THE FIELD TRIAL SCENARIO OF AN INTER-MODAL, END-TO-END AND REAL-TIME TRACKING AND TRACING SYSTEM

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BACKGROUND

Transport and logistics today have evolved into a high-technology industry. Distribution is no longer about moving cargo over road or via air from A to B, but is a complex process based on intelligent systems for sorting, planning, routing, and consolidation that supports faster transportation, different transportation modes, fallback scenarios in case of failures, value added services such as time sensitive deliveries and tracing of products throughout the supply chain or transport network. Many larger companies have developed solutions for delivering these services in order to meet the requirements of their customers and to offer them methods for tracing their consignments. As smaller companies cannot afford these investments, they are mainly active in the "old" point-to-point transportation market.

Continuous information about the current position or status of transport goods (in the sense that the exact geographic position can be queried at any time) at a piece level is not commonly available today. Typically, this information is provided - if at all – at a vehicle or container level only. Existing tracking solutions are typically based on scanning bar codes at process or control points. In daily business, products are frequently shipped by subcontractors of the transport company. If the subcontractor does not provide a point-to-point service, tracing is no longer possible. Only in a few cases do carriers exchange tracing information, but in most cases the costs for adapting the proprietary systems to each other are prohibitive.

THE PARCELCALL ARCHITECTURE

In order to support all kinds of logistic companies the main objective of the ParcelCall project [1] is to develop and verify an inter-modal, real-time, end-to-end, tracking and tracing (T&T) system for transport and logistics applications – operating across all borders of carriers and transportation modes. The key idea is to provide common open (and ideally standardised) interfaces among all system components on top of standardised communication protocols, e.g., TCP/IP, GSM, GPRS, Bluetooth. Low costs, easy installation and adaptation of the legacy systems operated by the carriers to the new information infrastructure were key design criterions.

In addition to this new infrastructure, 1-D and 2-D bar code labels complemented by new developed RFID tags, i.e., passive transponders with limited functionality and data capacity, are used for the automatic identification upon transhipping, without the need for manually handling the consignments and scanning the labels. As a further innovative step, ParcelCall explores the technological issues of active "Thinking Tags" in addition to passive RFID tags.

THE PARCELCALL SYSTEM COMPONENTS

The ParcelCall system consists of three main components, the Mobile Logistic Server (MLS), the Goods Tracing Server (GTS) and the Goods Information Server (GIS) as depicted in Figure 1. A passive or active tag identifies each transport good.

By using the public and mobile data communication networks, the information from the tags and the MLSs is relayed to a network of (E.)GTSs operated by the different transport and logistic companies. The network of E.GTS servers uses public communication networks (e.g., the Internet) as a low-cost communications backbone and makes T&T information available using unified interfaces. The GIS servess as gateway between the distributed E.GTS system and a multitude of mobile and fixed end-user devices, e.g., mobile phones, PDA's, or PC's.

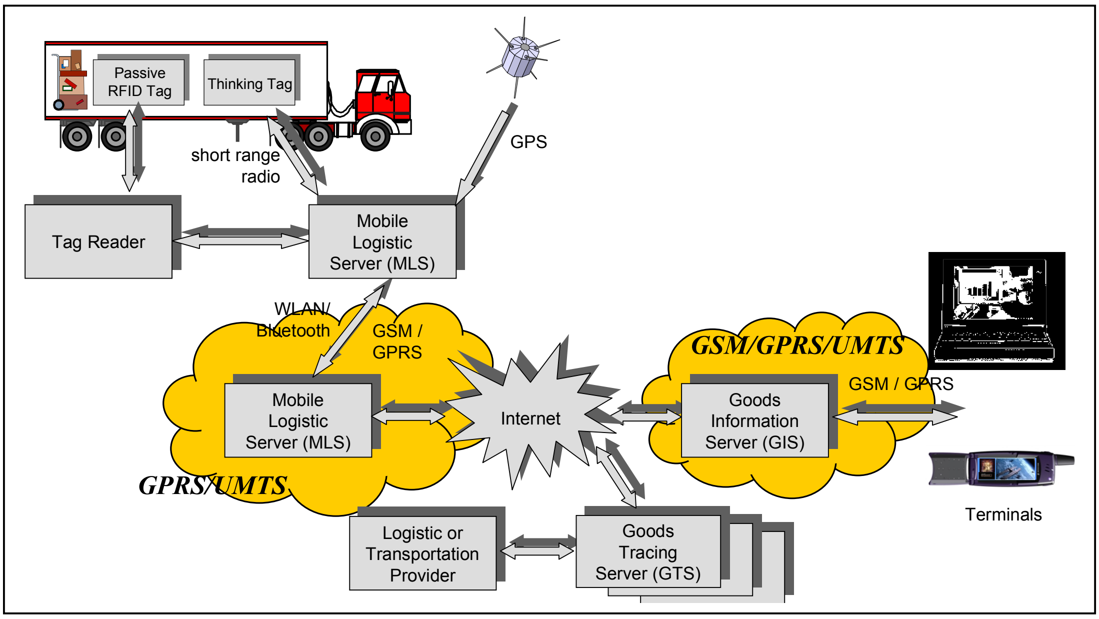

Figure 1. The ParcelCall Architecture.

THE MLS AND PASSIVE AND ACTIVE TAGS

While passive tags are only used to identify a transport good, active tags are also equipped with sensors and radio interfaces. Thus, active tags are capable of sending alarm messages if certain environments constraints are exceeded. The identification information stored on a passive tag is read by a tag reader and transferred to a MLS inside the transport unit, i.e., container, trailer, freight wagon etc. Using the tag reader and the GPS satellite positioning system the MLS is always aware of its current location and about the identity of the goods, which are contained in the respective transport unit. Furthermore, using sensors located on active tags or attached to the transport unit, the MLS can check environment conditions.

The idea of the MLS architecture is to completely encapsulate the communication functionality, and to allow the application running on the next higher layer to access its functionality via a standardized API. This way, the details of the physical communication between the different elements of the ParcelCall system, e.g. GTS to MLS, MLS to MLS or MLS to Thinking Tag, are completely hidden from the application. Different kinds of Thinking Tags with entirely different physical communication protocols can thus be easily integrated into an MLS as long as the same API to the MLS application is supported. Additionally the communication between the EP.MLS and the GTS as well as within the MLS hierarchy is based on the exchange of XML messages [2]. That allows providing an open interface to the MLS.

THE GTS AND E.GTS

The GTS network acts between the GIS, the human machine interface, and the MLS, which records entities and monitors sensor devices. In the initial system design, the GTS was split in an E.GTS and a GTS. This is a logical decomposition, which does not necessarily lead to decomposition into different processes or physical entities. The reason for this division was that with this construction, the GTS only implements the core T&T functionality tasks and the business logic whereas all additional features like filtering, authentication, and encryption aspects are done by the E.GTS. It depends on the configuration of a specific company network whether all company GTSs communicate with or without added security mechanisms. A company with a secure intranet can do without an E.GTS for communication between company GTSs, whereas GTSs not located in a secure environment require the services of an E.GTS.

The most important functionality of the GTSs is the processing of entity announcements and registrations. The registrations are triggered by MLSs and routed upwards the tree hierarchy. Announcements are initiated on GTS level and sent down the tree hierarchy. The business logic of the GTS has to track differences between these two kinds of messages and has to inform all interested components.

THE GIS AND ITS INTERFACES

The GIS is one of the key elements of the ParcelCall system and provides a portal to the information maintained by the GTS network. The Goods Information Server (GIS) provides customers with status information about their transport goods. Each GIS will connect to a single E.GTS of the carrier. The E.GTS will be connected to zero or more GTS of the carrier.

Figure 2 depicts a typical scenario where the consignor has sent one or more parcels and wants to check the status (e.g., current geographical location) of the consignment. The user has the opportunity to use a mobile or a fixed device to establish a connection to the main contractor’s E.GTS through a GIS. The consignor then sends a request for status information of the parcels in the consignment. The GIS retrieves this information from the system via the E.GTS, formats the information according to the consignor’s device, and then sends it to the device to display it for the consignor.

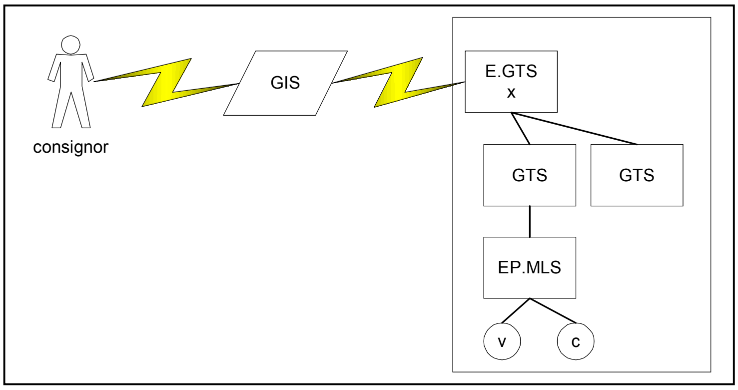

Figure 2. Getting parcel information via the GIS

The GIS provides several mechanisms to the consignor for retrieving status information of parcels. Queries can be made using parcel IDs to get the status information of one or more parcels. In addition, queries can be made using reference IDs that are assigned by the consignor. This provides added flexibility and convenience since the consignor or the consignee need not track parcels using parcel IDs. A reference ID can make it easier for a consignor to coordinate with his or her own (or their customer's) billing or filing system. For example, the reference ID could be a purchase order number, a customer's job number or a group of words that identifies that shipment.

Figure 3. The WAP Interface for the GIS

The GIS also provides the mechanism for a consignor to retrieve the status of one or more parcels without entering either parcel IDs or reference IDs. To facilitate this, the consignor needs to register with the GIS using a unique user ID and password. When sending the parcel, the consignor should then specify the user ID so that it gets associated with the parcel. The consignor can then connect to the GIS and login using their user ID and password. Once the consignor has logged into the GIS system, the status of all currently active parcels for that user ID can then be retrieved without having to enter any parcel IDs or reference IDs.

Figure 3 and Figure 4 show the user interfaces of the GIS which allow users to access the GIS via multiple underlying communication technology such as HTTP and WAP. The Protocol Adapter does the adaptation of different protocols. Since the GIS displays the information received from the GTS network to the user, it is therefore responsible for conversion of different formats, for example from XML to HTML or WML etc. This functionality is provided by the Presentation sub-component that is part of the GIS. Depending upon the supported protocols at the GIS, the Presentation sub-component may internally encapsulate additional functionality to support the necessary protocols. For example, it may include a web server to handle HTML/WML pages.

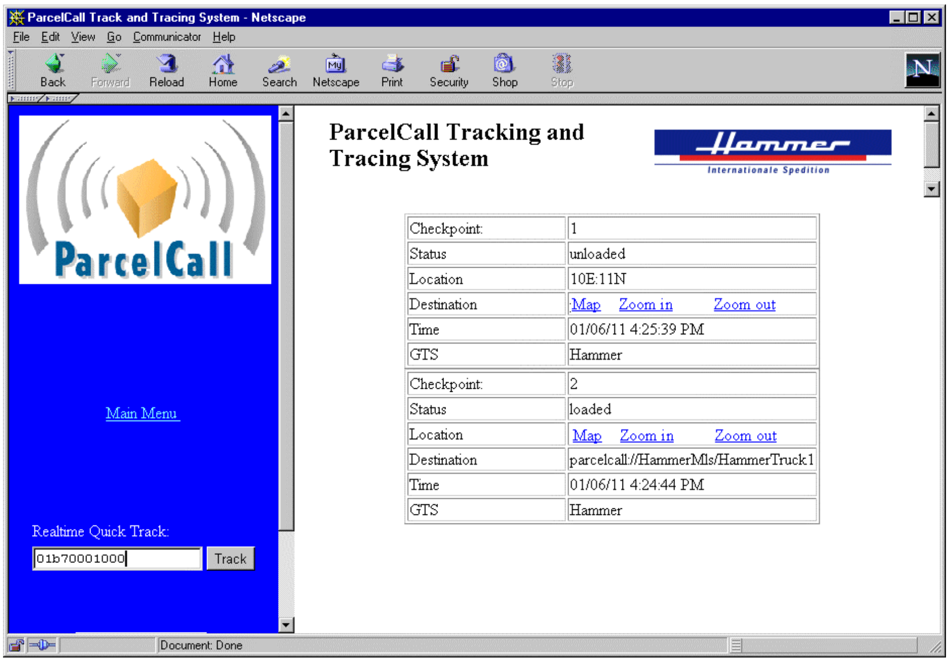

Figure 4. The Web Interface of the GIS

Active Alerting

Taking a look at the GIS from a communication point of view all application layer communication either with a customer's mobile or fixed terminal or with a GTS is based on the HTTP protocol. This is excepted for the active notification. The content transferred within the HTTP data units depends on the communication partner and its characteristics. It can be XML messages, which are exchanged between GIS and GTS, as well as HTML or WML pages.

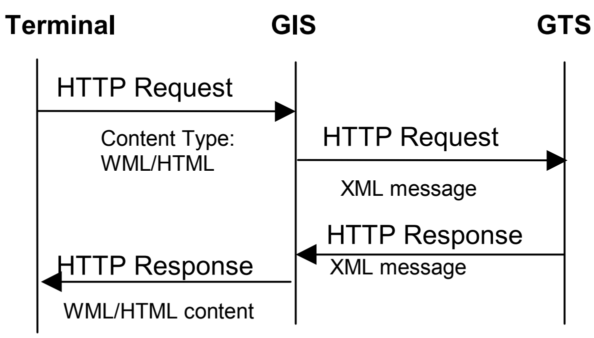

Figure 5. GIS communication

As shown in Figure 5 a user request for freight information is issued in form of a HTTP request from its browser. This request contains information about the concerned shipments as well as the type of content, which is expected in the HTTP response. The GTS interface of the

GIS creates an XML message and sends it to the GTS, using an authenticated HTTP connection. Within the content of the HTTP response XML encoded shipment information will be available. This is handled to the presentation module of the GIS, where WML decks or HTML pages will be created depending on the content type that is supported by the customers browser. In a last step the content is transferred to the user terminal and will be displayed there. The enhanced service of active notification is realised within the respective module of the GIS. Events such as “threshold value exceeded” or “shipment delivered” might pop up at the GIS from the GTS network. Users, which subscribed to these events, will then be notified either by SMS, email or by the use of WAP push [3]. The kind of notification desired can be assigned by the user within his personal profile.

THE FIELD TRIAL SCENARIO

With the help of field trials two capabilities are primarily tested - the benefit of passive RFID, as well as thinking tags for the logistic companies and the real-time information flow of data across different carriers and transport modes. The use of thinking tags offers opportunities far beyond the mere transmission of static identification information, such as:

- continuous measuring and monitoring of environment conditions (temperature, humidity) for sensitive shipments (e.g., food) at the level of individual pieces,
- active alerting of the responsible carrier in case of an alarm, i. e., deviation from the planned transport route, inadequate environment conditions, etc.,
- recording of the history (location, environment conditions, status) of a shipment in order to provide evidence in liability issues (e.g., for security transports).

The system trial is implemented in three phases with increasing complexity and functionality:

1. The first trial phase uses the active tags from Philips. It involved, for each transaction, a single carrier and road and sea transportation only. The tested applications comprised identification of pieces using simple active tags, and real-time tracking of positioning and status information. This included the alerting if a parcel is delayed or if it is loaded into the wrong truck.
2. In the second phase, passive RFID and active thinking tags are used during the trial, along with the novel alerting and monitoring services they provide. Applications to be tested comprise identification of pieces using thinking tags, real-time tracking of environment conditions, recording of positioning and environment data history, and active user alerting. The transportation is limited to two single carriers. For this evaluation threshold values are set in such a way, that if the environment constraints (i.e., temperature) exceed the threshold an alarm should be generated and send via MLS and GTS to the local IT system of the responsible carrier.
3. Finally, in the third phase, the trial realises a more complex, multi-modal, international logistics chain, involving various freight nodes and at least two carrier organisations and the combined use of passive and active tags. Applications tested are identical with those in phases 1 and 2, but the exchange of tracking information among different transport operators and transport modes will be verified.

The three phases of the system trial are depicted in Figure 6. The field trial started in June 2001 with a duration of three month, whereby in June the phase 1, in July phase 2 and in August phase 3 took place.

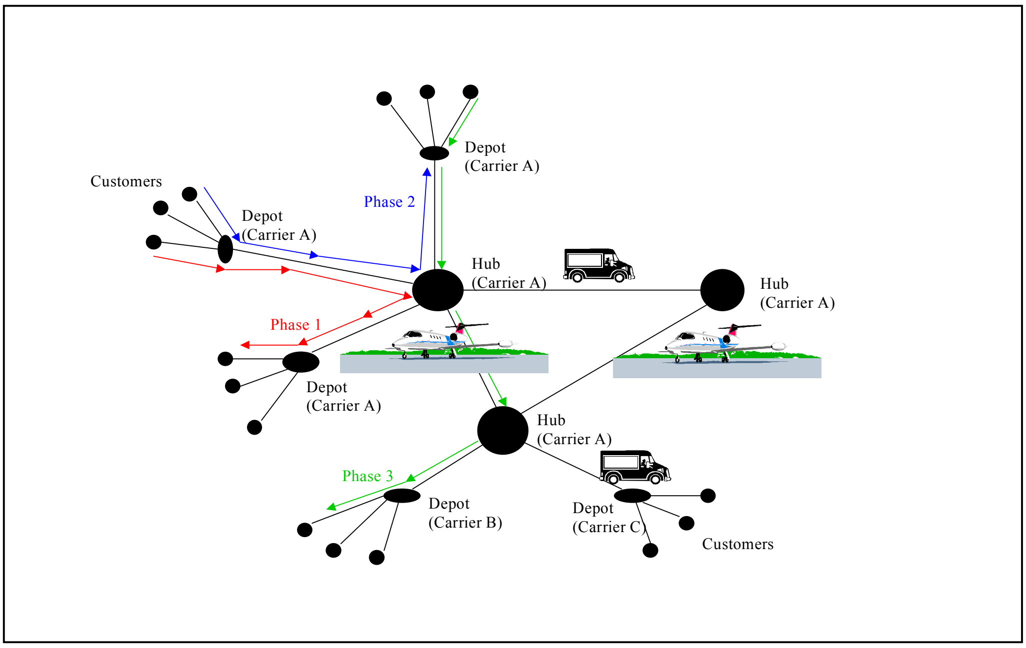

Figure 6. The three phases of the field trial.

CONCLUSIONS AND FIRST EXPERIENCES

The field trial of the new T&T application has been conducted in a live environment. Thereby the networks of the international transport companies TNT and Hammer have been used for this purpose. Processes of the system trial have been integrated as much as possible into the existing handling and transport processes to achieve realistic results. In road transport TNT and Hammer used modern long haul trucks within the system trial. These trucks carried regular freight from various customers that is usually carried on these routes. Specially prepared dummy shipments has been moved in addition to the regular volumes on these vehicles.

In phase 1 Hammer has chosen a route that is used for the distribution of Ericsson mobile telephone equipment in Katrineholm, Sweden to Hammer's sorting hub in Aachen, Germany. TNT's route connects two of the main road sorting Hub's within its European road transport network. The hub used as origin station is located in Wiesbaden in Germany, the hub that acts as a receiving station is based near Arnhem in the Netherlands. In phase 3 these both routes will be combined. TNT will receive goods from the first carrier Hammer at the hub in Arnhem, Netherlands. The goods will be moved from Arnhem via Belgium, France and the Eurotunnel to Northampton in the UK. From Northampton the goods will be moved to a TNT depot in the south of London.

Five active tags and one mobile MLS has been prepared for the first phase 1 trials. Standard packaging material commonly used in transport was used. The active tags were packed in fiberboard boxes surrounded by cushioning material. These fiberboard boxes were all placed into one wooden box on a pallet. The MLS was packed in a small wooden box with several layers of cushioning material around it. This wooden box was placed in a larger wooden box together with a 12 V battery commonly used in trucks or mobile homes, both box and battery sufficiently secured to prevent any movement inside the wooden box.

Then the MLS was connected to the parent (fixed) MLS located in Aachen with its built in GSM module and registered it GTS located in Konstanz, Germany. The identifiers of the five transponders/shipments were entered into the LIT (Legacy IT system of a carrier) simulator and announced to the GTS without any problem. Once the tags were activated the mobile MLS scanned and registered all five active tags within 2 minutes.

The wooden boxes containing the mobile MLS and the active transponders were loaded onto the trailer. The box with the MLS was placed on top of the box with the transponders and secured in this position. The distance between the MLS tag reader and the transponders was 50 to 80 cm. The GPS antenna was attached to the left side of the trailer in about 1,7 m height from the ground, facing away from the trailer. Throughout the journey the MLS had continuously been in contact with the transponders and the position and speed as received from the GPS module were being indicated and recorded.

The GIS history showed a series events that occurred since departure of the truck. These are unload or load events which are shown as checkpoints in the history for each shipments. It appeared that during transport tags lost and regained contact to the mobile MLS. Various tags lost and regained contact to the MLS just before or shortly after the ferry crossing between Denmark and Germany.

Every query of the MLS triggered a response received with a delay of about 2 to 3 minutes. A second query about 5 minutes after the first request provided us with position, speed and time data. The position data was shown on a map that allowed us to track the truck with delay of about 5 minutes. During the off-load process three tags registered with the fixed MLS at the hub of Hammer within about 3 minutes. The two remaining tags registered with the MLS after they were switched on and off by interrupting the power supply for a short moment. This triggered the GTS to sent for each of these three tags a "missing from load" alarm to a specified email address once the 3 minute threshold was exceeded. After all tags had registered to the fixed MLS we were able to poll them via the GIS, both via an ordinary web browser and a WAP-enabled mobile phone, and receive real time information on status ("loaded") and location ("HammerHub").

ACKNOWLEDGEMENT

This work was partly supported by the Commission of the European Community (CEC) as part of the IST project ParcelCall (www.parcelcall.com).

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