Web Technologies for Maritime Single Windows

Ornulf Jan RODSETH[1], Kay Endre FJORTOFT[1], Maria A. LAMBROU[2]

[1] Norwegian Marine Technology Research Institute (MARINTEK),
Otto Nielsens veg 10, NO-7052 Trondheim, Norway
(e-mail: Ornulf Jan Rodseth ornulf.j.rodseth@marintek.sintef.no,
Kay Fjortoft kay.fjortoft@marintek.sintef.no;)

[2] University of the Aegean, Department of Shipping, Trade and Transport, Chios, 82100 Greece
(phone: +306972887287; fax: +302271035299; e-mail: mlambrou@aegean.gr).

Abstract

The Single Window concept, as strongly encouraged or even directed by international and EU policy initiatives today, appears in a number of forms, where it primarily addresses the need for collaborative, efficient electronic transactions between governmental and business trade and transport entities. Ship formalities, cargo declarations and safety and security notifications are all services that should be rationalized and offered in a harmonized manner by a transport and trade Single Window application. Modern process definition and information systems development methods and technologies can significantly support a Single Window application design and implementation process. A robust, combined approach is necessary in order to design a Next Generation Single Window application as a service-oriented system, in the maritime transport context, where redefined collaboration and communication strategies and patterns among maritime transport applications users and increased agility in the application development, operation and maintenance procedures emerge. Organizational and technical interoperability aspects are important towards seamlessly integrated business collaboration models. We propose a service-oriented computing approach for Single Window semantic web services as a blueprint of multimodal freight transport Single Window systems.

Keywords: maritime transport, information technology, single window, service oriented computing, semantic web services

1 Introduction

The one stop shop business model has been exhaustively researched and applied in the context of e-business and e-government service provision over the last decade (Wimmer, 2002; Lambrou et al., 2008). In a similar vein, in the trade, transport and shipping sector, the "Single Window" (SW) concept was formalized by the United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT 2005) to enhance the efficient exchange of information between trade and government agencies.

A SW primarily addresses the need for efficient and collaborative electronic transactions between governmental and business entities; however the co-coordinating SW authority and the core functionality may differ, thus we typically observe a customs-centric, import and export oriented approach, a port and ship oriented (maritime focus), and a safety and security centric approach. In both cases pertinent SW service design aspects include the SW ownership model (public, private or public-private partnership - PPP), and the SW cost model (e.g., free use, membership or transaction fee). The organizational level of the SW competent authority, e.g., international, national regional, or local is an important differentiating factor, as well. Often, vested interests and policy choices dictate the dominance of one model implementation over the other.

Modern ICT tools may significantly help to organize and improve the efficiency of a SW design and implementation process. In this paper, Web technologies and service-oriented (SOA) business process modeling techniques are examined towards the efficient implementation of different SW service models with different technological capabilities. We also present a design approach and corresponding technological solutions based on research work within the EU eFreight project (http://www.efreightproject.eu/).

2 Different types of SW

Public authorities and maritime transport businesses develop and operate numerous information systems in order to provide efficient e-services to their users. The driving factors are normally a need to reduce the high complexity and costs related to timely and accurate reporting and processing of administrative and regulatory data. Recently, more rigid requirements for advanced trade and transport notifications for security purposes, and requirements for improved interoperability between stakeholders in globally distributed supply chains, strengthens the demand for more efficient solutions.

Trade and transport public authorities have established an extensive range of agency-specific and country specific regulatory and operational requirements at local, national, and international level with little coordination amongst each other. As a result, traders and transport operators are faced with a complex set of duplicative and redundant reporting requirements, forms, systems, data models, and messages. One analysis performed in the MIS project (Fjortoft et al.) shows that more than 40 messages was required when a ship crossed a border line, with more than 20 IT-systems involved.

The principal SW service paradigm aims at streamlining the operational efficiency in mandatory regulatory reporting and control processes. Two main SW development streams, namely SWs for trade facilitation (customs-centric) and for transport (monitoring vehicle and cargo movements - maritime authorities or port-centric) have been evolved independently.

Currently the EU e-Maritime policy initiatives examine and cautiously promote their unified and integrated development (Pipitsoulis, 2010).

The concept of the trade centric SW has been promoted by UN/CEFACT (2005) to enhance the efficient exchange of information between trade and government with the following definition: *SW is a facility that allows parties involved in trade and transport to lodge standardized information and documents with a single entry point to fulfill all import, export, and transit-related regulatory requirements. If information is electronic then individual data elements should only be submitted once.*

This type of SW system is generally managed centrally by a lead agency, enabling the appropriate governmental authorities and agencies to receive or have access to the information relevant for their purpose. Thus, the necessary prerequisites for the successful implementation of a SW facility are the political will and ability of the governments and their authorities to implement the SW as well as the new work processes supporting the efficient use of the SW.

The adoption by the business community is obviously also important, but can in many cases be enforced by legislation or fee structures. An appropriate legal framework, ensuring privacy and security of sensitive and valuable business information exchange is accordingly of paramount importance.

The SW promoted by UN/CEFACT is primarily catering for efficient import and export of goods. In the maritime transport sector, a similar SW concept has been developed to facilitate the clearance of foreign ships into port and, in some cases, to simplify logistics related to the port call. The processes related to this type of SW is to some degree centered around the developments in IMO Facilitation Committee (FAL) where a new work item is to develop a guideline for the implementation of single windows. A draft was presented at FAL 36 (FAL36/5/1 2010) and the work is expected to be finalized at FAL 37 in 2011.

Recently, the concept of a National Single Window (NSWs) has been used in the maritime domain to provide a single national interface for mandatory reporting by ships in European international traffic. This NSW relates to Directives 2009/17/EC and 2002/59/EC for establishing a Community vessel traffic monitoring and information. One of the main objectives of the Directives is to ensure that all Member States will be interconnected via the Community maritime information exchange system SafeSeaNet (SSN), in order to obtain a complete overview of the movements of ships and dangerous or polluting cargoes in European waters.

As can be seen by the previous discussion, the Single Window is not currently an unambiguous concept, particularly not in the maritime domain.

However, some developments points to an integration of different SW concepts into more integrated information management hubs.

3 SW Development Methodologies

The integration of SWs into information hubs can be seen as one example of the networked business models that are becoming an indisputable reality in today's shipping environment (Kia et al., 2000).

A robust, combined approach is necessary in order to design a Next Generation Single Window application. Requirements specification, which combines use cases with a number of different techniques from both software engineering and social sciences - management science in particular - is necessary in order to articulate an emerging legal, economic, business and technological reality in the international shipping sector. Use cases complemented with techniques such as creativity workshops and scenario walkthroughs can provide a solid foundation for the specification of application requirements for complex socio-technical systems, such as the next generation SW. Requirements capture derived through a combined approach using multiple reference models and formalisms, ensuring multiple, integrated viewpoints and representations, enables a systematic and visionary approach to the development of the envisaged SW application.

Thus, we argue that a combined approach, focusing also on policy, legal, regulatory and organizational aspects of an emerging socio-technical system, namely the SW , enables a more accurate identification of the peculiarities of the application system boundaries, and embodies a more systematic approach to the elaboration of pertinent user, functional and non-functional system requirements.

4 Single Window Framework

Software service engineering entails the consideration and application of a multitude of concepts, models, methods, and tools to design, develop, deploy, test, operate, and maintain business-aligned and, very commonly, service oriented architecture (SOA) based software systems in a systematic and efficient manner (Zimmerman et al, 2004; Papazoglou and Heuvel, 2006; Papazoglou et al, 2006, Cubera et al. 2005).

The developments of new SW paradigms and the use of SOA principles in the maritime domain promotes advanced process definition and systems development methods and technologies. This new context poses requirements, such as redefined collaboration and communication strategies and patterns among maritime applications users and increased agility in the development, operation and maintenance procedures.

Service Oriented Systems Technology

Service Oriented Computing is an architectural paradigm whose goal is to achieve loose coupling among a collection of interacting software services. Services are usually defined as autonomous, platform-independent computational elements that can be described, published, discovered, composed and consumed using standard protocols for the purpose of building distributed, collaborative applications within and across organizational boundaries (Manolescu et al., 2005). Web services (Curbera et al., 2002) provide the basis for the development and execution of business processes that are distributed over a value chain infrastructure and are available via standard interfaces (Web Service Description Language, WSDL) communication protocols (SOAP), and publishing standards (Universal Description Discovery and Integration - UDDI). Composing larger services out of smaller (atomic) service is the core principle in SOA.

Services in SOA generally have the following characteristics:

- Services may be individually useful, or they can be integrated (composed) to provide higher-level services. Among the benefits of service composition is that it promotes reuse of existing functionality.
- Services communicate with their clients by exchanging messages: services can be defined by the messages they can accept and the responses they can give.
- Services can participate in a workflow, where the order in which messages are sent and received affects the outcome of the operations performed by a service. This notion is defined as "service choreography".
- Services may be completely self-contained, they may depend on the availability of other services, or they may depend on the existence of a resource such as a database.
- Services advertise details such as their capabilities, interfaces, policies, and supported communications protocols. Implementation details such as programming language and hosting platform are of no concern to clients;

and, therefore, they are not revealed.

Web services are web based distributed software components that provide information to applications rather than to humans through an application-oriented interface. The information is structured using XML based formats, so that it can be parsed and processed easily rather than being formatted for display. Web services publish details of their functions and interfaces, but they keep their implementation details private. As a result, a client and a service that support common communication protocols can interact regardless of the platforms on which they run, or the programming languages in which they are written. This makes Web services particularly applicable to a distributed heterogeneous environment, such as the maritime transport application environment.

The process of *service composition* encompasses necessary roles and functionality for the consolidation of multiple services into a single composite service (Pistore et al., 2005). SW services are considered as especially supported by developments in service compositions with methods, such as model-driven service composition and semantic web-enabled composition. Quality of Service (QoS) aware service composition aspects are also considered as relevant to the maritime application domain as ships may suffer from highly varying QoS on their ship to shore communication (Rødseth et al., 2009).

Web Semantics for Single Window Services

Interoperability is often discussed in the context of technical integration related to platforms as well as syntactic and semantic data formats and artifacts. With the broader use of web technologies, a multitude of interoperability issues have to be solved at higher levels in order to allow for seamless integrated collaboration.

Aligning application semantics is an eminent issue, however interoperability should be seen in the broader context of value chain integration (Papazoglou et al, 2006). Thus, business process compatibility, adaptability of business processes, leveraging legacy assets, support for business transactions and network security services are important design factors driving business and technical interoperability in the context of shipping and integrated multimodal transport value chains.

Data models, such as database or XML schemas, typically specify the structure and integrity rules of data sets of applications such as the SW application. Devising a harmonized, interoperable and reusable SW data model depends on specific requirements and operational tasks, in particular, which mirror a specific SW organizational setting.

Today there are three main standard data models that are intended for use in SW implementations:

1. The Trade Data Element Dictionary (ISO7372 2005) defines data elements used in cross border trade and is the basis for UN/EDIFACT messages.
2. World Customs Organization (WCO) has recently finalized version three of the WCO data model. This is also intended for cross border transport and trade and covers more generally reporting requirements to authorities.
3. The International Standards Organization has published a more specific data model ISO/FDIS 28005-2 (2010) covering electronic clearance for ships. This is not yet finally approved, but is expected to be finalized in early 2011.

As the semantics of data models constitute a shared understanding and agreement between the designers/developers and the users of the data model, the overall conceptualization and the vocabulary of a SW data model should satisfy requirements of this particular application domain and its foreseen evolution (Sheth et al, 2006).

A SW application ontology should facilitate and optimize the sharing of semantics and domain rules for ship formalities, customs declarations, safety and security, and environmental protection SW services.

Modeling and engineering a shareable and reusable SW ontology offered for a broad use in an open environment, such as the Semantic Web, represents a challenging task (Linehan, 2007; Yarimagan and Dogac, 2009). Unlike task-specific and implementation-oriented data models, a SW ontology, in principle, should remain generic and task-independent as possible, able to interoperate with other multimodal transport applications.

SW Semantic Web annotations, will facilitate higher automation of service discovery, composition, invocation, and monitoring on the Web that is by exploiting ontology expressiveness (and languages such as Web Ontology Language - OWL) and ontology based reasoning in the context of Web maritime transport services. Several initiatives such as WSMO, OWL-S, and WSDL-S are considered in order to address the goals of Maritime Transport Semantic Web services, including the SW application (Zdun and Dustdar, 2007).

SW System Architecture and Platform

The SW actors operating within a shipping value network strategically define the set of organizational and informational conventions they adhere to by means of shared process and information models, i.e. public processes and ontologies. The latter will be implemented and executed by a service-oriented mediation platform which supports the integration of heterogeneous information systems. Whereas the technical feasibility and robustness of these concepts and artifacts has been proven, maritime transport and logistics companies will apply and implement them in a real life productive environment by deciding which standards and platforms they will support in the future.

By developing reference architectures and methodologies, we provide guidance to companies and public authorities in order to design their process and system architectures for meeting regulatory compliance interoperability requirements.

A SW system for maritime transport can be designed on the basis of a service-oriented architecture (SOA) approach. From a SOA perspective, we consider port, customs and inspection services are business process services. The essence of SOA is to design a system in a service-centric way, unlike legacy IT systems.

As a SW System for maritime transport is interconnected using Web-services, business process services for presentation are defined with a structure to utilize Web services. The services defined in this way include clearance of ships (ship formalities) and cargo reports, among many others to evolve and be integrated into the system.

In SOA, when components supporting business process services are defined, they are not developed by business services experts but by software engineers. In other words, components are developed by necessary functions without knowledge of their future reuse. In developing components, resource optimization and development efficiency can be maximized by redefining the existing modules by the unit of components. The information produced in processing business services can be stored in a repository for future use when necessary.

As illustrated, designing a SW system in a service-oriented architecture can ensure independence among layers or modules. This approach guarantees that a SW system is not affected, as long as an interface is not changed, even when business services are added or existing components are modified.

Open issues such as how to (a) integrate SW regulatory and business rules into Web service descriptions; (b) make use of semantically annotated Web services in SW Web service compositions; and (c) use software engineering methods to develop such an evolutionary SOA are currently under consideration in the e-Freight and MIS projects. This is expected to facilitate the move towards devising a coherent software maritime transport SOA development framework and toolset while leveraging all the benefits stemming from the use of Semantic Web services and Web services standards, applicable and pilot tested in the case of the SW application environment.

Implementing SW requirements in a particular process-aware information systems, as enabled by the expressiveness of a BPMN and WebML-based SOA development approach with respect to workflow patterns implementation is an admissible approach. Extending modern business process modeling languages such as BPMN to support capturing business rules and leveraging ontologies, and thereafter the discovery and binding of abstract maritime transport service models, i.e SW service models with concrete software services is an open issue. Once created, SW process models can be used as either blueprints for construction of service-oriented systems or they are automatically translated into (skeletons of) implementation artifacts such as executable service compositions in BPEL format. Further exploration of the integration of rules and ontologies with the service composition standards (e.g., BPEL and WS-CDL) is necessary in the scope of the SW application development.

Applying SOA principles to the SW application design enables us to: (a) leverage human-understandable business vocabularies, machine-understandable ontologies, business rules, and process models into a unified design realm with complementary robust, formal reference models and software development artifacts for service-oriented systems; (b) effectively communicate expectations and requirements of maritime transport business users as well public authorities users to the implementation plane; and (c) support automatic generation of high quality web service compositions from business process models capturing rich and sustainable maritime ontologies and rules.

5 Conclusions

As maritime transport organizations move to introduce SOA and develop SOA compliant applications, such as a SW, many issues arise that demand considerable guidance and support in terms of robust methodologies, techniques and tools. In this paper we have outlined some of those issues and proposed certain solutions and directions towards implementing a SW application by means of modern technologies, such as semantic web development and provision environments. We have also outlined several pertinent open issues regarding intertwined policy, strategic, technological and design aspects where further attention and research is necessary. In particular, a systematic and robust design approach to the SW application case is considered as primarily an issue of an informed and knowledgeable decision about SW stakeholders market and business strategy in the context of regulatory and policy constraints, underpinned by governance, funding, and ownership aspects of the SW collaborative SOA environment. Organizational aspects such as business and administrative structures, processes and governance mechanisms are of central importance.

Acknowledgements

This work has been partially funded by the EU eFREIGHT 7FP DGTREN Project (www.efreightproject.eu) and partially by the MIS project (Maritime Information Centre - http://www.sintef.no/Projectweb/MIS/), funded by the Norwegian research Council.

References

Curbera, F., Duftler, M., Khalaf, R., Nagy, W., Mukhi, N., & Weerawarana, S. (2002). Unraveling the Web Services Web: An Introduction to SOAP, WSDL, and UDDI. *IEEE Internet Computing*, 6(2), 86–93.

FAL36/5/1 (2010) ELECTRONIC MEANS FOR THE CLEARANCE OF SHIPS, The use of the Single Window concept, Submitted by Brazil, May 2010.

FAL36/5/2 (2010) ELECTRONIC MEANS FOR THE CLEARANCE OF SHIPS, Justification for Single Window Guidelines for Maritime Transport, Submitted by the Republic of Korea, June 2010.

Fjortoft, Hagaseth, Baltzersen, Tjora, MIS Report A; Identification and organization of MIS users and processes, 2010

ISO/FDIS 28005-2 (2010) Security management systems for the supply chain -- Electronic port clearance (EPC) -- Part 2: Core data elements

ISO 7372 (2005) Trade data interchange -- Trade data elements directory

Kia, M., Shayan, E. and Ghotb, F. (2000), "The importance of information technology in port terminal operations", *International Journal of Physical Distribution & Logistics Management*, Vol. 30, 3(4), pp. 331-44.

Lambrou, M. A., Pallis, A. A. and Nikitakos, N. V. (2008). 'Exploring the applicability of electronic markets to port governance'. *International Journal of Ocean Systems Management*, 1, 14-30.

Linehan, M. (2007). Ontologies and Rules in Business Models. In A. Gokhale & V. Rachamadugu (Eds.), *Proceedings of the 11th International IEEE Enterprise Distributed Object Computing Conference* – Workshops (pp. 149-156). Washington, DC:IEEE Computer Society

Manolescu, I., Brambilla, M., Ceri, S., Comai, S., & Fraternali, P. (2005). Model-driven design and deployment of service-enabled web applications. *ACM Transactions on Internet Technology*, 5(3), 439–479.

Papazoglou, M. P., and Heuvel, (2006). Service-oriented Design and development Methodology. *International Journal of Web Engineering and Technology*, 2(4), 412 – 442.

Papazoglou, M. P., Traverso, P., Dustdar, S., Leymann, F., & Krämer, B. J. (2006). Service-Oriented Computing Research Roadmap. In F. Cubera, B. J. Krämer, & M. P. Papazoglou (Eds.), *Service Oriented Computing (SOC)* - Dagstuhl Seminar Proceedings (05462). Dagstuhl, Germany: Internationales Begegnungs und Forschungszentrum für Informatik.

Pipitsoulis, C. "The EU e-maritime Initiative", In *Proceeding of European Maritime Day, 2010*, http://www.skematransport.eu/uploadfiles/e-Maritime%20Gijon%202010%20CP%20Version%206.pdf

Pistore, M., Marconi, A., Bertoli, P., and Traverso, P. (2005). Automated composition of web services by planning at the knowledge level. in *Proceedings of the International Joint Conference on Artificial Intelligence* (IJCAI), 2005.

Rødseth Ø.J., Kvamstad B., Tjora Å., Drezet F. (2009), Flagship report D-D1.3 Ship-shore communication requirements, Published by MARINTEK, 2009-12-31. EU contract no. TIP5-CT-2006-031406.

Sheth, A., Verma, K., & Gomadam, K. (2006). Semantics to energize the full services spectrum. Communications of the ACM, 49(7), 55–61

UN/CEFACT (2005) Recommendation No.33:

"Recommendation and Guidelines on Establishing a Single Window".

Wimmer, M.A. (2002) ‘Integrated service modeling for online one-stop Government’, *Electronic Markets*, Vol. 12, No. 3, pp.1–8.

Yarimagan, Y., & Dogac, A. (2009). A Semantic-Based Solution for UBL Schema Interoperability. IEEE Internet Computing, 13(3), 64–71.

Zdun, U., & Dustdar, S. (2007). Model-driven and pattern-based integration of process-driven SOA models. *International Journal of Business Process Integration and Management*, 2(2), 109–119.

Zimmermann, O., Krogdahl, P., and Gee C. (2004). Elements of Service-Oriented Analysis and Design - An Interdisciplinary Modeling Approach for SOA Projects. http://www-128.ibm.com/developerworks/library/ws-soad1/. IBM developerWorks.