutions are still optimized for large or medium-sized enterprises which handle large volumes of material with little variation, and are able to mobilize considerable financial resources for the required investment in the enterprise IT architecture. Unfortunately, none of these properties are typical for small companies.

### 3. TRASER—A FEASIBLE SMALL-BUSINESS ALTERNATIVE

Especially for filling the latter gap, one has to go beyond the state of the art, offering a solution platform which is standardized but flexible enough to cover the needs of a considerable range of small enterprises and allow adaptation to existing track-and-trace networks (e.g., if the company concerned is a supplier of a larger manufacturer) and provides assistance in establishing a common information sharing infrastructure if a given production network is not dominated by the standards of one major player.

The initiative for such development can be taken by the research community which has the potential of bringing forth—while receiving the necessary feedback from the industry—a solution platform and a knowledge repository which can bridge the technological gap caused by the sparse spreading of AutoID-based tracking and tracing among small enterprises. The three-year project TraSer [14], funded within the EU 6th Framework Programme, was called to life with exactly this purpose (<http://www.traser-project.eu>). The main output to be issued by the end of the project is a free, open-source solution platform for tracking and tracing applications on the item level. The platform, providing the background for tracking and tracing in the form of web

services, will suit the industrial needs represented, especially those of small enterprises, offering the following key benefits:

- Low initial investment, as the basic software package, along with tutorials, case studies and surveys, will be free and open-source, and will not require large, constantly employed IT specialist staff.
- Lower identifier allocation and maintenance costs, in case users apply TraSer's internal identifier notation which requires no registration with a centralized ID provider.
- Adaptation to existing IT infrastructures and communication protocols (e.g., ERP, peripheral middleware), as well as integrating already established ID numbering schemes will be fairly easy with clearly defined principles and requirements of communication interfaces.
- A TraSer-based tracking system can be coupled to other networks through adapters—this is especially advantageous for enterprises that are suppliers of several large manufacturers with different material tracking systems.
- Easy entry into existing TraSer networks which is especially advantageous for dynamically changing collaboration networks. TraSer also handles operation across organizational borders as a part of its routine capabilities.
- Scalable access control and configurable encryption of communication and ID tag data will avoid unnecessary exposure of confidential information to unauthorized parties or malicious intervention. TraSer also allows special measures for data/transaction consistency.
- An open-source community will extend possibilities of developing TraSer-based systems.

### **3.1 Principles of the TraSer network architecture**

The TraSer solution platform is based on communication through web services (WS), a standard which is by now well-established and supported by numerous commercial and free frameworks. Web services also allow data exchange to be flexible and easier to configure than most of the 'conventional' EDI (electronic data interchange) channels. The TraSer solution platform allows participants to build a TraSer network where two components can be distinguished: nodes (servers) and clients. (See also Fig. 2 with a simple TraSer network.)

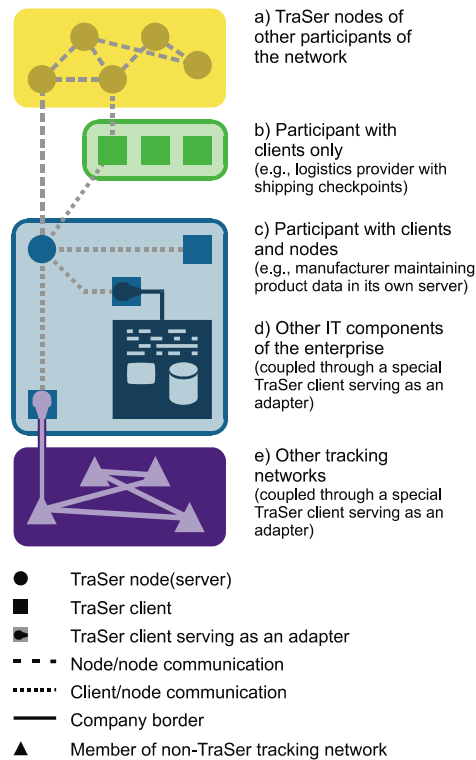


Fig. 2. Simplified example of a TraSer network.

**TraSer nodes** are the servers responsible for storing item-related data and providing authorized parties with access to them. The nodes receive requests in the form of XML queries, which allow more flexibility in customizing the data models used by the partners. TraSer nodes can also forward queries or updates to each other—these node-to-node connections span a part of the TraSer network (Fig. 2: part a) depicts a small network of several nodes and part c stands for a company which operates a TraSer node within its own IT infrastructure.

The forwarding of queries or updates is required if some parts of the item information in question are maintained by different nodes. This practice is typical for production networks where the products of several manufacturers are combined to a composite item—in that case information about the sub-assemblies possibly resides in different TraSer nodes of the same TraSer network. Also, the data of a certain item can be extended by further properties which are not necessarily located in the same node (e.g., when a manufacturer wishes to add its own relevant notes to the item description of its supplier). Therefore, TraSer nodes can forward queries or update requests to each other.

Adding a new node to the TraSer network (e.g., when a new manufacturer joins the community) consists in matching the data models and messages to the requirements of the network and setting the access rights for existing network members if required.

**TraSer clients** form the other main group of components in a TraSer network. Clients connect the nodes with the rest of the world by providing external interfaces and addressing one or more nodes with item-related queries or updates. Clients can be fitted with various kinds of interfaces, i.e., they can be designed for human operators, peripheral devices (readers etc.), other components of the enterprise infrastructure (stock management, ERP), and other tracking and

tracing systems. Since TraSer interface specifications are freely available, users can develop specific clients tailored to their specific needs.

Fig. 2 shows several specialized cases of client use. Companies which do not have their own TraSer-tracked items (e.g., logistics partners not maintaining their own transportation asset data in a TraSer system but updating the shipment information of a manufacturer's products; or a small supplier which lets a larger partner care about hosting its product data) are not required to operate their own node, as shown in part b. The company in part c operates, aside from the TraSer node, several specialized clients. One of these serves as an adapter for accessing other components of the manufacturer's IT infrastructure (part d), while another client was customized as an interface towards another tracking network (part e).

If the consistency of transactions and protection from eavesdropping or intrusion by unauthorized parties are a concern, several implementations of the relevant web service standards (WS-Reliable Messaging, WS-Security) can be used.

#### **4. PILOT APPLICATIONS**

In order to make the TraSer solution platform fit for industrial use, a roadmap of application pilots is followed where subsequent releases move from simple use cases towards higher levels of functionality, and from closed circulation of relatively few identified items to flow-through identifier handling. This allows an incremental development and refinement of the TraSer platform where practical experience contributes to the support material for prospective users as well. Several industrial participants of the project are currently testing pilot implementations; two of them are highlighted below.

##### **4.1 Closed-circuit asset tracking**

An application pilot already using the first release of the TraSer platform is the lab equipment management system used at various labs of the Dutch research institute TNO. This is a 'classical' closed-circuit asset tracking scenario where both the items and identifiers remain in the system for a longer time. The main characteristics of the application example are as follows (see also Fig. 3 for a simplified architectural overview and a sample transaction):

- Several labs within TNO participate in the inventory system, each of them being responsible for maintaining information about its own pieces of equipment. To this end, each lab runs its own TraSer node and issues its own lab-specific identifiers.
- Lab staff members have their own identifiers issued through TNO's own staff administration. While employee IDs are, at the moment, not included in the TraSer application, they can be easily entered later on (e.g., to be able to list all instruments a given person is in charge of).
- Specific access points at the institute, so-called booths, are equipped with clients which can access the inventory management nodes run by labs. Operation of these booths is permitted upon entering a valid staff identifier—in this case, therefore, access control is taken care of in the client, as opposed to typical TraSer networks in an open environment with potential threats.

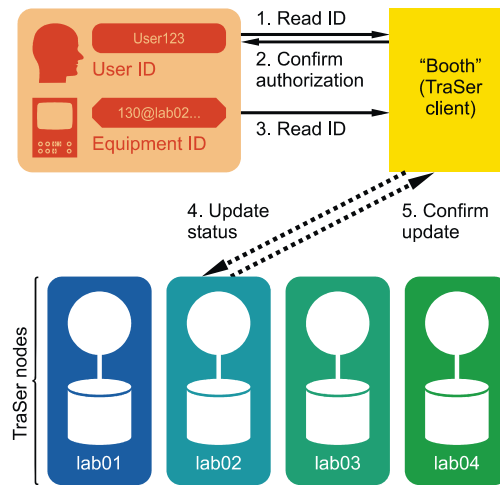


Fig. 3. Closed-circuit asset tracking with TraSer.

#### 4.2 Working towards tracking in supply chains

The most complete evolution path from closed-circuit asset management towards multiple-partner tracking in supply chains is hosted by Itella of Finland (formerly Finland Post). As of December, 2008, the initial parts of the pilot have already been tested and, plans for further stages are already specific. These span several scenarios which are built on each other as follows:

**Asset identification.** Here, the goal is to identify vehicles and roll cages entering or leaving Itella's facilities. Suitable equipment was, in part, already installed in a given logistics center, and TraSer nodes can readily take over the task of enter/leave transactions. The new solution based on TraSer offers a good basis for further enhancement as well: specific clients could report yard traffic to office personnel or other components of the enterprise IT infrastructure.

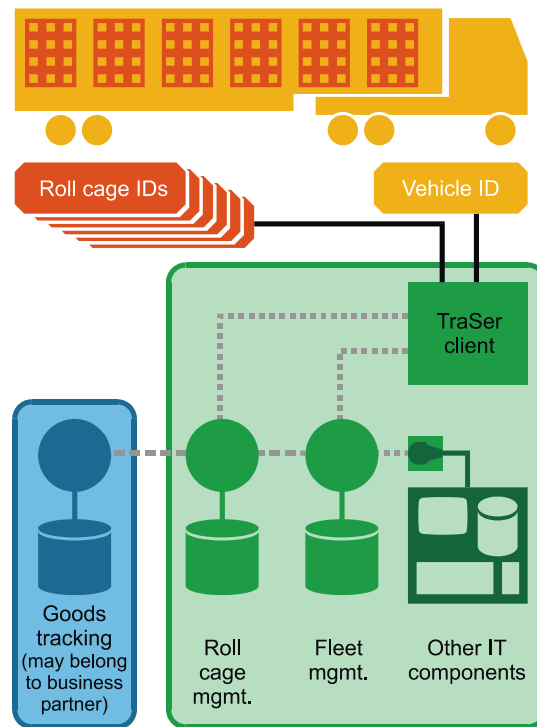


Fig. 4. Application of TraSer for logistics services.

**Asset tracking.** Recording and forwarding vehicle movement, as described above, are, in fact, already leading to a higher functionality level, as it introduces tracking services. This phase allows the transparent surveillance of departure or arrival at several client-equipped locations, enabling the progress of logistics processes to be monitored. The extension of tracking to smaller transportation assets (specifically roll cages) makes it possible to give specific instructions for loading and unloading vehicles, checking the contents of a vehicle, and keeping track of the location of roll cages, thus helping to prevent loss, theft, shortage or surplus build-up of roll cages at various locations. Applying mobile clients would, at this stage, provide a cost-efficient alternative to installation of TraSer clients at destinations which are less frequented by Itella's deliveries.

**Asset-based tracking of goods.** Here, the transportation assets tracked by the TraSer network are still in a closed circulation (as are their IDs), however, the goods moving together with the roll cages are usually participating in a flow-through supply chain and the latter items only appear in Itella's tracking system once, for a limited amount of time or logistics operations. These goods belong to companies using Itella's logistics services, and Itella can, by providing them with information about delivery progress, offer them goods tracking services, either through a human-readable web interface, or, in more advanced cases, through giving them limited access to the TraSer network by specific TraSer clients. Fig. 4 shows a simplified picture of the logistics tracking pilot in its envisaged final configuration.

## 5. CONCLUSIONS

The paper summarized common challenges in today's production, supply chains and production networks which can be met by introducing identity-based tracking and tracing services. Though solutions of this kind have already emerged in the past decades, and the state of the art has advanced to off-the-shelf business integration solution frameworks and services, a number of barriers still exists which keeps especially small enterprises from adopting them.

The paper presented a solution for breaking the investment and technological barriers by using an open-source framework, the currently developed output of the TraSer project. Advantages of the TraSer solution platform were highlighted from the point of view of small-business-users. From several ongoing pilot applications involving the TraSer platform, two examples for closed-circuit asset management and supply chains were presented in details.

The paper has shown that AutoID technologies, supported by appropriate software solutions, can bring numerous immediate or long-term benefits for operations within a company, as well as across organizational borders [5], [8], [10], [11], [8], [12]. Moreover, AutoID-based solutions can act as enabling technologies for facing many of the challenges of future production, such as autonomous processes [11], plug-and-produce real-time manufacturing execution systems, real-time enterprise and supply chain management [15].

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