

# A SERVICE-ORIENTED INFRASTRUCTURE FOR ADVANCED CROSS-BORDER TRADE

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**Keywords:** Web services, service oriented architectures, SOA, e-commerce, smart seals, environmental sensors, public sector, IT innovation, cross-border trade, security, e-business.

**Abstract:** This paper presents an advanced e-custom infrastructure designed to streamline trade procedures, prevent potential security threats and reduce tax related fraud in cross-border trade. The paper focuses on the advantages of service infrastructure for the implementation of highly distributed systems, making use of internet to distribute and exchange data. In particular we highlight the use of service oriented architecture (SOA), web services, and smart seals in an integrated framework named EPCIS. The EPCIS system and its infrastructure are presented and analyzed in relation to the strategic objectives for future e-custom systems as expressed by the World Trade Organizations (WTO) and the authorities in major trading nations. The paper highlights the main advantages of use of such an architecture. The concrete case included in the paper illustrates how service oriented applications can ensure a more secure and advanced solution for monitoring goods along its supply chain. As a conclusion we highlight the fact that novel technologies are the main drivers of IT innovation, however the case study showed that organizational and political decisions are key for diffusion and adoption of such advanced solutions.

## 1 INTRODUCTION

In a fast-moving global economy, facilitating cross-border trade while at the same time increasing the security of trade are important objectives for governments worldwide. In order to facilitate cross-border trade, the EU member states have committed themselves to endorse 'a simple and paperless environment for customs and trade'. (Taxation and Customs Union 2007). Paperless trade is an important instrument to increase security development and revenues from international trade. At the EU level, the tax fraud alone is estimated at 200 to 250 billion Euros (EU Commission 2006). Electronic customs also aim to make customs clearance more efficient, to reduce administrative burdens, to serve fiscal interest, to increase the security of international trade and to enhance health and environmental protection. The big challenge for a next generation of e-custom systems is to cut red tape, to combat fraud and terrorism while at the same time allowing a seamless flow of data between export and import countries. Accordingly, EU governments are under pressure to introduce modern custom systems that increase the security of

international trade and reduce tax related fraud while at the same time lowering its administrative burden. (Bjørn-Andersen et al. 2007)

The European Commission has defined three strategic goals for e-Custom development in Europe: achieving pan-European interoperability, establishing Single Window Access Points, and granting Authorized Economic Operator (AEO) status to trading partners. These strategic initiatives are defined as follows:

- Pan-European interoperability involves that different European governmental systems will be able to communicate and exchange data independent of their heterogeneity and the different implemented standards.
- The *Single Window* initiative involves providing on-line 'Single Window Access Points' where businesses and public administrations can exchange the data required by legislation for the EU cross-border movements of goods. By January 2013 it is planned that the single window will replace the current 'silo solutions' (Taxation and Customs Union 2007).

- The Authorized Economic Operators (AEO) status may be obtained by businesses fulfilling certain requirements regarding their business processes. This involves a special partnership between the private sector and custom administration. Certified AEO will enjoy simplified trade procedures and fast custom clearance.

The EU envisages that the transformation of paper trade documents to electronic ones along with the redesign of custom procedures and the implementation of new e-custom systems will help achieve these objectives. This paper is primarily concerned with the description of a software infrastructure to support inter-organizational business processes for international trade. The focus is placed on the advantages of advanced e-custom systems. In particular we highlight the use of service-oriented architecture (SOA), web services and Tamper Resistant Embedded Controller (TREC) device in an integrated framework. The TREC is an intelligent wireless monitoring device mounted on a container communicating with a GPS (Global Positioning System) in order to position the container precisely. Apart from monitoring the physical location, the TREC device collects information related to the state of the container (e.g. temperature, humidity, ambient light, acceleration, door status). The Electronic Product Codes Information System (EPCIS) is implemented based on a SOA using an advance track and trace technology. The EPCIS system ensures a more secure and advanced solution for monitoring containers through the excise supply chain. It raises alerts in case of problems (exceptions) for cross-border trade. EPCIS system is designed to be compliant with EPCGlobal standards (see: [www.epcglobalinc.org](http://www.epcglobalinc.org)) and it's integrated in the EPCNetwork.

The remainder of the paper is organized as follows. The second section introduces EPCIS architecture in a concrete scenario of trade. The main building blocks of advanced infrastructures and their novel features are introduced. It provides a theoretical background of web services, service oriented architectures and smart seals. The 3<sup>rd</sup> section discusses evaluation results and the benefits of employing such a system in connection with the objectives addressed by the project. In the final section we conclude and discuss some challenges associated with the adoption of e-infrastructures and new e-custom systems.

## 2 A SERVICE-ORIENTED INFRASTRUCTURE

This section introduces the service-oriented infrastructure named EPCIS prototyped within ITAIDE<sup>1</sup>. The redesign of administrative procedures for international trade is subject of research within ITAIDE (Information Technology for Adoption and Intelligent Design for e-Government, [www.itaide.org](http://www.itaide.org)) project. The ITAIDE project is an EC funded project within the 6 Framework Programs which has two high level objectives: it aims to lower the administrative costs in international trade transactions while increasing the security and control of the trade procedures.

E-infrastructures can be defined as networks and webs that enable locally controlled and maintained systems to interoperate more or less seamlessly.

A concrete scenario of use in trade procedures is presented in Figure 1. In this scenario, businesses with AEO status will no longer have to submit the many export declarations to custom authorities. As mentioned earlier in the paper, AEO status is granted to businesses, who meet certain requirements regarding their security, quality, transparency and audibility of their business processes. The advantages are that the business is granted simplified customs and tax procedures.

As represented in Figure 1, BusinessCo makes its commercial data available from its Enterprise Resource Planning (ERP) system via an EPCIS database. Using specialized web services, custom administrations can access the commercial data at any time from the EPCIS database. In addition custom administration can audit BusinessCo periodically in order to make sure that the data provided are valid and updated. The international trade scenario involves three stakeholders: the business who exports goods, a carrier responsible for the shipment of goods and the custom administration. Currently the trade procedures based on silo solutions require businesses to submit various declarations containing commercial data. These various declarations often require large, redundant amount of data from businesses and represent a heavy administrative burden (Baida et al. 2007).

The architecture relies on a software-oriented architecture (SOA) that enables the deployment of

<sup>1</sup> ITAIDE (Information Technology for Adoption and Intelligent Design for e-Government, [www.itaide.org](http://www.itaide.org))

the solution in a geographically dispersed environment. The solution makes use of EPCglobal (Electronic Product Code Global) standard (EPCglobalinc 2007) for capturing shipment data. EPCglobal is the globally accepted standard that ensures universal applicability and optimal functionality across the globe for all industry sectors. This standard is intended to facilitate the development of interoperable systems for industries, commercial sectors and/or geographic regions and facilitate collaboration across industries independent of physical location and geography. The EPCIS Standard (EPCIS 2006) provides the foundation necessary for the capture, communication and discovery of EPC event data. In order to enforce security policies, the EPCIS portals are located behind firewalls which can be only passed by users from restricted IP addresses.

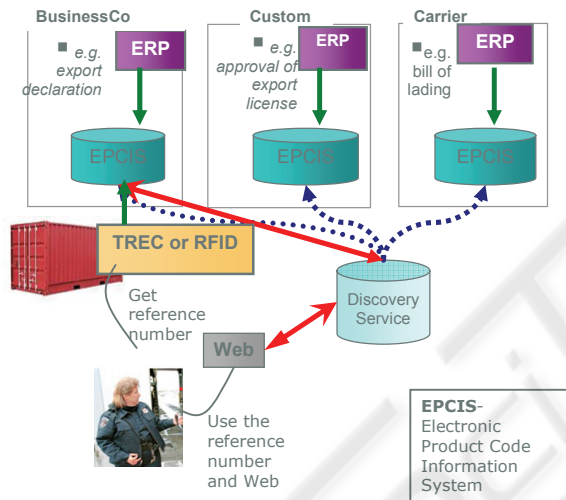


Figure 1: EPCIS distributed architecture, modified from IBM conceptual view of Secure Trade Lane.

EPCIS databases capture events related to the export declarations and other predefined events related to shipment data. The events are stored in EPCIS repositories of the parties that own the data and are made available to authorized parties.

Web services enable the tracking of goods as they move through the supply chain. **Web services** are software applications that can be discovered, described and accessed based on XML and standard Web protocols over intranets, extranets and the Internet (Daconta 2003). Initially the web service efforts focused on interoperability, standards and protocols for performing business to business (B2B) transactions. Web Services enables a new way to establish more flexible, low-cost connections across applications. Web services communicate using

messages. Web services are viewed as a next generation of web-based technology. Web services are emerging to provide a systematic and extensible framework for application-to-application interaction built on top of existing Web protocols and based on open XML standards (Curbera 2002). Typically, messages exchanges are using SOAP (Simple Object Access Protocol) and their description is done with WSDL (Web Service Description Language). A service provider publishes the service profile for a web service in a registry. A service requester, which can be a human agent, a software agent or a business application, finds the service based on the service description provided in the service registry and can execute the service. A business application subsequently sends a request for a service at a given URL using SOAP over HTTP. Web Services are built on a foundation set of standards and protocols, including Internet protocols (TCP/IP, HTTP). These standards enable the establishment of automated connections between applications and databases. The design and implementation of Web Services is associated with 3 basic aspects: communication protocols, service descriptions and service discovery. Industry specifications build on top of XML and SOAP standards.

**SOA** is an architectural style that has emerged in the last few years. SOA is a piece of software that implements a well-defined functionality that can be consumed by clients or other services regardless of the application or business model. Services communicate with each other by means of message exchanges. SOA provide a number of features that make them very advantageous to be employed in different business applications. The main characteristics of a SOA are: interoperability, loose coupling, isolation, composability, and machine processability.

The **Tamper Resistant Embedded Controller (TREC)** is wireless monitoring device that can be mounted on containers. It has been developed by IBM Zurich research labs. The TREC enables the creation of an audit trail of container movements and events from the point of origin to the destination. The TREC device collects and transmits information via a satellite network, a cellular system (GSM/GPRS), or a Wireless Personal Area Network (WPAN) based on ZigBee/IEEE 802.15.4 radio (Dolivo 2007). The information that can be collected and transmitted includes the location of the container and other parameters of the container (eg temperature, humidity, door status, velocity). Information related to the container's precise location can be sent to the different supply chain partners including custom administrations. Handheld

devices can also communicate with the TREC device. The TREC can process information, analyze events and control certain actions or predefined events (e.g. to open the door based on input from an authorized person in certain geographic areas, or to trigger alerts in case of deviations or abnormal physical conditions of the container). The tracking and security device (TREC) is mounted on a container and transmits data about the precise location of a container along its supply chain. The TREC is configured to signal when the container enters or leaves a predefined location and can detect the loading or unloading of the container onto or from a vessel. In the pilot scenario the TREC was set to monitor the containers' inside temperature and generate alert whenever the container deviates from its intended route. Specialized web services capture various events related to the shipment of goods, their location and/or container condition. Notifications and alerts can be triggered when containers deviate from their predefined route or other abnormal conditions occur, thus enhancing security of shipment of goods. The architecture is designed as a Secure Trade Lane. Secure Trade Lane (STL) is a solution for making container shipments more predictable and more secure.(Schaefer 2006). Supply chain visibility and security together form a compelling business case for monitoring container shipments globally.

The query interface is designed for obtaining and sharing data about unique objects in the supply chain within and across organizations based on an authorized access (Koldijk 2007). Compliant with the world custom organization recommendations, each container has assigned a Unique Consignment Reference (UCR) number and an identifier. This number is used by discovery services to search for data associated with the container within EPCIS database. Thus specialized web services enable authorized parties in the supply chain to retrieve timely data related to the status of the container. The stakeholders can also be notified by the system when the container arrives at its destination. This kind of notifications will enable the elimination of the current paper-based export evidence procedure.

### 3 EVALUATION RESULTS

The EPCIS system has been tested in relation with the export of beer from Heineken in the context of ITAIDE project. EPCIS has been implemented by IBM between July and November 2006.

Subsequently, between November 2006 and January 2007, 14 containers have been equipped with TREC devices and EPCIS pilot has been tested in two phases. The first pilot test has been shipped from Netherlands to United States (9 containers) while the second one has been sent to United Kingdom (5 containers). During the transportation phase the TREC could help as a 'witness device' for import/export procedures. When an export declaration is published an alert event is triggered to the custom authorities who can then calculate the risk and decide on whether a physical inspection is warranted.

Even the overall system worked according to its overall specifications, some glitches have been identified in the technical solution and further developments are in progress. For instance, the TREC functionality and its battery lifetime has to be improved, the register and query interfaces associated with the discovery service are only in beta version, and the discovery service is still to be finalized within the pilot. EPCIS does not only enable the publishing of custom declarations but it also enables the tracking of products through the whole supply chain. EPCIS is a massively, distributed, integrated solution based on SOA and Web Services. It allows authorized parties (custom administration) to track products through the whole supply chain (each party in the supply chain can track products). The TREC device also enables ubiquitous access to information about the location of the container, can trigger events/alerts in case of deviations from the predefined routes or unauthorized container access thus improving security and control. Web services enable ubiquitous, timely access to data about the container and support customs related queries. Web services integrated in service oriented architecture enable the implementation of the Single Window access concept. Finally, SOA and the use of EPCglobal standard ensure the interoperability of the proposed solution. SOA facilitates integration with other backend systems used by businesses and customs administration.

### 4 CONCLUSIONS

New technologies provide the technical platform to facilitate trade, and enhance security while cutting the red tape. The paper has presented a system operating in a novel type of e-infrastructure architecture. It has highlighted the advantages of such a system in report with increasing security,

facilitating the cross border trade, reducing transaction cost. The system is designed in line with strategic objectives of the WTO and the customs authorities in the US and EU. However, the technological solution is just a first step towards the diffusion and adoption of such an advanced e-custom system. The development of new e-custom solutions is a very complex issue that involves not only technical aspects underlined in this paper, but also organizational and political decisions. A complementary picture of the whole processes associated with innovation and transformation of e-Customs focusing on political, organizational aspects and control procedures are further discussed in publications from the ITAIDE project (Liu et al. 2007; Tan et al. 2006).

The establishment of the e-customs infrastructure described above is a huge task, which can only be addressed through an active involvement of government. A reduction in administrative costs for the business partners involved in cross-border trade can not justify the cost of migration towards e-infrastructures and new systems such as EPCIS, and therefore we think that the diffusion and adoption of such a new type of e-infrastructure or other innovative solutions should be reinforced through legislation and governmental support (Bjørn-Andersen et al. 2007; Scherlis and Eisenberg 2003).

In conclusion this paper highlights the fact that novel technologies are the main drivers of IT innovation, however the case study showed that organizational and political decisions are key for diffusion and adoption of such advanced solutions.

## ACKNOWLEDGEMENTS

This research is part of the integrated project ITAIDE (nr. 027829), which is funded by the 6th Framework IST programme of the European Commission (see [www.itaide.org](http://www.itaide.org)). We are greatly indebted to all participants of the project for their valuable contributions to the work presented here

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