Reprinted from:

2005 3rd IEEE International Conference on Industrial Informatics (INDIN) Perth, Australia 10-12 August 2005

IEEE Catalog Number ISBN 05EX1057
ISBN 0-7803-9094-6

An Eco-Solution for Track & Trace of Goods and Third Party Logistics

Kaspar Roos[2], Martin West[1], Elizabeth Chang[1] and Brendan Armstrong[1]

[1]Centre for Extended Enterprise and Business Intelligence
Curtin Business School, Curtin University of Technology, Western Australia
k.w.roos@student.utwente.nl, elizabeth.chang@cbs.curtin.edu.au

[2] The project is in conjunction with
Faculty of Business, Public Administration and Technology
University of Twente, Enschede, The Netherlands

Abstract - **This paper presents a new economic cost-effective solution known as web and telephony based method for tracking and tracing of goods and small and medium sized third party logistic providers. Considering that these companies usually operate on very flat margins, a comparison is made of the available track and trace technologies like GPS, Mobile Phone Approximately GPS and Java based cell tracking in terms of costs, operating risks, and other evaluation criteria.**

Keywords - **track and trace, small and medium sized third party logistic providers, interactive voice response system**

I. INTRODUCTION

Tracking and Tracing solutions can be seen as a cost-effective solution for firms to gain control over manufacturing and fulfilment processes, This control allows firms to produce the following:

- Higher quality services.
- A more innovative and adaptive context in which to change the provider's behaviour.
- Ability to gain more insights in the actual productivities and costs.
- Improvement in supply chain process in areas such as scheduling, inventory management, demand management, and material handling.

The Tracking and Tracing solution is one of crucial tools for any supply-chain companies; however, the costs and the ability of developing a tailored solution is large and sometimes unpredictable. Large logistic companies such as FedEx, UPS, and DHL have the resources and infrastructures to develop such solutions, which is not the case for small and medium sized logistics enterprises. In Australia, 99% of logistics services are small to medium sized enterprises that are privately owned [3]. Logistics services are a substantial part of the manufactories, supply-chain, and transportation industries. Reports are indicating that SMEs have difficulties with the adoption of new information technology as result of cost issues and a lack of experience [1, 2]. Thereby, as many logistics SMEs are dependent on large partners [1], they are sometimes forced to work with partners' information systems that may not suit their business needs properly. In the following section, we give compare and contract of existing technologies, based on a set of criteria we have developed. we also assess their appropriateness towards logistic SMEs, and discuss our proposed economic, flexible, and integratable solution that can be used by small and medium sized third party logistic providers for track and trace purposes.

II. TRACK AND TRACE SOLUTION

Track & trace is defined as the monitoring and recording of shipment movements from origin to destination. What we are tracking and tracing is business dependant. For goods (in terms of geographic location and time-delays) tracking, the data and information collection depends largely on the nature of the business operation and the power of the track & trace technology and methodology used. For a railroad company it is usually sufficient to know that a shipment is between point A and B, while a taxi company will have a precise need for geographic information in order to locate the nearest driver in a customer's vicinity. In this article, we focus on Small and Medium sized Third Party Logistic providers (SM3PLs), such as truck and railroad companies. During a field study, we found that it is important for these companies that:

- The location and the status of the goods can be tracked and traced.
- The solution is cost-effective.
- It will reduce the amount of paper work.
- The solution can inform the 3PLs' customers at once about the status and location of their goods the 3PLs are transporting.

III. EXISTING TACK AND TRACE TECHNOLOGIES

Currently, there are a number of well-known track and trace solutions. Each of these solutions have their own objectives, requirements, methods, techniques and tools. Namely:

- Global Positioning System (GPS)
- Mobile Phone Approximated GPS (AGPS)
- Java Mobile Cell Tracking
- Web-based telephone tracking

In order to evaluate this set of complex and advanced methods and technologies, we have developed the following criteria:

- Fixed costs (minimize)
- Ongoing costs (minimize)
- Ease of use (maximize)

3rd International Conference on Industrial Informatics(INDIN 2005)

- Ease of implementation (maximize)
- Speed (maximize)
- Automation (maximize)
- Risk of failure (minimize)

We compare and contrast each of the above methods against this set of criteria. A table below (Table 1) shows a summary of our findings.

Table 1 Compare and Contrast of existing trace and trace solutions

Methods and Technologies	*[2]Fixed Cost $	*On-going cost $	Eze Use	Eze Implementation	Speed	Automation	Risks
GPS	$2000 p/v	$500 *[2]pva	V.High	Low	Instantaneous	Yes completely	Low
AGPS	$0	Cannot be defined	V.High	Cannot be defined	Fast	Yes	Medium
Cell ID	$260 p/v	$480 pva	High	Med	Fast	Mostly	Medium
Web	$0	$0	Med	High	Medium	No	High
***[3]Mobile and Not Phony**	$500	$360 pva	High	Med	Instantaneous	Little	Low

Note that in above Table:

***[1]** Fixed Cost and Ongoing cost - These costs refer to the purchasing and operating costs of the track and trace equipment. Development and maintenance costs of the information system were not taken into account, because these costs do not differ for each system.

***[2]** pva = per vehicle per annum

***[3]** Mobile and Phony, this is a new economic solution that we proposed

From the above table, we can see that traditionally Global Positioning System use satellites from the American army to track the exact latitude and longitude of a transponder. Each truck, railroad car, ship, or plane should be fitted with a transponder to allow for the tracking of the movement of goods the vehicle is carrying. The satellite tracks the location of the transponder and relays this information to a base station. This station relays the information to an information system connected to the Internet. The great advantage of a GPS system is real-time synchronisation, meaning that the location of the transponder can be obtained with nearly no time-delays.

Also, there is two-way communication, which implies that the location of the transponder can always be immediately attained. Additionally, this system is quite easy to integrate with other information systems and navigation software can be used to display geographic locations on a map or to calculate the shortest distance between two locations. Disadvantage for SM3PLs are the high costs.

Each vehicle needs to be fitted with a transponder and for each transponder an annual operating fee has to be paid. The risks of the systems are quite low. One disadvantage is that the system is owned by the American army, but in the meantime so many public services have became dependent on it that the American army will not likely refrain the public from using this system. Nevertheless, it can be decided to shut-down the system if America's enemies use the system, i.e. for missile attacks.

The European Union gave permission to start with the Galileo project, which will be a civil system, be compatible with GPS, and is planned to come available in 2008. So, GPS has much potential, but its main disadvantage for SM3PLs is its high price. The price of expensive transponders is likely to drop in the coming years, and with Galileo's competition ahead, the price will surely drop in the future, but it is presently out of the reach for small and medium sized third party logistics providers because of the high costs.

Another disadvantage is additional equipment that is needed for updating a change of state. For example, if goods have been delivered to their destination, an additional system has to be in operation to inform the system the state of the goods needs to be changed. All telephone based tracking and tracing systems are not limited by this restriction, since they allow for two way communication.

In regards to Mobile Phone Approximately GPS, this emerging technology is being developed by telecom operators all over the world. It uses mobile towers to determine the approximate location of a mobile phone, and would return location data as used in the GPS system. The functionality of this system can be compared with full GPS. At the moment of writing, these systems are still being developed, but it is likely that the operating costs will be lower than the GPS system. The speed of obtaining the location will be just as fast as the GPS system, and the system will track and trace the mobile phone fully automatically. The risks of failure are higher with this system, because at least three towers need to receive a

signal to calculate the exact position. In densely built cities or in the countryside with no reception, this calculation cannot be carried out. In conclusion, this solution is interesting because of the low operating costs and ease-of-use, but since it is not available yet, it is not viable for the SM3PLs.

In regards to Java Mobile Cell Tracking, some modern mobile phones are enhanced with a Java-based operating system. On this platform, custom made applications can run with access to the phone's cell ID. This cell-id corresponds with the tower location to which the phone is connected. When a cell-id changes, the phone can send this event to an information system using GPRS or SMS. This system does not provide an exact location, but gives an approximate location of the vehicle driver's mobile phone.

For this system, java enabled cell phones need to be purchased which can work on the GPRS network. This will allow them to be always-on, meaning that we only have to pay for the amount of data traffic they generated. This implies that we can change the accuracy according to the budget. The more location data they send the more accurate but also more expensive the solution will be. The implementation will be relatively straightforward, as long as we have access to the geographic location of mobile phone towers.

The retrieval of location information can be achieved relatively fast, because the phone is online all of the time. This system is also completely automatic; the driver does not have to take care of any location updates. The risks are comparable with the mobile phone AGPRS tracking: without reception the system does not work. For this reason, AGPRS would be a more desirable solution since that solution would work with any phone and not the more expensive Java enabled phones.

In regards to Web based solutions, the solution is based on the customised solution design and implementation that includes a complete web-application implementation, front-end and backend databases and integration with existing legacy systems. The cost of such a system is usually high, this is because the business or organization either has to have their own IT team to develop it from scratch or out-source. The performance of the web-based track and trace solution is dependant on the web technology used, the track and trace methods, system design, and quality of implementation.

In conclusion, we can say that all methods and technologies have disadvantages for small and medium sized logistic operators who work on very flat margins. The GPS solution is the best solution in terms of accuracy, risk and availability, but it is also the most expensive one.

Mobile phone approximately GPS is a very promising technique, but currently not available and has the limitation that it does not work outside built-up areas where there is no network coverage. This is also the case for Java mobile phone tracking, which has the advantage that the accuracy can be based on the budget, although Java equipped phones are presently more expensive than phones without Java.

IV. Proposed Economic Track and Trace Solution

Based on the constraints posed above, we have developed a cost-effective track and trace solution though the use of normal or low-end mobile phones and computer based telephony systems for small and medium sized third party logistic companies working on very tight margins. The solution we propose has insignificant initial and ongoing costs, is fairly easy-to-use, is easy-to-implement, has faster updates than paper-based operations, but is not fully automatic (see Table 1). The trade-off between the costs of automation and the benefits it delivers in terms of efficiency usually depend on the type of business. The solution we propose here focuses on delivering a tracking and tracing solution for logistic companies would like to track and trace their goods along the route, basically to provide a value-added service to their customers as a way to inform them about the location and state of their goods. However, the proposed solution is not suitable for logistic companies who need the tracking and tracing data for automatic routing, like express or courier services.

We propose to use a web-based system in conjunction with an interactive voice response system (IVR) for tracking and tracing of goods. Although the goods cannot be tracked to the exact geographic location, for most logistic companies we studied it is sufficient to know between which points the goods are located and what the state of the goods are. Along the route, operators update the system via the web or by calling an IVR. An IVR is an 'interactive answering machine' style system where users push buttons to indicate their choices. The system is accessible by any telephone (either fixed line or wireless) and is quite useful for locations where internet access is limited.

V. The Prototype Eco-Solutions

In this section, we demonstrate how our solution works? An example, a customer enters an order via the 3PL's website or by making a phone call to a customer service representative, thereby indicating the pickup date, pickup location, type and quantity of the goods, delivery date, delivery location, and possible additional services as refrigerated transport. The system now generates pickup lists for truck drivers. Once a truck has picked up the goods at the customer's site, the truck driver uses its mobile phone to make a call to the Interactive Voice Response system, keys in the order number and change its status to picked-up.

When the driver returns at the warehouse, the warehouse operator can assign all orders that are picked up by that particular driver to be received by the warehouse. If customers want to trace their orders, they see (or they can be informed, for example by XML messages like RSS feeds) that their goods are now in the 3PL's warehouse.
Suppose the goods are now shipped by rail between a warehouse in city A and a warehouse in city B. The operator in warehouse A will indicate which orders are assigned to a train and will change their status to something similar with 'on the train between A and B'. When the goods arrive at B, the warehouse operator in B will change the status of all orders to 'received at warehouse B'. This process is repeated for every step in the transportation network. At last, when the goods are delivered at the desired destination – usually by truck – the truck driver uses its mobile phone to call the IVR, keys in the order number, and change its status to 'delivered'. Other states

could be 'lost', 'damaged', or other events which might prevent the goods from being delivered. Default procedure:

1. Customer submits order via website or customer service representative
2. System generates pickup lists for trucks
3. Trucks pick ups good at customer's site
4. Truck driver calls IVR and change order status to 'picked up'
5. Truck driver return to warehouse (after picking up other orders)
6. Status of all orders in truck is set to 'arrived at warehouse X' by warehouse operator
7. Order is either sent to next warehouse or to delivery site
8. If order arrives at delivery site, the truck driver calls the IVR and updates the system

The order status can be retrieved at any time once it has been created as described in step 1. The prototype system can be viewed on websites www.ceebi.curtin.edu.au/ and http://www.logistics.cbs.curtin.edu.au/

VI. Advantages and Disadvantages the Proposed Eco-Solution

The main benefits of this system are clearly the costs. Compared to the other technologies, this proposed system does not need expensive transporters or requires expensive tracking services from telecom operators. The IVR hardware is relatively cheap, around AUD 500,-. Besides the costs, the system allows for a paperless workflow which increases speed and it delivers a service to clients who want to order and track and trace their orders via the web. Another advantage of this system is inter-operationalisation, meaning that different providers can use this system, although issues like ownership and accountability has not been addressed. In that sense, it would also be possible to add billing services to the system.

The main disadvantage of the proposed system is the limited type of business models it supports. Innovative business models, like GPS based taxi or courier services, which routing schemes are dynamically created based on demand, cannot be supported because our system to works with fixed routes. Although most SM3PLs do not have the need for dynamic routing right now, they might have it in the future. Hopefully GPS has become a commodity by that time.

VII. Conclusions

As we have seen, common tracking and tracing solutions are usually too expensive for small and medium sized third party logistic providers. These kind of companies do not need advanced options such as dynamic routing which is possible with exact geographic tracking and tracing. However, their customers require that they can track and trace their goods, so we proposed a cost-effective tracking and tracing solution based on the World Wide Web and an Interactive Voice Response system. After each pickup or delivery the status of the order is changed so users can follow their goods. Multiple companies can join the system and in the future even billing information can be included.

The benefits for SME are at several levels namely: (1) the new eco-solution provides Australian industry with a competitive edge (2) they will extend the reach of companies particularly SMEs beyond the borders through international track and trace. This is particularly the case in the logistics where the e-logistics model has give access to other logistics providers in other countries and an information infrastructure that allows both track and trace and seamless order segmentation and distribution. As SMEs employ the largest number of people, and 99% are privately owned, this has the potential for increasing employment though creating new jobs.

VIII. References

[1] Industry Steering Committee of the Freight Transport Logistics Industry 2002, 'Freight Logistics Australia An Agenda For Action', retrieved from: http://www.dotars.gov.au/transinfra/pdf/Action_Agenda_Final_Report.pdf on May 17th, 2005

[2] Nelson, D., 2002, 'Small businesses look to free up IT', retrieved from: http://www.theage.com.au/articles/2002/05/25/1022243282082.html on May 17th, 2005

[3] Chang, E., Dillon, T.S. & Talevski, A., 2003, 'Re-configurable web services for extended logistics enterprise', *IEEE Conference on Industrial Informatics,* Banff, Canada.