XML-based freight information over mobile networks

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There is a high demand for accurate and up-to-date information of freight items. At the same time, supply chains are becoming more and more complex, involving multiple carriers and multiple transport modes. The European IST project ParcelCall focuses on interoperability, open interfaces, and standardization in order to allow seamless tracking and tracing across the entire logistics and transportation chain. Owing to its open and scalable system architecture, the ParcelCall system can be easily extended by adding new server components. A small trucking company can adopt the ParcelCall tracking and tracing services as well as a huge multi-national integrator. In this paper the XML-based communication between the various components of the ParcelCall system is investigated. A particular focus is given to the Mobile Logistic Servers, which are the mobile communication entities in the entire system.

I. Introduction

The ParcelCall system [PWKH00] consists of four main components: the MLS, the GTS, the E-GTS, and the GIS. A Mobile Logistic Server (MLS) keeps track of all transport items inside a vehicle or container. It is, at any time, aware of the identity, current location and status of all goods in the unit. Beside a connection to the GSM[1] cellular mobile network [Wal99] MLSs are equipped with GPS[2] receivers to provide accurate and secure global tracking and tracing (T&T). The MLSs transfer this information upwards via GSM data calls or GPRS[3] packets [Wal99] on demand and on a real-time basis. It can actively alert the owner of the goods or the transport operator if for example freight is deviating from a predefined route, a delay occurs, or an alarm has been generated. The MLS is described in detail in chapter 3.

Information are stored in a network of Goods Tracing Servers (GTS). Each GTS also represents an interface between the ParcelCall system and the respective Legacy IT (LIT) infrastructure. Users may access T&T information via Goods Information Servers (GIS) on the Interent or with the help of a WAP[4]-enabled cellular phone.

All T&T data within the ParcelCall system is acquired, stored, and managed at the level of individual transport items (parcels). Detailed tracking and status information is available in real-time and for each complete transport cycle - even if a single item out of a large shipment gets lost, damaged, or takes a different route to the rest of the shipment.

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[1] Global system for Mobile communication
[2] Global Positioning System
[3] General Packet Radio Service
[4] Wireless Application Protocol

Accurate T&T requires efficient and reliable identification of transport units and items. ParcelCall will employ Radio-Frequency Identification (RFID) tags to complement existing automatic identification methods using bar codes and labels. Smart RFID labels will allow reliable automated data capture and status acquisition for individual movements, key processes and events throughout the transport cycle. ParcelCall will go beyond mere item (parcel) identification. Sensitive transport goods is equipped with so-called thinking tags - compact reusable devices, equipped with sensors, processing power, memory and capable of active, two way radio communication. Thinking tags monitor their environmental conditions, such as temperature, humidity or shock, record a history of status information, location, and measurement data, and actively send alerts or messages. Thinking tags are associated with individual freight, rather than with a container or other transport unit, to provide seamless end-to-end surveillance of status, location, and environmental data. Thinking tags are particularly useful for perishable, sensitive and high-risk goods. These might include items such as pharmaceuticals, whose temperature needs to be monitored without interruption, or shock-sensitive electronic devices. This provides invaluable information in the case of theft or loss, and help in settling liability issues if damage or mishandling has occurred.

II. XML for transport and logistic applications

The eXtensible Markup Language (XML) is a universal format for putting structured data in a text file. Structured data could be every organized data, e.g., configuration parameters, financial transactions, or technical drawings. It may also be registration or location data of transportation freight or other information necessary for individual T&T solutions. XML is a set of rules and guidelines for designing text formats for such data, in a way that produces files that are easy to generate and read, that are unambiguous, and that avoid common pitfalls, such as lack of extensibility, lack of support for internationalisation and platform-dependency. Its character nature makes XML particularly suitable for asynchronous data exchange.

Starting as a recommendation of the W3C XML is now a well-established model for enhancing interoperability via simplified sharing of data and content [Con01]. In addition to its promotion by the ISO[5], XML is strongly supported by all major industry vendors, including Microsoft, IBM, Sun Microsystems and Hewlett-Packard. In the following paragraphs a closer look will be taken on the main features of XML. They will focus on those, which lead to the decision to use XML as an information exchange format within the ParcelCall information architecture. XML is not another markup language as for example HTML[6]. As shown in Figure 1 SGML[7] and XML are framework or meta-languages whereas XML is a simplified version of SGML. This simplification proceeded to make the very powerful, general and complex SGML standard “light” enough for use on the Web. With XML being a subset of SGML all XML documents are valid SGML documents. Outside the ellipses of Figure 1 examples for applications of these framework languages are given: HTML, WML[8] and DocBook are SGML applications, whilst OFX[9], CDF[10] and ParcelCall are XML applications.

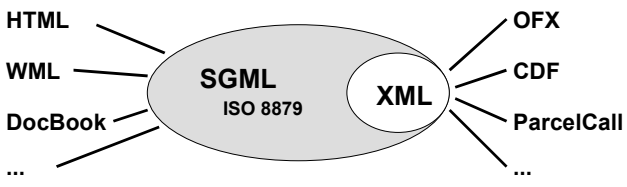

Figure 1: Relationship among SGML, XML and their applications

[5] International Standardization Organization
[6] HyperText Markup Language
[7] Standard Generalized Markup Language
[8] Wireless Markup Language
[9] Open Financial Exchange
[10] Channel Definition Format

Due to these close relationships of the framework languages and their applications it is easily possible to convert XML documents to applications of SGML. This is of special interest, if information, which is available in XML, should be published by a transformation to either HTML or WML [WAP00]. For the adaptation of internal or external interfaces, where information are exchanged within XML the same mechanism can be applied. Here, XML files are transformed to other XML files following different rules and uses different tags, but still uses an eXtensible Stylesheet Language (XSL) formatting vocabulary. XSL itself is a stylesheet language for documents marked up using XML. XSL Transformation (XSLT), as shown in Figure 2, is used to describe how an XML source document is transformed into its destination format.

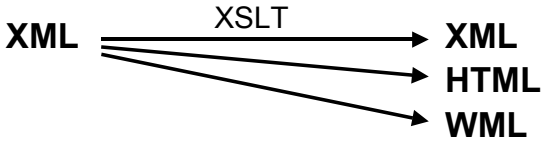

Figure 2: XML transformation with XSLT

It shall be mentioned that this feature related to XML is of importance for applications in the area of transportation and logistics, which may have to interface with a huge number of heterogenous systems in a multi-carrier scenario. The adaptation of the interfaces could become more easy, if XSLT is used. In addition, XML is helpful, whenever T&T information has to be presented on the intranet, Internet or on mobile devices by using HTML and WML to show dynamic, real-time contents. Thinking of information exchange it has to be agreed on a document format to be used. Later this format has to be validated before any further processing may take place. This is of importance in a system which relies on the information flow between an increasing number of components from possibly multiple vendors. XML allows to validate its applications on two different levels, see Figure 3.

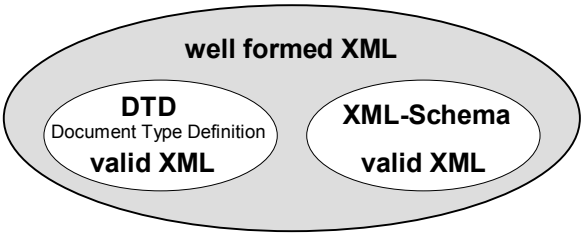

Figure 3: XML validation

First, the given XML document should be well formed, e.g., the syntax should be correct. Then an XML document could be validated against a Document Type Definition (DTD), which is an SGML way of describing valid XML documents, or against an XML schema. XML-schemas use XML to describe valid XML documents and are a lightweight alternative to a DTD. Due to these attributes XML is suitable for the use within the ParcelCall information architecture, as it allows to provide common, open and standardized interfaces among all system components as shown in Figure 4.

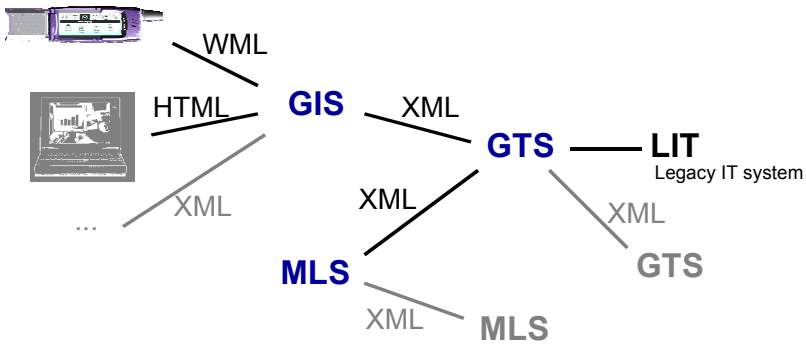

Figure 4: Overview of the ParcelCall interfaces

III. Mobile Logistic Servers

Within in the ParcelCall system and information architecture Mobile Logistic Servers (MLSs) are located between the Goods Tracing Server (GTS) and the smallest entity of the ParcelCall system, the tagged freight item. Logically, from a GTS point of view the MLS represents a gateway to the information available on MLS level as well as on tagged item level. These information are the properties of the respective MLS or item. The major task of the MLS is to provide an interface to these properties for the GTS. Physically, an MLS can be found everywhere, where there is a need to keep track of a tagged item. This can be in fixed and mobile locations as for example Hubs, onboard a truck or within a container. Derived from this a MLS has to support wireline and wireless networks for either short range or long distance communication.

To enable communication between a GTS and a tagged item MLSs form a network, which may consist of at least one or an unlimited number of nodes. This network is organized in subtrees, with the GTS being the root element of all of these subtrees and the tagged items as its leaves. The MLS being the root element of one subtree is called Exchange-Point-MLS (EP.MLS) as it will be located at an exchange point or hub in most cases. This tree hierarchy enables the GTS to ask a EP.MLS for a property of any element (MLS, Thinking Tag, other any othe tag) within the tree and the MLS is then able to route the request through the hierarchy until the target is reached. Likewise the response can be routed back to the GTS. Due to the physical boundary conditions of each MLS on the path from the GTS to the addressed tag, the used communication service may change from hop to hop. From a logical point of view, the interfaces between GTS and MLS (D-interface) and the inter-MLS interface (alos D-interface) should not be affected by these physical circumstances. Also the possibly proprietary interfaces (E-interface) between MLS and various tags must be invisible. In addition the necessary effort to be able to support the given interface over new bearer services should be minimal.

Thus, the application level interface of the MLS and its implementation has been completely separated from communication management, see Figure 5, to achieve a network (bearer) and protocol independent information exchange and method invocation via asynchronous exchange of XML messages. Also requirements towards mandatory services of the used bearer services have been kept low.

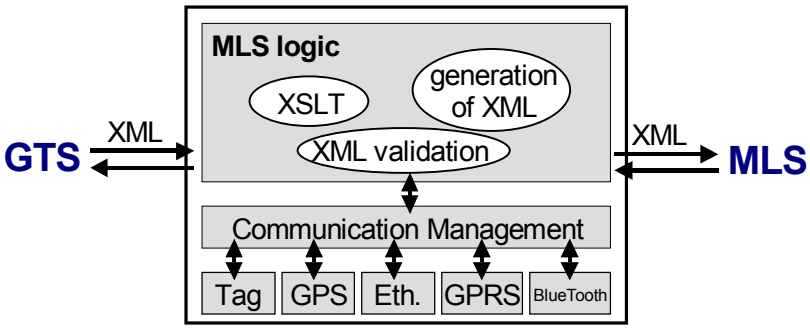

Figure 5: Mobile Logistic Server

The MLS only receives and sends XML messages over its communication manager. These XML messages describe the D-interface and are, because of their limited size and good opportunities to be encoded, also well-suited for packet-data switched mobile networks such as GPRS. Additional need for communication, e.g., with tags or GPS is done over the proprietary E-interface. Beside its own logic the MLS may validate incoming XML messages and transform them into its own XML-format. However, ideally this communication is not necessary.

IV. The D-interface

Within this paragraphs the D-interface of the MLS, which is used for the communication between the MLS and the GTS, respectively other MLSs, is outlined. The general framework for all messages of the D-interface is shown in Figure 6.

```
<?xml version="1.0" ?>
<ParcelCall>
        <ParcelCall-Header>
                <entityURI>parcelcall://mls-HH-AK25/</entityURI>
                <!-- optional elements -->
        </ParcelCall-Header>
        <ParcelCall-Body>
                <!-- MLS interface related element(s) -->
        </ParcelCall-Body>
</ParcelCall>
```

Figure 6: MLS skeleton XML message

Each message contains a header (ParcelCall-Header) and a body element (ParcelCall-Body) within the message root element (ParcelCall). The task of the header element is to carry the mandatory entityURI element and other optional elements, e.g., for error handling. The entityURI contains routing information for the MLS. Starting with the name of the EP-MLS it lists the names of each node within a subtree the message has to pass separated with '/'. This information is analysed by each MLS, which receives a ParcelCall message, to determine if further processing of the message is needed (this MLS' name is the last name in the URI) or if this message has to be forwarded to the next node either upwards or downwards the hierarchy.

Within the body part elements related to a required method invocation or result values are situated. These elements represent the virtual interface of the MLS and provide methods for maintenance of the hierarchy of MLSs and tagged items, for setting and retrieving properties and for event notification. Table 1 gives an overview of the used elements within the ParcelCall body related to the D-interface.

element name	direction	Comment
registerEntity	to the MLS	adds an entity as child to the addressed MLS
unregisterEntity	to the MLS	removes a child from the addressed MLS
getAllEntities	to the MLS	retrieve the names of all entities related to this MLS
registerParent	to the MLS	adds an entity as a new root node to this MLS
registerParentACK	to the GTS	acknowledgement of the precedent message
loadEntity	to the MLS	load an entity virtually without scanning it
entityLoaded	to the GTS	indication to the GTS of loaded entities
unloadEntity	to the MLS	unload an entity virtually without scanning it
entityUnloaded	to the GTS	indication to the GTS of unloaded entities
setProperties	to the MLS	set porperties of a tagged item or MLS
getProperties	to the MLS	retrieve properties of a tagged item or MLS
getAllProperties	to the MLS	retrieve all properties of a tagged item or MLS
properties	to the GTS	property information of entities
enableEvent	to the MLS	enable event/watchdog functionality
disableEvent	to the MLS	disable event/watchdog functionality
event	to the GTS	event/watchdog notification

Table 1: XML elements

In Figure 7 an example message, which could be a response to "getAllProperties" message, is shown.

```
<?xml version="1.0" ?>
<ParcelCall>
        <ParcelCall-Header>
                <entityURI>parcelcall://mls-HH-AK25/</entityURI>
        </ParcelCall-Header>
        <ParcelCall-Body>
                <properties>
                        <entityLP>parcel001</entityLP>
                        <property Name="TEMPERATURE" Value="20" />
                        <!-- further properties … -->
                        <entityLP>parcel002</entityLP>
                        <!-- further properties … -->
                </properties>
        </ParcelCall-Body>
</ParcelCall>&
```

Figure 7: Example properties response message

V. Conclusion

Carriers in transport and logistic work in heterogenous environments. To allow seemless T&T applications in these environment the ParcelCall project has decided to use XML documents as information interface between the different components in a logistic system. These standardized XML documents represent virtual interfaces of the different components and are easy to read and unterstand. In this paper mainly the concept and the functionality of the MLS component of ParcelCall's T&T system has been elaborated. The MLS receives, sends and validates XML messages asynchronously via its sophisticated communication manager. Through this unit a network and protocol independent information exchange is achieved. The XML messages send and received by the MLS are, because of their limited size and good opportunities to be encoded, well-suited for packet-data switched mobile networks such as GPRS. Thus, the authors have shown how they adapted latest developments in XML for transfering real-time information of freight over different access networks, in particular public cellular mobile networks. The feasibility of this technical approach to current problems in the transport and logistic branch, has been tested and proven in a three phased field during the lifetime of the ParcelCall project.

References

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