# Deployment of Service Oriented Architecture for a Business Community

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## Abstract

*This paper describes the deployment of a Service Oriented Architecture in the specific context of the "Business Communities" i.e. Communities of heterogeneous actors that cooperate in the same business area. The architecture is based on XML and Web Services technologies.*

*More specifically the paper analyzes the structure and the requirements Business Communities in general, derives the requirements of the architecture and describes its implementation. Finally a case study is presented to show how the architecture has been implemented for the Business Community of the Port of Genoa characterized by users operating in the cargo and transport business area.*

## 1. Introduction

The evolution of the Internet is increasingly driven by the demand for applications in the business domain, so that a primary goal of the Internet Community is to make the network support business and commercial relationships among enterprises, in a *secure* and *efficient* way. *Business-to-Business* services, frameworks and infrastructures enabling integration and safe communication among companies using the Internet are the main research topics in this direction. Among the new technologies, the *Web Services* are emerging as the basic methodology to support the integration of applications and systems of different companies and organizations using open Internet standards (HTTP and XML) (e.g., see [1][2][4][5]). Web Services is a promising approach to the problem of "communicating on the Internet" among enterprise information systems that several previous technologies, such as CORBA, do not solve [3].

This paper focuses on the deployment issues of Web Services in a specific business context formed by cooperating enterprises belonging to the same business area, covering different parts of the service/product chain and coordinated by a business expert. We called this specific business context a "*Business Community*".

The concepts and the results presented in this paper, including the definition of Business Community, derive from the experiences done working on several projects funded by the Italian Government aimed at designing the network service architecture for the transport operators located in the Port of Genoa[1].

The aspects that characterize this work are related not only to the technology but also and especially to the application of the technology to Business Communities, namely:

- The analysis of the specific requirements of a Business Community, i.e. the features and functionalities that network services and infrastructure should provide to support a Business Community
- The definition of the guidelines and of the methodologies to deploy the services in a graceful incremental way, providing different User Access Points to the partners of the Business Community and offering possible participation to the community for business entities at different speeds of information technology evolution
- The definition requirements and of the functionalities of a communication infrastructure supporting the Business Community and supporting the deployment methodologies defined.

The main contributions of the paper can be summarized as follows:

- A conceptual definition of "*Business Community*", i.e. an organization of enterprises sharing a common business area and interacting to perform commercial transactions, that can be instantiated in many different contexts (from Public

[1] The projects involved the University of Genoa (project coordinator), the Port Authority of Genoa, and several system integrators and were carried out according to the guidelines stated by the Italian Authority for Informatics in Public Administration (AIPA).

Administrations to private organizations)

- A study on the integration among the operators (enterprises) of the Business Community, defining the guidelines for a *distributed*, *peer-to-peer interaction* among the operators, opposed to a centralized architecture where every operator is client of a single service provider
- The definition of the *Business Community Service Infrastructure (BCSI)*, providing the infrastructure for the integration among the operators, exploiting XML structured information [8] and emerging technology such as the Web Services [1][2][5] and the UDDI Registry [6].
- The integration within the BCSI of a *Security Infrastructure*, namely a Public Key Infrastructure [10], to enable secure transactions between the trading partner operators based on Digital Signature [11] [12].
- The application of best practices to *deploy network services*, ranging from simple Email services to Web Services, based on such infrastructure. The application took place within the business community of the Port of Genoa, involving the Maritime Cargo Transport enterprises [13].

The paper is organized as follows. We first introduce the definitions of the actors having a role in the Business Community scenario and their requirements (Section 2); secondly we provide a description of the architecture of an infrastructure supporting the Business Community (the Business Community Service Infrastructure), along with the rationale for our architectural choices (Section 3); then we explain the method proposed to deploy the network services on this infrastructure (Section 4); finally we illustrate the case study (Section 5) and provide some concluding remarks (Section 6).

## 2. The Business Community

The application environment for these experiences, which lead to the definition of the infrastructure and related methodology, has been provided by a government-funded research project [13] targeted at the development of a communication system for the community of operators (enterprises, agencies, small companies, offices) of the Port of Genoa.

The business of the Operators of the Port of Genoa is the provisioning of logistic services (handling, management, transport, etc.) for maritime freight transport (Cargo). The system that supports the cooperation among the Port Operators is called Cargo Community System.

A good abstraction for such an environment can be provided by what we call the "**Business Community**" model. A Business Community is a community of heterogeneous and autonomous users, **Business Operators,** tied together by a common business. A Business Community can be described as a set of enterprises that:

- Share a common market sector (like the cargo freight transport, in our case)
- Hold existing mutual business relationships
- Are heterogeneous with respect to their roles, i.e., they are involved in different activities within the same market (different part of the product/service chain)
- Are heterogeneous with respect to their size and information technology level, that is they range from small professional offices to large companies
- Are coordinated and supported by a **Business Authority**, who is generally an expert of the specific market (like the Port Authority, in our case)

We can find this type of organization in various contexts, for example in public administration and government, complex business organizations, etc.

The strength and the cohesion of the Business Community, both internally and with respect to external business partners, can take advantage of the existence of deployed network services that can improve the communications between Business Community Operators; such services should enhance common trading practices and take place on communications infrastructures enabling secure transactions.

In the case of the Port of Genoa Business Community, the advantages have also impact on the improvement of the freight mobility, speeding up the whole freight transport process, enhancing the overall quality of the offered transport services and reducing the impact on the transport infrastructures like motorways, railways, ship terminals, etc.

### 2.1. Requirements of a Business Community

In order to reach a better comprehension of the type of network services and infrastructure to deploy, we have first analyzed the requirements that a Business Community presents, based on the experience of the Port of Genoa Business Community:

1. **Pervasivity**: all the Business Community operators should be able to access the services independently of the characteristics of their infrastructures (e.g, network numbering, firewalling policies, etc.).
2. **Interoperability**: the services should allow communication not only between human operators but between enterprise information systems as well, enabling integration of application for business-to-business interactions; this interaction should happen independently of the base, middleware and

application software adopted.

3. **Openness**: the Business Community operators should be able to interact between them even in presence of different technological gaps and different internal system types and organizations
4. **Extensibility**: the Business Community partners should be able to update the formats for data interchange and the protocols for software interoperability with rapid and low cost upgrades, even in presence of radical innovations in the application domains and in the technological scenarios.
5. **Security**: the Business Community partners should be able to exchange message or do transactions with guarantees of authenticity, integrity and secrecy
6. **Service Provider Independence (unbundling)**: the Business Community operators should not be forced or compelled to use a unique or privileged service provider to access network services and applications; in other words, support to Business Community operators must be allowed to more than one single actor.

## 2.2. Models of network services infrastructure

We can distinguish two types of architecture that can be the base for providing services to support a Business Community:

- **Centralized services model**
- **Distributed, de-centralized services model**

The centralized services model is generally based on a single provider, which deploys all the services accessed by the Business Community operators. According to this model, the Business Authority generally plays the role of the service provider.

Figure 1 provides a graphical description of the centralized services model.

This kind of organization is the most common, but it does not fulfill the requirements since

1. Service Provider Independence is not achieved, due to the presence of a single service provider.
2. Interoperability is not achieved due to the fact that service implementations are hard-wired at the service provider's site and details of services interfaces are difficult to be known by Business Community operators willing to integrate an enterprise information system.
3. Security is an obstacle to the service provider, since processing of service request by the operators often needs that the provider discloses requests thus preventing the securing of data with encryption of service request content by the operators.

According to the distributed services model, while

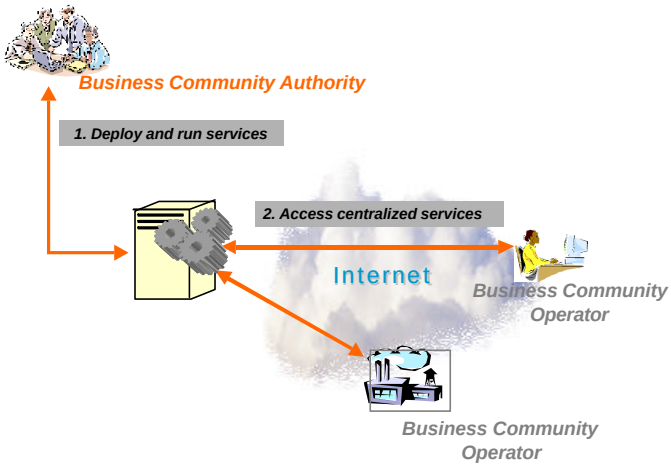



***Figure 1: Centralized Services Model***

services are not provided by a single provider, they are deployed at the Business Community operators' site, so that the interaction model becomes more similar to a **peer-to-peer** communication among the Business Community operators.

The type of interaction taking place within the Business Community actors adopting a distributed service model can be summarized as follows:

1. The Business Authority is in charge of maintaining the communication infrastructure that enables secure communication services, definitions and recommendations for application service implementations, and commonly agreed document exchange format for transactions, also capitalizing on its knowledge of the business sector
2. The Business Operators discover the definition of services and provide implementation of the services to the other operators, in a peer-to-peer fashion, conducting secure transactions over the secure communication services.

Figure 2 provides a graphical description of the distributed services model:

Within the distributed services model, the Business Authority plays the role of managing an infrastructure that enables services provisioning and consuming by the Business Operators, rather than being the service provider. This seems more appropriate for a business expert and regulation authority, and leaves space for other service providers to exist (service provider independence).

Moreover, being the specification of services available as part of the infrastructure, interoperability can be achieved since the Business Community operators are aware of services details and can comply to the recommendations of the Business Authority (interoperability).

Since service provisioning and service consuming take place at the operator's sites (peer-to-peer), security can be

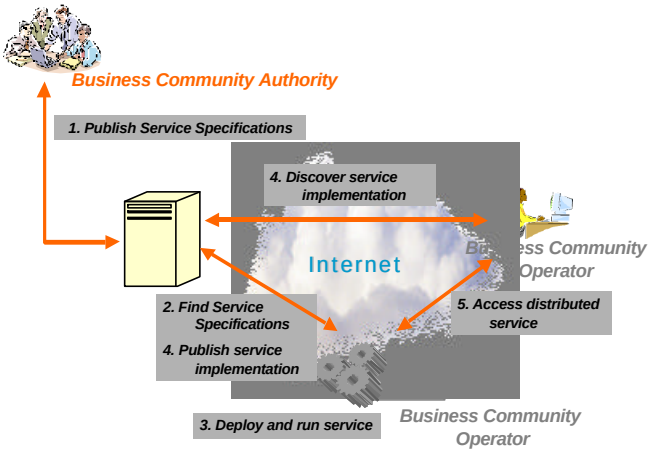



***Figure 2: distributed services model***

achieved by establishing suitable security policies for service content encryption (digital signature) [12].

Being the requirements satisfied, we took the decision to adopt the distributed services model, and the approach we have followed is based on the emerging technologies and methodologies of Web Services in order to set up a secure collaboration infrastructure for a Business Community, the **Business Community Service Infrastructure (BCSI)**, and the accompanying methodology for deploying network services. Security issues have been solved introducing a Security Infrastructure (PKI) [10] supporting peer-to-peer security between operators, based on Digital Signature.

### 2.3. Services Deployment Methodology

The task of publishing the service specifications is of crucial importance for the Business Community Services Infrastructure to evolve into an efficient and open collaboration infrastructure.

For this purpose, guidelines are needed for defining which type of services and which information is published on the registry and how the operators use it to deploy services (*services deployment methodology*).

The guidelines that have been adopted can be summarized as follows:

1) The BCSI architecture should rely on services that are available in all networks and operate across networks boundaries, independently of network types (i.e., Internet or Intranet), network configurations (e.g., Firewalling, Tunneling, NAT etc.) and network access (i.e., dial-up, always on). We anticipate that, according to this architecture requirement, Internet E-mail and Internet Web will be selected as base services, adopting SMTP and HTTP as transport protocols for all the services of the BCSI.
2) The BCSI architecture should support services that can evolve from the Base Services to more sophisticated services in a graceful process. The evolution is graceful in the following aspects:
   a) The evolution takes place in a appropriate time horizon
   b) The evolution is such that more sophisticated services are based on the less sophisticated services, recursively up to the base services.
   c) The user, who evolves along with the services and may slow down or speed up the evolution process, also controls the evolution.
   d) Appropriate frameworks aid the evolution and tools that make the transition to more sophisticated tools as much natural as possible.

We called this deployment methodology **Stepwise Deployment**.

In the following sections the Business Community Service Infrastructure architecture is discussed, together with the stepwise deployment methodology.

## 3. System Architecture: the Business Community Service Infrastructure

The system architecture must be the base for a communication infrastructure supporting the business collaboration between the different operators of the Business Community, as defined by the requirements.

Our main architectural choice is to model the infrastructure over a Service Oriented Architecture, but several recommendations and modifications to this model are needed due to the peculiarities of the Business Community, as explained in the following.

### 3.1. Architectural Choices

#### 3.1.1 Service Oriented Architecture

The infrastructure is an instance of a Service Oriented Architecture (SOA) [5] that enables the provisioning and the consuming of Business Services (Web Services)[1] [2], providing tools and infrastructure services to the business community operators for specifying, publishing, finding and binding business services.

The following features of the Service Oriented Architecture, partially satisfying the requirements stated in the previous chapter, are the rationale for this architectural choice:

- Integration of enterprise systems and collaboration using Internet wide transport protocols (HTTP/SMTP) (*Pervasivity* requirement)
- Interoperability achieved by exploiting XML formats [8] for document exchange and service

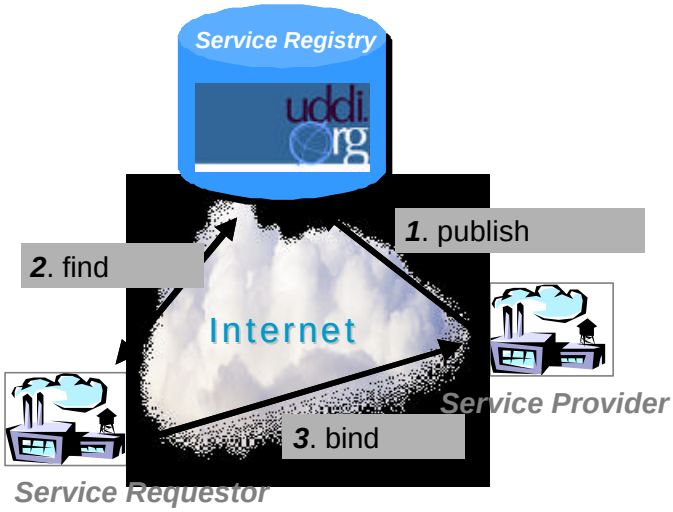



***Figure 3: Service Oriented Architecture***

access through SOAP protocol [4] (*Interoperability, Opennes and Extensibility* requirements)

- Registry-centric, distributed architecture adopting UDDI Registry [6] standard (*Distribution* requirement)

#### 3.1.2 Private, "Business Authority" managed UDDI Registry

Leaving the task of publishing the services templates (interfaces) to the Business Community Operators could lead to the existence of functionally equivalent services with different interfaces, or to the existence of services that are not relevant or useful for the business community. In other words, there is a need for a "harmonizing" actor who must be a domain expert (a "**Business Authority**"), who will be the responsible for publishing the services templates and who will run the Service Registry.

#### 3.1.3 Different levels of technology and different User Access Points

Service Oriented Architectures (and all the tools and commercial platforms by now available) aim at supporting the deployment of Web Services, which can be considered the last steps of the evolution of deployed services. In other words, there is a need for a "**stepwise**", **incremental** methodology in the deployment of services, as defined by the requirements, enabling the participation to the community of all the business operators, from the smallest offices to the largest companies (different **User Access Points**). In our case, it means that the deployment (publishing and adoption) of services must begin with simple, "base" services like free text Email message exchange and proceed towards Web Services.

Also, particular services must be identified which should be deployed in the middle of the evolution from base services to Web Services, and a methodology is needed to publish "software components" (like software plug-in modules) which can be downloaded by the operators and used in order to provide/consume the service. This particular services have been identified as **XML Email Messages,** and software components can be provided as plug-in components for popular email agents.

#### 3.1.4 Security Infrastructure

Since the system is used by Business Community Operators to conduct business transactions, as placing purchase orders, security is a key factor for the effective use of such an infrastructure. In other words, there is a need for an authentication methodology, which can ensure identity between trading partners. A Certification Authority [11], providing support for Digital Signature [12] and Public Key Infrastructure [10], which have been integrated with the Service Oriented Architecture, supports authentication.

### 3.2. Architecture Description

The following figure shows the components of the Service Oriented Architecture, and their relationships, providing the infrastructure needed by the Business Community (Business Community Service Infrastructure).

The key components of the architecture are the Service Registry, based on the UDDI Registry, and the Certification Authority.

The Service Registry is a Private UDDI Registry managed by the Business Authority. The Registry is

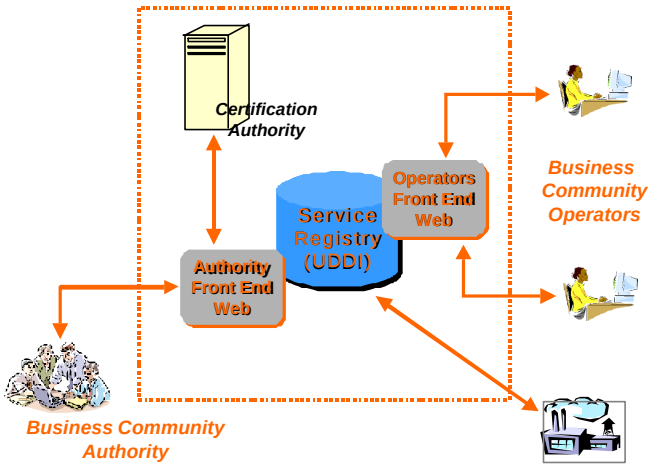



***Figure 4: Service Oriented Architecture for the Business Community (Business Community Service Infrastructure).***

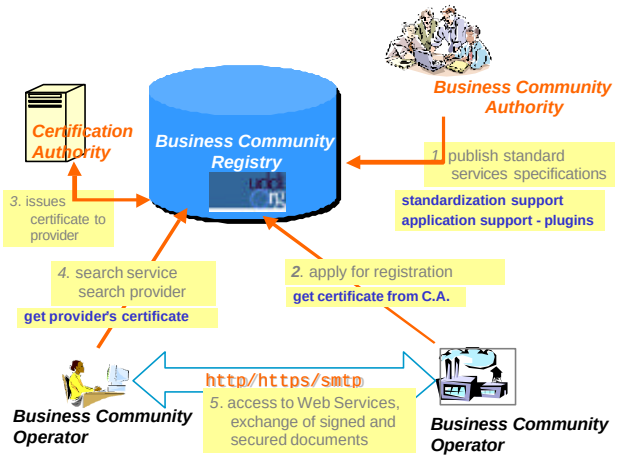



***Figure 5: Operation of the Business Community Service Infrastructure***

accessible by Community Operators either through the standard SOAP API [4] of the UDDI Registry, by external applications, or through a Web Front End (**Operators Front End Web**) by "human" operators

The Web provides functionalities to the Business Community Operators for

- Applying for registration and for receiving a **personal certificate** from the Certification Authority;
- Editing their own **Operator Profile** (the Registry UDDI Business Entity structure) containing specifications for their identities ("White Pages"), categories ("Yellow Pages") and services provided ("Green Pages") [6];
- Browsing and finding the other Community Operators profiles and the Services they provide;

The Business Community Registry is accessible by the Business Community Authority through a dedicated Front End Web (**Authority Front End Web**) that provides functionalities to the Business Authority for:

- Publishing the services models (the UDDI tModel)
- Managing the whole community profiles

The following figure describes the operation of the Business Community Service Infrastructure.

According to the previous picture, the following interactions take place:

1. The Business Community Authority publishes the services definition, like the interface definition for Web Services [7][9] and the XML Schema [8] for XML document exchange, on the Business Community Registry.
2. The Business Operators join the Business Community asking for registration and receiving a Certificate for Digital Signature provided by the Certification Authority.
3. The Business Operators provide an implementation for the services defined; the implementation can be speeded up, for certain type of services, by pre-deployed software components provided by the Authority as well.
4. Business Operators publish the implementation of a service on the Business Community Registry
5. Accessing the Business Community Registry, Business Operators can meet each other and discover provided services
6. Business Operators provide and consume services in a secure environment exploiting certificates provided by the Certification Authority for exchanging Email messages or accessing Web Sites or Web Services.

We now describe how this system architecture supports an "incremental", stepwise deployment of network services guided by the Business Community Authority (hereon, BC Authority), enables secure services access and document exchange and enhances the integration and cohesion of Business Community Operators (hereon BC Operators) at different User Access Points.

## 4. Stepwise service deployment methodology

The stepwise methodology is a key aspect in the deployment of the SOA for a Business Community. The BCSI architecture supports this methodology providing user access point at different levels, from Base Services to Web Services, at the different deployment steps.

Table 1 reports the deployment step details defined by the methodology and indicates, for each step, the preconditions for the deployment, the architecture components used (architecture support), the user access points visible to the user (user point of view), and the actions performed by the BC Authority (deployment issues).

Line 1 shows that the initial user's preconditions of the first step are fully affordable even to small offices, so that the BCSI deployment is almost free by any "digital divide" effect. At the following steps, the completion of the previous steps is the only precondition required, according to the incremental approach described in Section 2.3.

Line 2 shows that, from the architectural point of view, the BCSI UDDI initially works as a simple LDAP, i.e., a directory of E-mail contacts. Then it evolves as a registry of services organized to discover the opportunities for providing or taking advantage of services (step 2), and then it implements a database that allows integrating the functions of different information systems (step 3).

Line 3 shows that BCSI does not provides tools in any step of the deployment, except for plug-ins optionally

| Table 1 | | | | |
|---|---|---|---|---|
| | | **STEP1** | **STEP2** | **STEP3** |
| **Enabling Technology** | | Base Services (SMTP/HTTP) | Standard Services (XML) | Web Services (SOAP) |
| **1. Preconditions** | | Users Interconnected to the Internet (E-mail & Web standard clients)<br>User mailbox and optionally user's web site available | Step 1 completed | Step 2 Completed |
| **BCSI architecture support** | **2. UDDI Registry** | Contact information , e.g., name, E-mail… (White Pages)<br>Category information (Yellow, Pages) | Standard Service format (tModel)<br>Plug-ins download | WSDL specification URL (tModel) |
| | **3. Support (Client or Server side)** | None | Optionally, Plug-ins for XML editing<br>Optionally Plug-ins for XML parsing | None |
| | **4. Certific. Authority** | Issuing certificates with Non-repudiation key usage (for signed E-mails)<br>Issuing certificates with Data Encipherment key usage (for encrypted E-mails)<br>Issuing certificates with Key Encipherment key usage (for HTTPS) | Support for signed plugins. | Support for signed SOAP requests |
| **5. User Point of View** | | Editing profile through Web<br>Finding partners (E-mail or Web address, certificate) by White or Yellow pages through Web<br>Sending secret/signed E-mails to BC members<br>Accessing/Publishing secure web pages of/to BC | Finding Services to implement and provide, searching the Yellow Pages<br>Finding Services to access, searching the Yellow pages<br>Getting server plug-ins to provide services<br>Getting client pug-ins to access services<br>Exchange formatted messages and transactions through SMTP (optionally encrypted)<br>Publishing Services | Finding Services to export to BC partners information systems<br>Finding Services to integrate in one's own information system<br>Getting WSDL to develop interfaces to export<br>Getting WSDL to develop stubs.<br>Integrated Services through automatic SOAP request exchange among BC information system over HTTP and SMTP |
| **6. Deployment Issues (in charge of the Authority** | | UDDI Setup<br>UDDI Web Front/End<br>Certification Authority Setup<br>Integration UDDI/CA<br>Security Policies | Definition of XML Schema or adoption of *de facto* schema.<br>Publication/Accreditation of XML Schema for each Business Transaction | Definition of WSDL Service interfaces from existing XML<br>Publication of WSDL |
| **7. Role of third parties (independent of the Authority)** | | Providing Internet Access<br>Providing Office Automation Tools for Internet<br>Optionally providing signing devices (e.g., Smart Cards) | Developing XML plug-ins for operators | Developing modules integrated in the information systems |

Table 1 – Stepwise deployment.

released by the authority at the second deployment step. This fact puts in evidence that the Service Provider Independence Requirement (see Sect 2.1, item 6) is preserved also in the software provision.

Line 4 shows that the Certification Authority is the only component of the BCSI for which the deployment is necessarily immediate after the first step. However, this component however is in charge of the Authority and not of the users, so this fact does not impact on the pervasivity of the BCSI. Line 5 shows that, at the first step, the users regard the BCSI as a simple Business vertical Portal that allows finding partners and exchange E-mails with them or visit their web site in a convenient and secure way. At the following step the BCSI gradually becomes a repository of

technical rules written in XML [7][8][9] that promote the development of automatic services within the BC, using the XML language as a message format description language. At the third step the BCSI works also as a system integration facility that allows the cooperation of information systems of different BC operators, using the WSDL [8][9] language to describe the system interfaces.

Line 6 shows that the Authority plays a role prevalently technical during the first deployment step to set up the BCSI. From the second step on, the role of the Authority is to define and approve the standards within the Community, using XML and WSDL as description languages. The maintenance of such standards is the enabling factor of service deployment within the BC, and represents a characterizing aspect of the BC, i.e., the private use of UDDI register.

Lines 7 shows that third parties, i.e. hardware and software suppliers and network and application service providers, do not take part of the business application development in the first step. From the second step on, the role of third parties becomes technically more relevant, as they begin supporting the increasingly complex needs of the operators that progressively adequate their services to the standards issued by the Authority (step 2), and update their information system to cooperate with other information systems (step 3). It is worth noticing that the Authority does not mediate the relations between the users and the third parties.

# 5. Case Study: the Port of Genoa Business Community

Both the architecture and the stepwise approach described in the previous sections has been experimented within a project funded by the Italian Government having as its primary goal the design of a BCSI (called the *Cargo Community System*, CCS) for the transport operators located in the Port of Genoa [13].

## 5.1. Short Description of the Port of Genoa Business Community

The Business Community considered for this project is made up of business operators involved in the cargo, logistic and transportation business within the area of the port of Genoa. We named this Business Community the Genoa Cargo Business Community (GCBC).

The GCBC is characterized by the presence of a public authority, the Genoa Port Authority (GPA), which is the natural candidate as the Business Community Authority previously defined and a large variety of different type of participants (large companies, public agencies, small and medium sized enterprises, professionals) some example of which are:

- Shipping agencies
- Terminal operators
- Inland transport operators
- Customs brokers and operators
- Port Master's Office
- Port fire department

In most cases these operators act as both service users and service providers. In fact the participants into the GCBC exchange services within the community since they usually take care of a single step within the chain of steps that constitute the transport process. Thus each operator of the GCBC provides services to other operators involved within the previous step of this chain and needs services from the next operator within this chain.

In addition to the service users and service providers of the community there is also a number of potential users (e.g. business operators which needs to send or receive goods, transport business operators in different geographic areas) and potential providers of services (e.g. bank and assurance companies, central government agencies) external to the community.

## 5.2. Architecture deployment

The system deployed within the CCS follows the architecture described in section 4.

Table 2 reports the commercial components of the platform that has been used.

| **Table 2** | |
|---|---|
| **Component** | **Product** |
| Certification Authority | Baltimore UNICERT 3.5 |
| LDAP Server | Netscape iPlanet 2.4 |
| Application Server | Apache Tomcat 3.2 |
| UDDI Registry | IBM UDDI Registry Beta |
| Web Services Deployment Tools | IBM Web Services Toolkit |
| Client Plug-in | MS Outlook™ |
| Client Smartcard | Schlumberger Cryptflex |

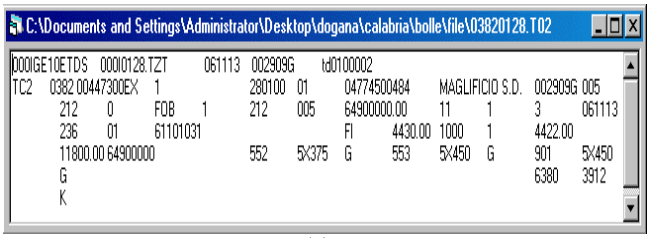
Within this framework the new type of services have been integrated with some existing services such as

- Cargo Manifest management
- Customs Tariffs
- Customs document exchange
- Hybrid Mail services

## 5.3. Stepwise deployment

As a case study of stepwise deployment this section presents the customs document exchange service. The exchange of documents describing a set of goods being imported or exported is part of the import/export procedures that must be completed in order to send or receive goods. A service supporting this procedure allows the freight forwarders to send the customs documents

electronically from their offices to the Customs Department and to obtain the acknowledgement of receipt and the response document from the Customs Department.

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(b)

***Figure 6: example of the EDI (above) and XML (below) document formats***

This raw service is presently offered by the Customs Department, that is an operator external to the GCBC, as a simple file transfer service based on the FTP protocol and available on a private access network based on the X.25 Italian public network (ITAPAC).

Therefore the raw service does not meet the user requirements because:

- The user interface is based on command line user interaction with no connection to office automation tools.
- The X.25 access network is not widely available
- The user support is poor (very limited call centre, no information about service health and performances, only manual transaction monitoring)

To meet the user requirements within the CCS this raw service has been deployed in the Business Community Service Infrastructure.

The first deployment step included:

- the set up of an application gateway that allows operators to send proprietary EDI formatted documents (see figure 7a) through a standard Web interface based on HTTPS (the Base Service), and
- the publication of the service implementation on the Business Community Registry.

The second deployment step included:

- the definition of a XML Schema that describes the customs documents (see figure 7b) and its publication on the Business Community Registry, under the responsibility of the Port Authority.
- the set up of a XML plug on the client side and of a XML parser on the server side for the editing and the processing of the documents, under the responsibility of the Service Provider.

The publication of the service implementation on the Business Community Registry and of the downloadable plug-ins, is under the responsibility of the Service Provider.

The third and final deployment step included:

- the definition of a WDSL document that describes the customs document exchange Web Service API, and its publication on the Business Community Registry, under the responsibility of the Port Authority
- the set up of the Web Service under the responsibility of the Service Provider that receives SOAP requests that include the custom document in XML format (see figure 7b) over HTTP/HTTPS.
- the publication of the service implementation on the Business Community Registry under the responsibility of the Service Provider
- the development of the Web Service client components integrated in the Web Service user's information system, under the responsibility of third parties.

The first and the second step of the deployment has involved 80 users of the GCBC and supported more than 130.000 transactions.

## 6. Concluding remarks

The paper described the results of a pilot project aimed at deploying the Web Service technologies in Business Communities. The main contributions of the work presented include *i)* the Business Community requirement analysis, *ii)* the set up of a deployment methodology based on a graceful approach called "stepwise deployment", *iii)* the design of a infrastructure based on Service Oriented Architecture specifically tuned for Business Communities and organized in such a way to support the stepwise deployment.

The lessons learned from this experience do not only cover technological results, while they are also related to business and service organization, defining the concepts of Business Community and Business Community Service Infrastructure; the BCSI will support the deployment, provisioning and consuming of services by all the members of the community, in a peer-to-peer and decentralized way, rather than providing centralized service implementation.

The results of this project have been validated, both from a technological and business point of view, through the set up of a pilot system in the Business Community of the Port of Genoa.

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