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Baltic Air CargoNet

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Future Concept for an Air Cargo Information Systems (F-ACIS)

includes:
Concept concerning new application forms of
service oriented ICT-methods and technologies within the AirCargo Sector

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Abstract

In an interconnected world, the need to exchange information across domain's boundaries is increasingly common, the concern is rapidly moving towards defining the content that needs to be consumed by numerous and different actors using different platforms and/or software solutions, since the internal processes have been consolidated and optimized. The transport logistics sector is no exception, the main issue in this domain is for ICT applications that allow to tag, monitor and transmit information about the freight along the whole transport chain, thus guaranteeing an efficient communication among the supply chain actors for a prompt intervention and resolution in case of problems and in general to increase the transport efficiency.

In this paper, the Concept concerning new application forms of service oriented ICT-methods and technologies within the Air Cargo Sector will present the technical aspects for an concept of a **Future Air Cargo Information Systems (**F-ACIS) developed in the BACN project and will link them to the concrete in-field applications that make the platform a great innovation and a step towards the realization of the Future Internet.

1 Introduction

Freight transport itself is a very complex system that is affected by globalization effects, integration of different transport modes, geographically distributed operations, extended business models etc. Complexity is furthermore increased by the **need for the real-time response** on the unexpected situations detected during the transportation phase (e.g. weather conditions, strikes, accidents, etc.). In a very competitive market, demanding on-time cargo delivery and with existing SLAs with strict obligations, transport efficiency is a critical issue, and the ability for real-time detection and resolving of all possible obstacles and exceptions becomes a core competency for logistics operators.

Exchanging information related to the cargo is the first necessary step to control its status and be able to timely intervene and solve possible problems, thus ensuring its optimal and efficient delivery. Such a necessity calls for ICT applications that identify, monitor and transmit information about the freight along the whole transport chain and make it available to the supply chain actors.

Frequently changing requirements and emerging technologies and devices are some of the challenges to be faced when building an information system for the logistic sector. Furthermore, the majority of the deployed IT systems in logistics are highly centralized on the supply chain and it is difficult to exchange data and information with moving goods, therefore no real-time action and intervention from the supply chain actors is possible.

This concept describes the overall architecture and the main components of a dynamic SOA solution, aimed at solving the above issues. The architecture has been developed in the context of the an future ACIS project, that focused on freight transportation with special attention to the concept of Intelligent Cargo: "*self-aware, contextaware"* freight corridors, *"connected through a global telecommunication network to support a wide range of information services for logistic operators, industrial users and public authorities."*

2 The concept based on the Internet of Thinks (IoT) Approach

The concept of the IoT exploits the idea of the Internet as a global interconnected network of computers to describe a network where the objects and products that pervade our routines are all connected among each other.

In the IoT, all everyday devices, from smartphones to white goods and car computers, will be enabled to connect to a data network and exchange information [Gershenfeld et al., 2004].

The concept is based on the existence of objects that are able to process information and communicate with each other and the environment. The capabilities of self-awareness, context awareness and electronic networking abilities, typical of intelligent or smart things, are a high priority for the IoT [“Beyond RFID – The Internet of Things”, Brussels 2008].

The technology of smart objects relies in the first instance on identification techniques, such as those of Radio Frequency Identification techniques (RFID) and Electronic Product Codes (EPC), which are especially seen as the cornerstone of the Internet of Things [“Beyond RFID – The Internet of Things”, Brussels 2008].

The realization of information systems based on smart things imposes to face a number of issues. First of all, the capabilities of smart objects imply, from a purely architectural point of view, the need to integrate different communication standards and protocols into the smart devices, in order to ensure a certain degree of interoperability with different devices. Although individual resources can be intelligent and autonomous, integrating various intelligent resources is not trivial due to their typically dedicated and propriety nature [Meyer et al., 2011]. Open architectural environments with “plug-and-play” connectivity are a possible solution to achieve interoperability among the different autonomous intelligent objects [Jammes and Smit, 2005]. Moreover, the complexity and the large amount of data to transfer to the network for the purposes of identification and context description imply the risk to overload the network itself.

The Intelligent Cargo concept is a possible solution to enable the IoT in the logistics domain, as it applies all the capabilities and features of intelligent objects to the cargo items. In an IoT-like logistics, every cargo item can be individually identified and addressed and it contains a certain level of intelligence and information allowing an autonomous communication with other units and/or infrastructures without human intervention.

F-ACIS is in line with the approach outlined above, the basic concept of am F-ACIS is, in fact, an information services platform centered on the individual cargo item and on its interaction with the surrounding environment and the user, the Intelligent Cargo connects itself to logistics service providers, industrial users and authorities to exchange transport-related information and perform specific services whenever required along the transport chain.

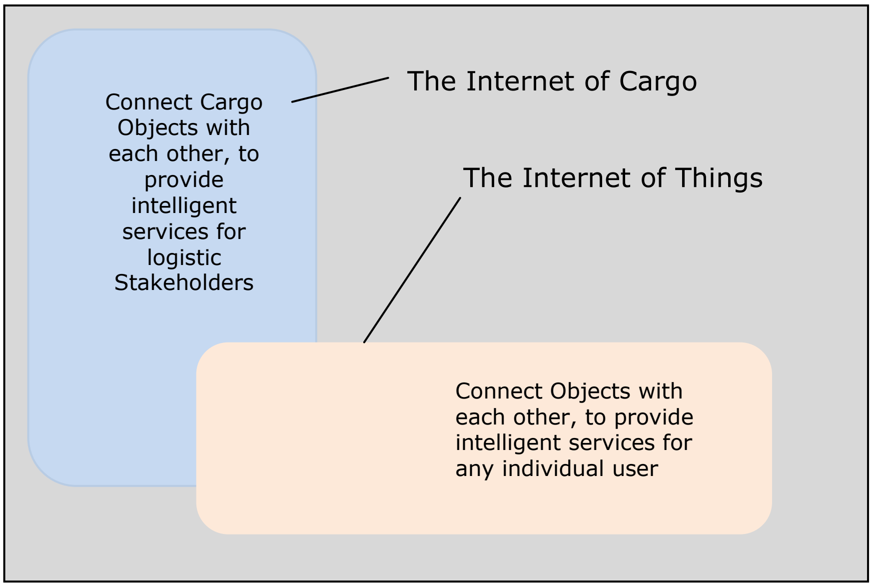

Figure 1: F-ACIS and the Internet of Things

To implement this, the F-ACIS provides a fixed and mobile web services infrastructure for public and private stakeholders to access and use the information they need on a cargo item at any point along its route across freight corridors, connecting the cargo with back-office and field staff.

In the F-ACIS , the Intelligent Cargo concept realizes an information system that allows the remote monitoring of cargo conditions all across its delivering and provides tools for real-time intervention in the transport chain. The F-ACIS provides a comprehensive framework that puts together services and software agents, logically and geographically distributed, capable of connecting and executing in interconnected nodes owned and managed by different stakeholders.

The main technical challenge in the realization of such an information system, is the above mentioned explosion of information, of possible decisions and of the related data volumes that should be transferred to and from the platform and across the network of smart objects. This difficulty is solved in the F-ACIS with the choice of delegating a portion of platform intelligence to the cargo itself by placing all relevant information on the cargo associated devices:

- all relevant information is at the right place to make decisions on site and in real time;
- the information at cargo level is sufficient to negotiate with interfaces successfully.

By deploying software components to mobile devices positioned on the cargo itself (item, pallet, container), onto vehicles, in storage areas, highway barriers, etc, the cargo becomes aware of its context, able to make autonomous decisions and to interact with the surrounding environment and the user through the F-ACIS infrastructure. In the F-ACIS, cargo identification is achieved through RFID active and passive tags, although also other older technologies are integrated to widen the spectra of interoperability. The devices on the cargo also act as sensor network manager reading data from the sensors and tags on the goods and transmitting them to the platform for further elaboration. The combination of identification with sensor information and satellite-based localization data, as is present in F-ACIS, allows a wide exploitation of the Intelligent Cargo concept, that goes beyond the identification purposes, enriches the information about the cargo item context, and allows to monitor the goods conditions (temperature, box orientation), early detect wrong routes, etc. In this way, for example, the thing in transit is able to make intelligent decisions on its routing based on information received either via readers or positioning systems.
The Intelligent Cargo, as it has been realized in F-ACIS and described hereafter, is not only adherent to the IoT approach, but also provides the completeness of an architectural framework and a business model. In fact, in the perspective of a pervasive application of Intelligent Cargo systems in logistics, the capabilities of the F-ACIS system will enable and support a number of operations and functionalities of the transport chain, such as:

- tracing of intra and extra company cargo flows;

- optimization of processes (warehousing, sequence of transport etc.);
- autonomous identification of events and the generation of decisions;
- visualization and control of the transport chains.

A number of functionalities have already been tested in pilot activities and shown a significant impact in the control and automation of transport and supply chain procedures. In all activities, every significant event or action triggered by the cargo came with the instantaneous, automatic alert (via email or communication on the backoffice tools or similar) of the interested actors in the supply chain, from the driver to the freight forwarder, to the final customer. These functionalities include:

- for trucks and on road deliveries:
- the control of the in-vehicle loaded and unloaded cargo, against the customer orders, and, upon arrival at destination, the automatic generation of the proof of delivery;
- the synchronization of combined orders, requiring little or no delay among the arrival times of the different transported goods, attained via scheduled calculations of the expected time of arrival of every cargo carrier and the cross-comparison of these values among the interested stakeholders;
- in case of perishable goods transported, the control and record of the cargo conditions, with particular attention to the temperature, and the timely notification of significant temperature change of the shipment;
- the on-route alert in case of bad weather or congested traffic conditions, triggering rerouting
- or nearby park-booking services. These services are based on the communication between the cargo and the infrastructures and result in messages displayed on the drivers mobile phone or on a similar device;
- the cargo anti-theft protection in parking areas, enhanced by the communication between the Intelligent Cargo and the security systems and security personnel of the parking area, e.g. triggering the security cameras to focus on the area of the vehicle and tape the possible relevant events;
- the monitor of the space occupied by the freight in the trucks of a 3PL company and the number of empty pallets and boxes. These data are predicted at the beginning of the delivery and monitored during it in order to optimize the levels of truck occupation.

Low levels of occupation are "sponsored" (Freight Space Advertisement) to allow the identification of the trucks that can return the empties without interfering with ordinary transport.

- for transport processes passing through ports and customs:
- support and automation of the procedures related to identification of cargo and of the related risk, to establish the need for security control;
- automatic fulfilment of the clearance documents and payment of the shipping duties through secure billing channels;
- automatic check and update of the cargo status after every step of the customs and port controls, to speed up the clearance of the cargo from the ship to the areas outside of the port and the warehousing areas.
- support in processes related to wagon fleets in intermodal transport;
- support in storage scheduling and deliveries forwarding for warehousing.

The impact on the global efficiency of the transport process from the application of the F-ACIS system is therefore expected to be extremely significant. By spreading the intelligence to the cargo, a number of operations, so far done only manually and occasionally, become automatic and constant or scheduled. Besides, the open framework that contains the F-ACIS solution allows new functionalities (e.g. sensor types, business cases) to be integrated into the mobile devices, thus enabling the continuous improvement and enrichment of cargo smartness.

3 Architectural Vision

Three major objectives have driven the design and realization of the F-ACIS platform:

- providing a highly adaptable platform behaving as a distributed service and application container for easy management of service life cycles, cross-domain security and communications. Adding, updating, removing, wiring – of services, domains, mobile devices, sensors networks - are all operations provided by the container.
- seamlessly integrating and managing mobile services executing on a series of non homogeneous mobile devices which provide access to real world items and attached sensors and actuators networks. Mobile services execution and communication patterns need to be highly dynamic and react according to the device physical characteristics and life cycle, network communication, etc.
- providing cross-domain secure data sharing and service invocation, where any hosts, nodes, services, devices and real world items must be accessible only through secure channels according to authorization policies defined by the different stakeholders.

In F-ACIS the Intelligent Cargo concept has been implemented decoupling the concept in two distinct logical and physical areas: the "fixed platform", for business and system services execution, and the "mobile devices", a network of different types of electronic devices, deployed into geographically mobile and sparse locations (vehicles, roads, companies locations, etc.).

Every device is enriched with a "local intelligence" through which different services – deployable at runtime and based on predefined and/or dynamic rules – can be called and executed either out of a "local" decision or triggered by requests from other nodes (devices and server services).

Both fixed and mobile devices have been considered, attached to a set of heterogeneous sensors and actuators (GPS, thermometers, odometers, pulse counters, accelerometers, etc.) and to local and wide area connection peripherals (GPRS/UMTS, WiFi, bluetooth, etc.). M2M and software agent technologies enable cross domain communication, data sharing and services relative to the deployment environments (nodes) across domain boundaries and with a strong security mechanism in place. New user applications, both internal and external, can be easily deployed and integrated. To achieve interoperability, data models are based on a set of ontologies providing the glue between domains and adaptable to evolving requirements and data definition.

F-ACIS is based upon a Service Oriented Architecture (SOA) and reflects the division into central platform and mobile devices, all functionalities are exposed as **Web services** and are accessible by other services, applications and agents via secured communication protocols, while the communication within the agent world is handled by the FIPA ACL Message protocol.

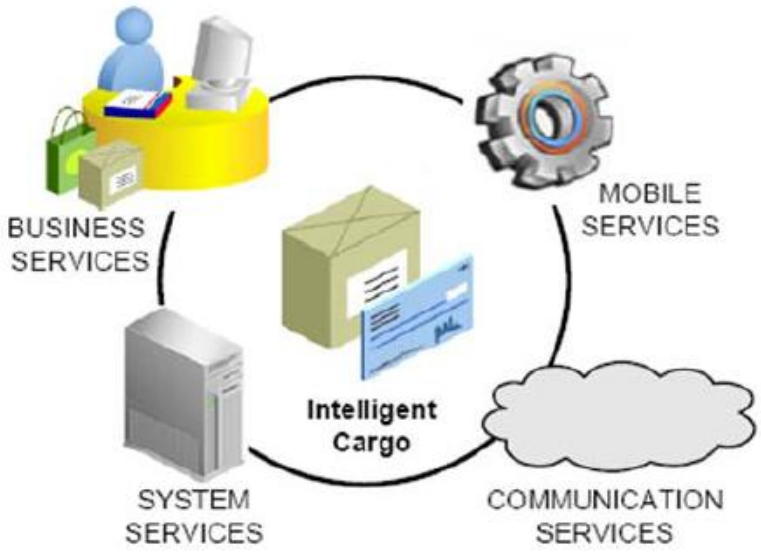

Figure 2: F-ACIS as a Platform of Services

In the fixed, central platform each service is implemented as a SOAP web service: a service can call another service, belonging to the same or to a different domain, via the security infrastructure. The identification mechanisms adopted are the common ones used by the freight industry, such as RFID and EPC, along with the EPCIS cross-domain data sharing infrastructure.

EPCGlobal specifications are extended in order to enable cross domain data discovery, that is not yet provided out of the box by EPCGlobal standards. The aim of this extension is to achieve a full distributed data storage and service infrastructure with a federated authentication and authorization system.

The architecture characterizing the mobile devices is based on the implementation of the "software agent" FIPA specification. Basically the pattern provides a distributed/networked environment where software components (agents) can execute, exchange messages with a standard protocol (ACL), be deployed, updated, removed, etc. A FIPA platform is composed of several containers, each deployed and executing on different network nodes. Within the framework, there are a fixed platform container and a set of mobile device containers, one for each capable device. In this architecture every service is exposed internally to the agent container as an agent behaviour and externally as a SOAP service, enabling the seamless communication among fixed infrastructure and mobile devices. The choice of an agent based architecture for mobile deploying of services aims at the realization of dynamic deployment capabilities on the mobile side. An agent can also be used to provide an appropriate driver to the device, in order to interact with sensors or other appliances previously unknown to the device.

Mobile devices are connected to sensors and actuators via a sensor network. Sensors can use different types of protocols to communicate data, such as RFID for identification or ZigBee for temperature reading, nevertheless they are homogeneously seen by the device and by the whole infrastructure. In this way, the functionality of sensor reading is kept decoupled from the concrete sensor implementation.

The architectural design is meant to cover a multi domain environment, to deal with services and data owned and managed by several domains. The communication between modules in the same node or distributed in several nodes handles data coming from possibly different domains. The applied security framework and the design of meta information, discovery and event service make sure that the correct authorization and authentication patterns are applied.

The cross domain security represents one of the most challenging elements of the whole framework. In a cross domain environment, it is mandatory to require both data interoperability between different systems and secure data exchange along with the possibility to have service invocations between different domains. A knowledge model based on identified and future ontologies and formalized in the Cyc format provides interoperability between partners. Such identified ontologies are used throughout the entire system to allow for data exchange, service context definition and reasoning capabilities. As a secure cross domain framework, the system must assure that an organization is able to expose only a subset of its own data to commercial partners, for example to protect its commercial interest.

The agent network deserves special care because multiple agents, built and deployed by different stakeholders, must run on the same device. JADE is used here as FIPA agent specification FIPA messaging is protected by the agent container using the same authentication token used by the SOAP call, therefore the agent and the web service world are connected by the same identification infrastructure.

4 Business model

In general, it is well known that a technological enhancement is not easily accepted by the final user as it implies a modification at organizational and operational level which means to devote resources and effort in changing consolidated habits and working flows.

On the other side, to define new business models it is necessary to understand the issues connected to the actual business model and see how an architectural approach could support such models and bring benefits to a company.

First of all we need to consider the major characteristics of the logistics industry and see how it could be improved to face the challenges posed by a global market.

In Europe transport and logistics services are provided mostly by SMEs, whereas the few big players tend to subcontract most of the low value activities (i.e. road transport) and are therefore far from controlling the overall highly fragmented traffic of goods.

The competition is still focused on minimized cost, while global market requires value added services to face the sustainability challenges, in a time when the environmental pressure is becoming more and more important, since logistics is one of the human activities with the highest impact on the environment and on society (traffic congestion, pollution, fuel consumption).

From an economic perspective, the actual model is based upon a closed cooperation among well identified actors that, in most of the cases, do not have means to support their collaboration.

Different actors use different ICT solutions that do not easily communicate with each other, which eventually causes a limited visibility and efficiency of logistics chains, a low capacities utilization (on vehicles & terminals), low levels of flexibility in logistics chains setup & operation, long reaction times, and the impossibility to manage unexpected situations due to a fragmentation in information publishing.

The F-ACIS architecture and its related services could potentially support and foster the collaboration among all different stakeholders involved in the value chain, though, during the project execution it became clear that the stakeholders who are closer to the cargo itself are the principal beneficiaries of the F-ACIS message.
Additionally, shifting the focus from the supply chain to the cargo, F-ACIS has set the basis for new business models that could improve the sustainability of the logistic processes and the efficiency of the transport phase (currently under development).
On the other hand the adoption of technologies is slow and difficult due to the perceived cost of technology, the lack of resources and the lack of opportunities for cost sharing.
The categories of users who will gain more from the F-ACIS Cargo Information Services platform are Cargo owners (manufacturers, distributors and retailers), who control large portions of the supply chain and need as much as possible accurate information on their planned and actual goods flows, as well as on any event that might disrupt these flows, and Third-party Logistics (3PL), operators who have as their core business the management of the customer's supply chain, and base their business success on improving the supply chain performances.

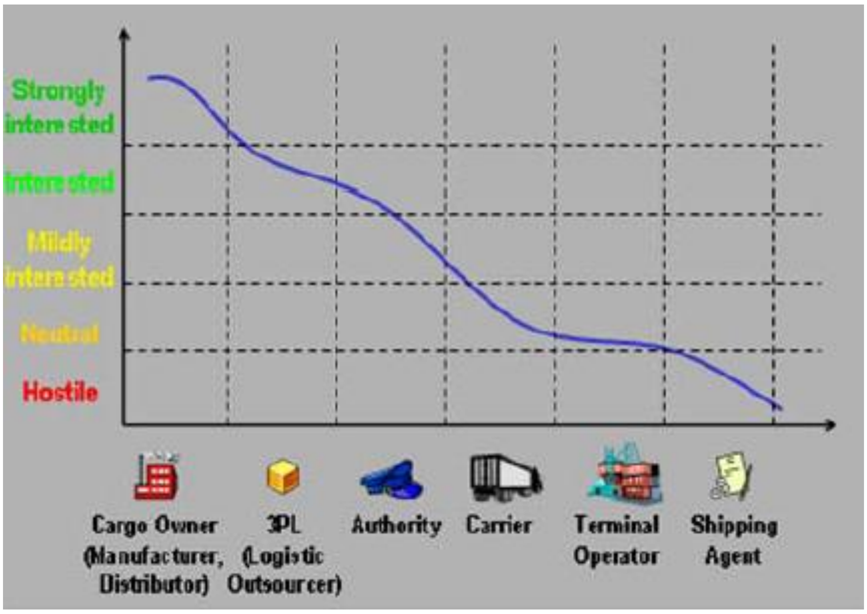

Figure 3: Stakeholders interest in Intelligent Cargo

Whilst past attempts to foster cooperation in the logistic chain have targeted one category of stakeholders as "promoters" since, due to their contractual power on other

parties, they could force them on board, the F-ACIS concept, like other similar approaches, builds on cooperation among different actors which are considered equal.
It is in the scope of a good business architecture to ensure a seamless collaboration and cooperation, based upon an appropriate responsibility and trustworthiness and using IT mechanisms to ensure that only authorized actors will be allowed to see business data (privacy/security/authentication and authorization).
Only in this way all involved actors will be able to overcome their natural hostility towards technology and data sharing.

5 Conclusions

In this concept, we have presented a future overall architecture and the main components of a dynamic SOA solution, developed for an future ACIS project, that implements the concept of Intelligent Cargo.
The solution adopts an Internet of Things approach in distributing intelligence on mobile, geographically spread devices and allowing them to communicate with each other as well as with a central platform. In this manner, F-ACIS provides a number of services including cargo localization, re-routing and monitoring of cargo conditions, to be performed without the human intervention.
The services offered by the F-ACIS system could be key in the development of new business models, focused on improving the sustainability of the logistic processes and the efficiency of the transport phases and targeting cases where the seamless collaboration between different stakeholders, working on different sectors in the logistics supply chain and using different levels and types of technology, is strictly required.
Due to its ability to retrieve real-time accurate information and exchange it among a secure net of interested stakeholders and to react to any event disrupting the normal supply chain flow, the F-ACIS platform could particularly match the interests of cargo owners and 3PL as business categories.

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