INTERNATIONAL JOURNAL OF EDUCATION AND INFORMATION TECHNOLOGIES
Issue 1, Volume 2, 2008

Definition of a Formal and Unified Model for a Smart Card based European-wide Electronic Seaman's Book

Fabrizio Lamberti, Simonetta Bettiol, Manuela Mallia, Andrea Sanna, and Claudio Demartini

***Abstract*—** The current scenario of sea transports is characterized by an ever increasing growth of people moved and wares exchanged, accompanied by significant advancements in employment and business opportunities. Unfortunately, education and training in the maritime field did not follow the same trend. Thus, on one hand, the sector is today characterized by a shortage of qualified workers. On the other hand, present training programs, certification instruments and competence standards are specifically managed at the national level, with a consequent lack of interoperability among international frameworks. Within the O.R.S.A. M.I.NO.R.E. project, the above issues have been addressed from a formal point of view, with the aim of defining a European-wide framework for the certification of seamen's learning and training outcomes. Given the transnational scope of the project, a unified modeling strategy based on an distributed Seaman's Book archive has been defined to homogenize the existing national experiences within a formalized electronic tool. Moreover, taking into account end users' mobility and security requirements, smart card technology has been integrated into the overall architecture, in order to allow seamen for a continuous access to their sensitive data. In this paper, project's results are presented, by showing the reference architecture, and providing details related to its two supporting components, namely the distributed electronic archive, and the smart card-based secure communication framework.

***Keywords*—** certification methods, distributed knowledge base, ontology, qualification profiles, Seaman's Books, smart cards.

I. Introduction

FOR centuries, sea has been considered as a central means for exchanging people and gods across countries. In particular, Mediterranean, and European countries in general, built up their politic and economic power by exploiting the numberless opportunities offered by the sector of maritime transports. Today, the European Union exchanges almost all its goods by the sea. Its transport sector is flourishing, and handles the largest naval fleet in the world. In this perspective it is quite easy to expect, for the mid-long term period, further developments in this field. This trend will be mainly determined by significant technological and organizational advancements, by the commercial exchanges' growth, as well as by the ever more marked shift to the choice of the sea as an effective alternative to road transports.

Despite the above scenario, the present situation shows a critical shortage of qualified seafarers, and it is characterized by a wide spectrum of difficulties related to the recognition – at an international level – of existing qualifications and certifications. In fact, in the context of maritime transports, different working contexts can be identified. Furthermore, with respect to a specific context (associated, for instance, to a particular ship's type or field of employment), different working areas can be further distinguished (like shipping, fishing, cruising, etc). Each area shows, in turn, a high degree of specialization, depending on the particular goods being transported on the considered ship, and/or on the specific navigation type being carried out by the ship itself.

Unfortunately, today's educational offer is not able to effectively match the professional needs which come out from the sector stakeholders, and does not prove to be capable of profitably dealing with time and requirement constraints emerging from a labor market that is stirred by extremely rapid changes. Moreover, qualification recognition is an extremely hard task to accomplish, especially when taking into account the lack of homogeneity of the transnational scenario, in which frequent mobility phenomena have to be addressed.

In 1978, in order to deal with the above difficulties, the international maritime transport organizations started working on the IMO-STCW convention. The final aim was to improve and homogenize the seamen' lowest standards of education and professional competences. Thus, the IMO-STCW'78 was proposed, and further extended with the IMO-STCW'95 revision. The main limitation of both IMO-STCW'78 and IMO-STCW'95 was that they had to be approved on a national basis. Thus, today there still exist countries in which the above

Manuscript received Jan. 23, 2008. Revised version received April 11, 2008. This work was supported the O.R.S.A. M.I.NO.R.E. "Organizzazione delle ceRtificazioni con applicazione di Smart cArd nei MestIeri e nelle inNOvazioni del maRE" project, funded under the Leonardo da Vinci programme (I/06/B/F/PP-154178).

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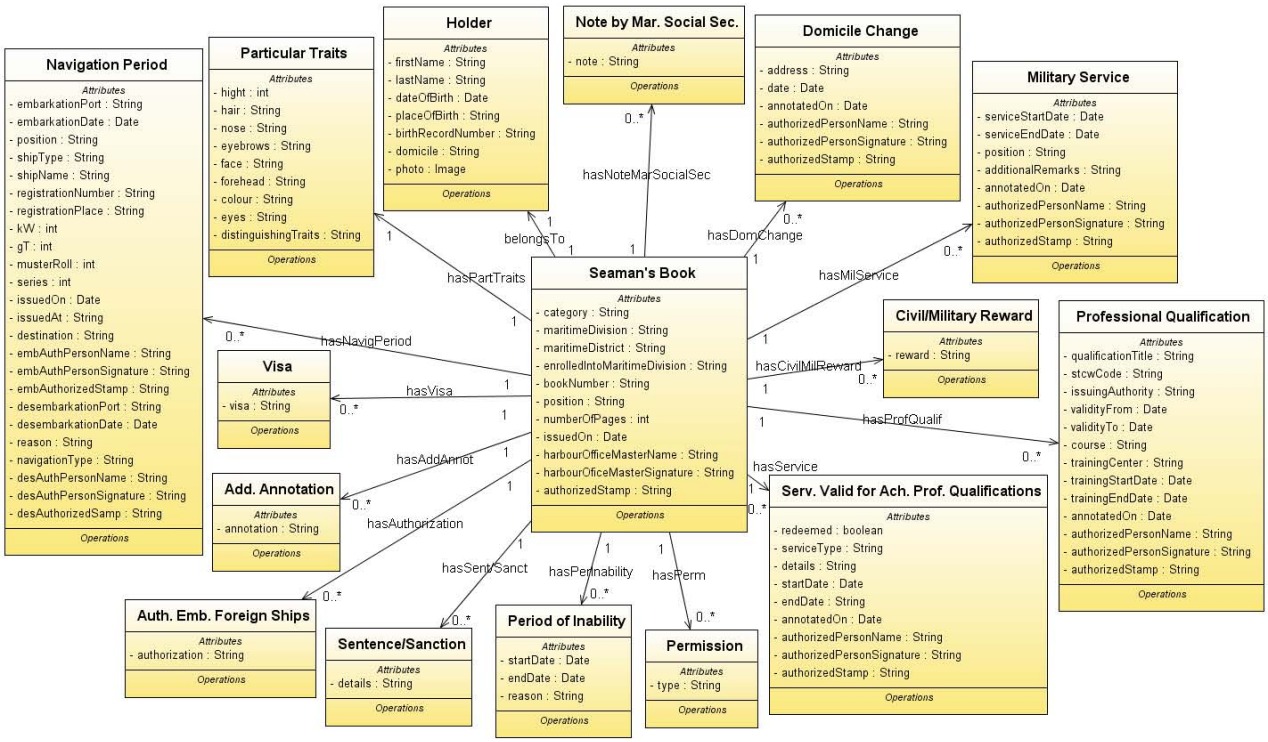

Fig. 1. UML diagram of the to the Italian Seaman's Book. A central role is played by the Seaman's Book class/concept, showing connection with all the remaining classes/concepts. Each class is endowed with a set of attributes, while each connection has a couple of multiplicity pairs.

recommendations have not been recognized at the national level, yet. In addition, it is also worth taking into account that, at the present time, ships are no longer considered as simple transport means, but they are progressively shifting into true enterprises. Thus, professional figures which are required today will need to further evolve, in order to be capable of (re)interpreting what it is ever more frequently referred as a complex "navigation process", in which ever more sophisticated and extensive knowledge, skills and competences (which are not addressed by recent regulations) will start to be requested by the labor market. Finally, seafarer's related data are currently recorded into a paper document called the Seaman's Book (SB), that has to be manually edited according to specific national rules. This further makes international cooperation and mobility a truly complex issue.

The global scenario summarized above results into a deep heterogeneity, that could possibly hamper the foreseen trend. The European plans aimed at solving these issues rely on adapting the education strategies to the emerging needs, while at the same time supporting integration among national systems, and fostering the improvement of present training modalities. By keeping in mind the experiences carried out in comparable sectors, these plans are expected to be supported by the integration of innovative ICT-based approaches derived from the emerging e-government solutions [1]. Thus, technologies like smart cards, digital signatures, and Web applications, among others, will be investigated as feasible methodologies to possibly improve seamen's (and workers's, in general) qualification and certification possibilities. In the following, it will be shown how European strategies have been declined into concrete developments and research activities carried out within various member states.

II. O.R.S.A. M.I.NO.R.E. Project Goals

The requirement above have been recently addressed by the O.R.S.A. M.I.NO.R.E. project (http://www.orsaminore.eu), funded under the Leonardo da Vinci European program. The main objective of this project was to make qualifications and achievements of maritime workers, which are today recorded into paper documents, readable within an international mobility-enabled scenario. At the same time, the project aims at allowing seamen's certifications recognition into a wider scenario, by fostering the adoption of suitable transparency measures. To reach this goal, the project proposes to integrate into the existing framework, ad hoc strategies based on a formalized description of seamen' professional profiles, shared through the use of smart card related technologies.

Smart cards, or integrated circuit cards, are pocket-sized devices that embed some kind of integrated circuits to handle electronic information in a secure way [2]. In the last years, smart card technology and related applications have been successfully applied into many concrete fields, since they proved to be capable of offering effective means for carrying out many types of electronic transactions in a secure, flexible, and standard way [2], [3]. Thus, electronic payment systems started to be developed by relying on smart card based architectures, thanks to their outstanding security features in terms of user authentication, data integrity and information

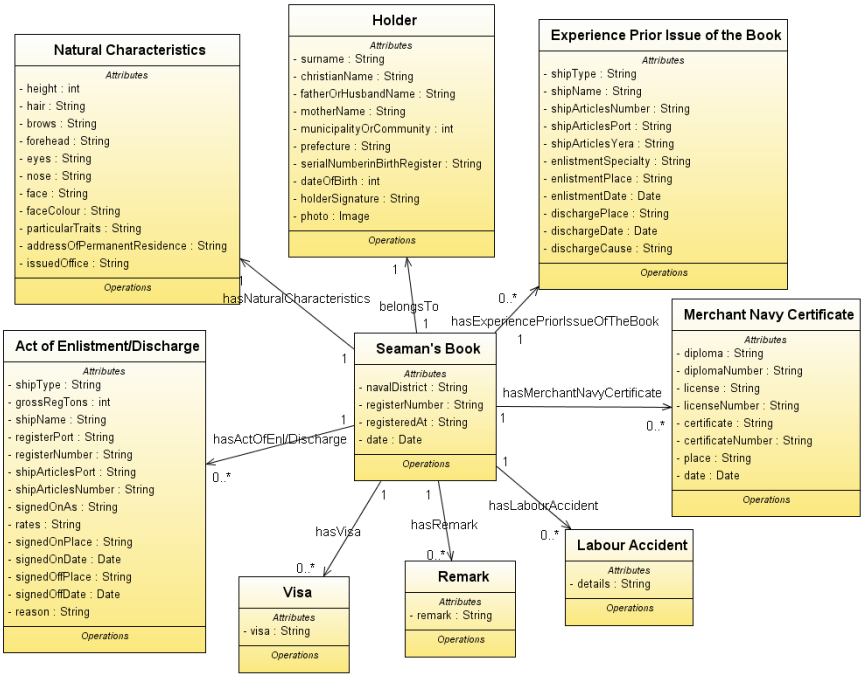

Fig. 2. UML diagram of the to the Greek Seaman's Book. With respect to the Italian Seaman's Book (reported in Fig. 1), the Greek document is characterized by a reduced number of classes, attributes and relations. Nevertheless, the central element is still the Seaman's Book class.

confidentiality [4]-[6]. With the progressive acceptance of Web technologies as a means for supporting social interaction, smart card based solutions started becoming ever more popular in e-commerce applications [7]. In more recent years, this technology has been profitably used into e-health, e-identity and e-procurement architectures, finally certifying smart card effectiveness in the deployment of sophisticated identification and authorization schemes in both national and international frameworks (citizen, drivers' licenses, and health cards [8], [9]). According to the homogenizing approach defined by the O.R.S.A. M.I.NO.R.E. project, smart cards become the main tool for supporting the migration of existing national-based SBs into a secure means providing transparent access to an electronic repository of seafarers' records distributed over the Web. The additional advantage of the above approach is that it allows to guarantee an effective traceability of the seamen's education and training paths in a seamless way. The expected migration process has to be necessarily supported by an accurate redefinition of the information currently recorded into national SBs into a shared knowledge base based on a formal description language (e.g., an "ontology") able to provide, from the conceptual point of view, those unifying capabilities required to favor a shared understanding of national details into a transnational scenario.

In this paper, the results achieved within the above project are summarized. In particular, the structure of current national-based SBs is analyzed in Section 3, while the modeling methodology followed for building up a shared international lexicon is discussed in Section 4. The architecture of the two main components of the proposed architecture (namely, the electronic archive and smart card based interaction framework) are illustrated in Sections 5 and 6, respectively. Finally, conclusions are remarks are reported in Section 7.

III. Formalization of National Seaman's Books

With the aim of defining a unified representation of seamen's related information allowing for the construction of the transnational repository and of the smart card enabled distributed architecture, in a preliminary phase of the O.R.S.A. M.I.NO.R.E. project the existing paper based SBs from the various European countries represented in the partnership (namely Greece, Italy, Netherlands, Romania, Slovenia, Spain, and Turkey) were collected and analyzed. The objective of this phase was to achieve an in-depth knowledge of the overall scenario, while at the same time developing a comprehensive lexicon with the whole terminology commonly in use within in the selected context.

For this, national SBs were individually analyzed together with related reference material (i.e. official documentation, national regulations, international agreements, etc.), and the core structural elements were identified. With the aim of fostering collaboration and getting a higher degree of mutual understanding capable of overcoming national specificities, a formal description recording inner details was produced for each SB. The above description was built by relaying on the well established UML (Unified Modelling Language modelling notation. In particular, UML class diagrams were used, since they allow for the construction of a structured view of any particular context of interest through basic notation entities such as classes (i.e. aggregators of instances, or concrete elements belonging to the domain under analysis), attributes (further detailing a particular class), and associations (i.e. relationships among instances/classes).

Field summ. from Seaman's Book	SI	ES	TK	RO	NL	IT	GR	UML attribute
Name of the ship	☑	☑	☑	☑	☑	☑	☑	shipName
Port of registry	☑	☐	☐	☐	☐	☑	☑	shipRegistrationPort
Registration number	☐	☑	☑	☐	☐	☑	☑	shipRegistrationNumber
Flag country	☑	☐	☐	☐	☐	☐	☐	
Type of the ship	☑	☐	☑	☑	☐	☑	☑	shipType
Gross tonnage	☑	☐	☑	☑	☐	☑	☑	grossTonnage
Engine Power	☑	☐	☑	☑	☐	☑	☐	enginePower
Type of navigation	☑	☐	☐	☐	☐	☑	☐	
Position/Function/Rank/Assignement	☑	☐	☑	☐	☑	☑	☑	rank
Port of embarkation	☑	☑	☑	☐	☐	☑	☑	embPort
Date of embarkation	☑	☑	☑	☑	☑	☑	☑	embDate
Name of auth. person at emb.	☑	☑	☐	☐	☑	☑	☐	embAuthPersonName
Signature of auth. person at emb.	☑	☑	☐	☐	☑	☑	☐	embAuthPersonSignature
Authorized seal at embarkation	☑	☐	☐	☐	☐	☑	☐	
Maritime Captaincy at emb.	☐	☑	☐	☐	☐	☐	☐	
Ship articles	☑	☐	☐	☐	☑	☐	☑	
Muster-roll	☐	☐	☐	☐	☐	☑	☐	
Muster-roster	☐	☐	☐	☐	☐	☑	☐	
Date of issue	☐	☐	☐	☐	☐	☑	☐	
Place of issue	☐	☐	☐	☐	☐	☑	☐	
Destination	☐	☐	☐	☐	☐	☑	☐	
Port of disembarkation	☑	☑	☐	☐	☐	☑	☑	desPort
Date of disembarkation	☑	☑	☐	☑	☑	☑	☑	desDate
Reason	☑	☑	☐	☐	☐	☑	☑	reason
Name of auth. person at dis.	☑	☑	☑	☐	☐	☑	☐	desAuthPersonName
Signature of auth. person at dis.	☑	☑	☑	☐	☑	☑	☐	desAuthPersonSignature
Authorized seal at dis.	☑	☐	☐	☐	☐	☑	☐	
Maritime Captaincy at dis.	☐	☑	☐	☐	☐	☐	☐	

Table. 1. Result of the analysis/comparison process on the SB's section dealing with onboard services.

For each SB identified by project's partners, all the sections were examined, and key conceptual elements (i.e. document fields) were identified. Then, UML diagrams were produced, by mapping SB's sections onto UML classes, and section fields onto class attributes. In these diagrams, class names roughly correspond to SB's section headlines, while attributes titles were defined from scratch by summarizing the meaning of the particular field being considered. The UML class diagrams produced, for instance, for the Italian and Greek SBs are illustrated in Fig. 1 and 2, respectively. In all the class diagrams, the central role is always played by the "Seaman's Book" class/concept that represents the overall container for all the other SB's concepts. It is worth remarking that this class also provides basic information (i.e. book number, date and place of issue, etc.), and it is connected with the remaining classes. Connections are indicated using UML directional associations, and are characterized by a name, and by a couple of multiplicity (cardinality) pairs.

IV. The O.R.S.A. M.I.NO.R.E. Electronic Archive

As illustrated in Section III, the formalization step carried out on national SBs was basically devoted at obtaining a precise knowledge of the "state-of-the-art" regarding the actual solutions allowing for the certification of seamen's entitlements and qualifications, as well as to keep track of their previous working and training history. However, given the fact the final goal of the O.R.S.A. M.I.NO.R.E. project is the deployment of a smart card based architecture supporting a shared view of common concepts, each national model was compared with the other ones, trying to find similarities, as well to identify hidden differences. In this way, improved support for workers' mobility can be provided, while at the same time supporting the development of effective lifelong learning solutions [10]. Thus, this procedure was carried out concurrently over multiple sections of the various SBs. This approach was requested by the heterogeneous structure of the considered documents, in which the same information could be recorded in distinct sections within different SBs. Because of national specificities due to the subsidiarity-based approach, it came out that SBs do not all require the storage of the same data (and in the same way).

```
<?xml version='1.0' encoding='UTF-8'?>
<librettoDiNavigazione>
 <movimentiDiImbarcoSbarco>
  <movimento>
  <luogoDiImbarco>Imbarco</luogoDiImbarco>
  <dataDiImbarco>Data imb.</dataDiImbarco>
  <inQualitaDi>Funzione</inQualitaDi>
  <tipoDiNave>Tipo nave</tipoDiNave>
  <denominazioneNave>Denom.</denominazioneNave>
  <numRegistrazioneNave>Iscr.</numRegistrazioneNave>
  <registroNave>Registro</registroNave>
  <potenzaApparatoMotore>Pot.</potenzaApparatoMotore>
  <stazzaLorda>Stazza lorda</stazzaLorda>
  <ruoloDEquipaggio>Ruolo</ruoloDEquipaggio>
  <ruolinoDEquipaggio>Ruolino</ruolinoDEquipaggio>
  <luogoDiRilascio>Luogo rilascio</luogoDiRilascio>
  <dataDiRilascio>Data rilascio</dataDiRilascio>
  <destinazione>Destinazione</destinazione>
  <nomePersonaAutImbarco>Inc.</nomePersonaAutImbarco>
  <firmaPersonaAutImbarco>Fir.</firmaPersonaAutImbarco>
  <timbroImbarco>Timbro aut. comp.</timbroImbarco>
  <luogoDiSbarco>Porto di sbarco</luogoDiSbarco>
  <dataDiSbarco>Data di sbarco</dataDiSbarco>
  <motivo>Motivo dello sbarco</motivo>
  <tipoDiNavigazione>Navigazione</tipoDiNavigazione>
  <nomePersonaAutSbarco>Inc.</nomePersonaAutSbarco>
  <firmaPersonaAutSbarco>Fir.</firmaPersonaAutSbarco>
  <timbroSbarco>Timbro aut. comp.</timbroSbarco>
  </movimento>
 </movimentiDiImbarcoSbarco>
</librettoDiNavigazione>
```

Fig. 3. Formal description of an excerpt of the Italian SB.

```
<?xml version="1.0"?>
<xsl:stylesheet xmlns:xsl="http://www.w3.org/1999/XSL/Transform" version='1.0'>
 <xsl:template match="/">
 <seamanBook>
  <servicesOnboard>
    <xsl:for-each select="librettoDiNavigazione/movimentiDiImbarcoSbarco/movimento">
     <service>
      <shipName><xsl:value-of select="denominazioneNave"/></shipName>
      <shipType><xsl:value-of select="tipoDiNave"/></shipType>
      <shipRegistrationPort><xsl:value-of select="registroNave"/></shipRegistrationPort>
      <shipRegistrationNumber><xsl:value-of select="numRegistrazioneNave"/></shipRegistrationNumber>
      <grossTonnage><xsl:value-of select="stazzaLorda"/></grossTonnage>
      <enginePower><xsl:value-of select="potenzaApparatoMotore"/></enginePower>
      <rank><xsl:value-of select="inQualitaDi"/></rank>
      <embPort><xsl:value-of select="luogoDiImbarco"/></embPort>
      <embDate><xsl:value-of select="dataDiImbarco"/></embDate>
      <embAuthPersonName><xsl:value-of select="nomePersonaAutImbarco"/></embAuthPersonName>
      <embAuthPersonSignature><xsl:value-of select="firmaPersonaAutImbarco"/></embAuthPersonSignature>
      <desPort><xsl:value-of select="luogoDiSbarco"/></desPort>
      <desDate><xsl:value-of select="dataDiSbarco"/></desDate>
      <desAuthPersonName><xsl:value-of select="nomePersonaAutSbarco"/></desAuthPersonName>
      <desAuthPersonSignature><xsl:value-of select="firmaPersonaAutSbarco"/></desAuthPersonSignature>
    </service>
   </xsl:for-each>
  </servicesOnboard>
 </seamanBook>
</xsl:template>
```

Fig. 4. A portion of the XML transformation stylesheet for translating the Italian SB to the European O.R.S.A. M.I.NO.R.E. common model.

Thus, for instance, the Italian SB is by far the most complete document in terms of sections; however, the format for filling-in a specific section's field is often left to the particular Port Authority and/or ship's master/owner. The main drawback of the above approach is that ambiguities and inconsistencies can possibly emerge. On the other hand, Greek, Romanian and Turkish SBs are three examples of extremely synthetic documents, in which only key data are recorded into a completely defined format. Results of the analysis/comparison process on the SB's section dealing with onboard services are shown in Table 1. In this table, the first column reports the fields which are related to the considered context (and their actual titles come from a summary of the fields' meaning). In columns from two to eight, a check mark is used to indicate the presence (or the absence) of the specific field. Selected countries are indicated in the table's first row.

By considering each single row individually, the number of check marks found gives a qualitative indication of the importance of a particular field in the transnational view. With the aim of defining a European-wide SB, two approaches are feasible: to define a comprehensive "container" able to record information from all the possible national records, or to find a common subset of fields capable of providing sufficient information contents. According to the unifying approach being pursued, in the O.R.S.A. M.I.NO.R.E. project the second strategy was followed. However, an approach capable of preserving national specificities was simultaneously adopted. The term "sufficient" used above needs an additional explanation: in fact, in the considered scenario, SBs are based on existing recommendations which are defined on a national basis. Thus, no field can be definitely removed without losing the expressiveness of the particular SB. Thus, in this case, the term sufficient actually means that, in almost all the considered situations, the selected subset should be able to guarantee the highest probability of successful understanding into a mobility scenario across multiple countries. Even if this choice has to be understood as a proposal, it allowed for the construction of the prototype of a European-wide electronic archive. Moreover, in the future, the selected strategy will possibly play the role of a forerunner experience to be taken into account by next studies in this field.

By applying the above methodology, a subset of the original UML classes/concepts was identified, and for each class/concept, a subset of information belonging to national SBs was extracted. For instance, an "Onboard Services" class was defined, that is characterized by the attributes reported in the last column of Table 1 (selected by applying a majority decision rule). In this way, a new UML class diagram describing the so called European Seaman's Book common model was defined. The construction of a unified model representing the unified vocabulary for the considered domain was only a part of project activities. In fact, even if UML diagrams can be used for creating a shared knowledge and for supporting a mutual understanding of a considered context, in the end, the integration of the newly generated information into a computer based system requires the expression of the model into a machine supported language (finally exploited by the unified O.R.S.A. M.I.NO.R.E. electronic archive).

```
<?xml version="1.0" encoding="UTF-8"?>
<seamanBook>
 <servicesOnboard>
 <service>
  <shipName>Denom.</shipName>
  <shipType>Tipo nave</shipType>
  <shipRegistrationPort>Registro</shipRegistrationPort>
  <shipRegistrationNumber>Iscr</shipRegistrationNumber>
  <grossTonnage>Stazza lorda</grossTonnage>
  <enginePower>Pot.</enginePower>
  <rank>Funzione</rank>
  <embPort>Imbarco</embPort>
  <embDate>Data imb.</embDate>
  <embAuthPersonName>Inc.</embAuthPersonName>
  <embAuthPersonSignature>Fir.</embAuthPersonSignature>
  <desPort>Porto di sbarco</desPort>
  <desDate>Data di sbarco</desDate>
  <desAuthPersonName>Inc.</desAuthPersonName>
  <desAuthPersonSignature>Fir.</desAuthPersonSignature>
 </service>
 </servicesOnboard>
</seamanBook>
```

Fig. 5. A portion of the common model produced by XSLT.

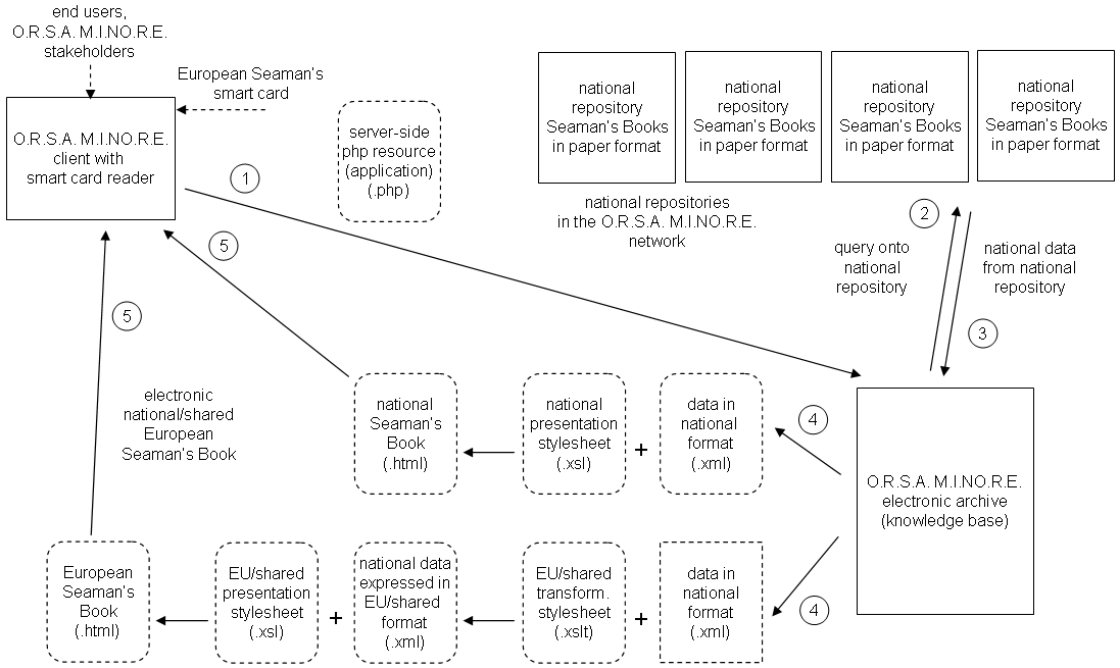

Fig. 6. Overall architecture of the O.R.S.A. M.I.NO.R.E. network. End users can (1) access the system through a workstation equipped with a Web browser and a smart card reader. A php application (2) interacts with the distributed repository and (3) produces a XML description of SB's data, that is "virtualized" in the unified electronic archive (4), and is then converted into a national or European (5) Web-based document.

Thus, the UML diagrams and associated data were translated into the XML format. The reasons for the choice of the XML notation were manifold. First, an immediate mapping between UML and XML can be achieved in a straightforward way. Moreover, the XML models preserve human-readability, while concurrently enabling machine based processing. Finally, if UML provides a way for describing the structure of data (but not the actual instances), XML adds the possibility of also including contents (today recorded into paper SBs), which need to be migrated into the electronic repository. Thus, an UML to XML translation step was carried out, by mapping both national and unified/ common models into XML schemas. Similarly, UML models were mapped onto relational databases (to be exploited in order to implement the necessary persistent data storage). Prototype databases were created, and populated with experimental data to be later used in order to validate system's effectiveness and performances.

V. The European Seaman's Smart Card

The objective of the O.R.S.A. M.I.NO.R.E. project was to integrate smart card technology into a scenario in which frequently moving subjects (i.e. seamen, and workers, in general) need to bring with them information (including qualifications, achievements and sanitary related data, etc.) that has to be shared into heterogeneous environments.

In this scenario, a secure certification scheme (which is today guaranteed by paper documents, authorized signatures and seals), is needed. When moving into a computer based scenario, sensitive data confidentiality and integrity has to be necessarily guaranteed with adequate tools and instruments. Given the above requirements, the device selected for the development of the prototype project architecture is a microprocessor-based smart card equipped with 64 KB of EEPROM memory and capable of efficient DES/3DES and RSA encryption/ decryption computations (Athena AseCard Crypto). A PKI infrastructure able to handle both seamen's and authorities' certificates to be exploited with the aim of securely accessing the distributed repository was deployed.

The surface of the plastic card can possibly allow to host basic identification information, that can be selected by following the above comparison procedure, and applying it to the "Holder" class/section (reported, for instance, in Fig. 1 and Fig. 2). Moreover, the persistent memory available on the selected device has been further exploited to record information which could need to be accessed even when a network connection to the proposed distributed framework is not available. In this case, information is securely stored in the exact format of the paper SB, thus constituting an exact replica of the national document (now in electronic format).

Despite the advantages in terms of privacy, the real benefits due to the introduction of smart card technology appear when this is used as an identification token for accessing the overall O.R.S.A. M.I.NO.R.E. system. In this case, the full potential of Web technologies, as well as of the proposed common representation, appear. In fact, national format can be automatically translated, upon request, into a unified notation favouring recognition and transparency into a mobility scenario (see Section 6). National data not included in the shared representation can be used to enhance the probability of system adoption by authorities that can be possibly reluctant to the introduction of this novel technology.

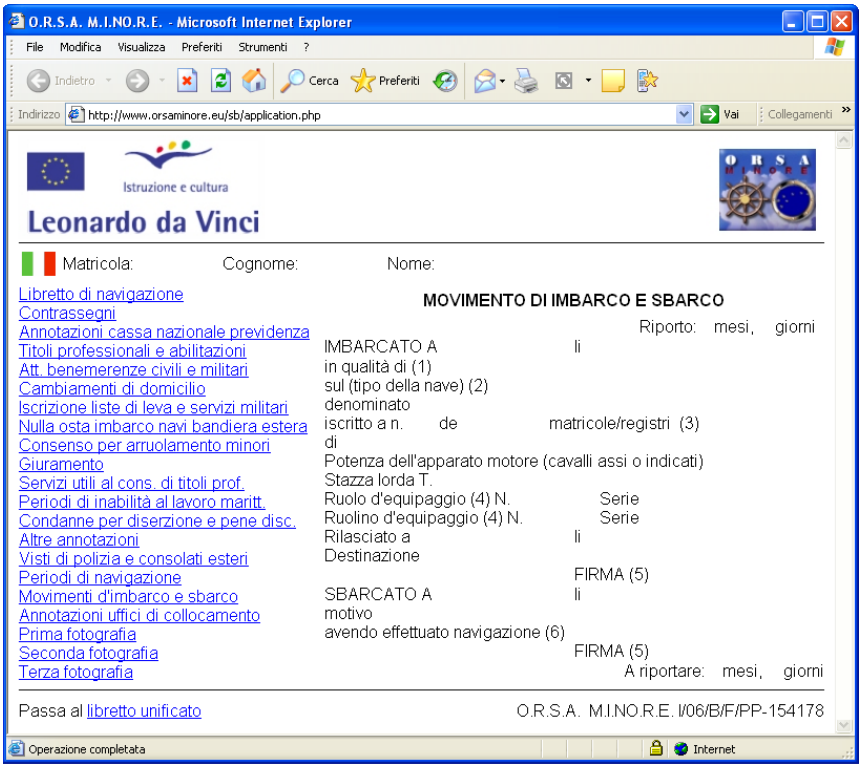

Fig. 7. A snapshot of the prototype Web based O.R.S.A. M.I.NO.R.E. application. Users are provided with a national-based view of Seaman's Book information. HTML contents are generated by extracting data in national format (represented in XML) from the distributed network of repositories, and by processing them through the application of the national presentation stylesheet (passing through the electronic archive).

Finally, the connection to the proposed server-side architecture allows to outline the link between a national qualification and/or entitlement with respect to international certification modalities, as well as to the underlying knowledge, skill, and competence framework defined within the O.R.S.A. M.I.NO.R.E. project.

VI. Overview of the Functional Architecture

From a functional point of view, system architecture is based on the widely adopted multi-tier paradigm that today represents the most commonly adopted approach for constructing Web-based applications. According to this paradigm, the O.R.S.A. M.I.NO.R.E. system can be accessed by any computer endowed with a traditional Internet browser, and a smart card reader. When the user logs into the system, he/she is asked to insert his own smart card, or the smart card he/she intends to work on (this is, for instance, the case of a member of the Port Authority's staff working to register a new smart card into the network). Data which are securely stored on the smart card (i.e. user's certificate and private key) are used to setup a SSL channel with the server-side software.

Once the secure channel is established, user's certificate recorded on the digital means is used to inform the system about the actual user, and to let the server-side application behave in order to produce the requested information. The software running at the server site comprises a virtual data repository (the electronic archive) and an application server, playing the role of both a Web server (handling client requests and delivering responses to end users), as well that of a service provider (bridging the gap between application and database/s). The repository is constituted by a collection of mySql databases (one for each country involved in the project), that are distributed at the European level and physically located in the various facilities belonging to the O.R.S.A. M.I.NO.R.E. network. Each database is designed to record only a portion of the whole knowledge base. Its relational schema (in terms of logical tables) has been defined starting from the national models presented in Section 3. Thus, the database schemas for Italy and Greece are based on a set of tables whose names and attributes reflect those in the UML descriptions shown in Fig. 1 and 2. The application server has been deployed using the PHP technology (under Apache). This choice was mainly due to PHP ability to generate dynamic contents, as well as to its native support for database and XML management. The application server manages requests coming from system end users and stakeholders which require to access the distributed knowledge base; basically, it behaves as a virtual repository, masking the presence of the underlying heterogeneous data structure. In fact, it is capable of extracting a (sub)view containing information of interest to the user, and to present it in the requested format.

Two access strategies are possible. According to the first strategy, the system is accessed by a national authority that requires an electronic representation of traditional data recorded into a specific SB issued by the same country. The

application server queries the national database, and generates a visual representation mimicking the original document through dynamically generated Web pages. This is a two-step process, in which first an XML description of requested data is produced; then, an XSL stylesheet is used to map XML description into the HTML language, that can be understood by the Web browser-based client.

Even if this approach for Web page generation is largely appreciated for its enhanced capability of clearly separating data from representation, its real effectiveness is definitely proved when considering the second access scenario. In this second situation, an international authority which complies with the unified SB format proposed in the O.R.S.A. M.I.NO.R.E. project, connects to the system and requests data related to certified qualifications and services of a seaman holding a SB issued by a foreign country. As in the first scenario, the application server extracts a structured description of SB data encoded according to the original model (an excerpt of this description for the Italian SB is reported in Fig. 3). The dynamically generated document undergoes an XSLT transformation (Fig. 4) that translates the national description into the proposed transnational notation (Fig. 5). This step can be carried out by either removing not matching details, or by maintaining also subsidiary information capable of expressing national specificities. The resulting XML document is then processed through an XSL stylesheet that converts it into its final Web-based representation (the overall architecture is illustrated in Fig. 6).

The layout of the dynamically generated electronic SB allows the user to navigate records natively stored into the original/national format through a unified virtual view. Moreover, if country-specific data have been embedded into the XML-based representation, the stylesheet generates separate contents that can be possibly visualized beside above data, thus integrating basic (shared) information. In Fig. 7, a sample section of the electronic document (Web page) reporting embarkation and disembarkation information related to the Italian (national) SB is shown.

VII. Conclusion and Remarks

In this paper, the design of the O.R.S.A. M.I.NO.R.E. unified electronic archive allowing for the sharing of sensitive data related to maritime workers (seamen) is presented. Access to the designed repository is ensured by a smart card-based Web architecture allowing for preserving content authenticity and confidentiality. The availability of a common vocabulary for describing traditional paper based Seaman's Books in electronic format lays the basis for the development of a transnational framework in which seamen's achievements, entitlements and qualifications can be mutually and transparently recognized within a true mobility scenario.

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