An Interoperability Service Utility for Collaborative Supply Chain Planning

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Abstract

One of the goals of iSURF project is creating an interoperability platform in order to enable the exchange of planning data between enterprises and especially across domains. The interoperability platform of iSURF is named iSURF Interoperability Service Utility (iSURF ISU). Interoperability should be regarded as a service that users can utilize anywhere and anytime they need. Therefore, iSURF ISU is projected to be a highly dynamic and flexible building block of the system which is envisioned to robustly respond to the user requests. The purpose of iSURF ISU can be regarded as creating "Virtual Organizations" for establishing semantic infrastructure for the interoperability of enterprise applications across multiple domains, in order to achieve planning data exchange.

Keywords

Document Interoperability, Collaborative Supply Chain Management, Virtual Organizations, Semantic Mediation, UBL Customization

1 Introduction

Today, building an environment for collaborative supply chain planning is a necessary condition for the survival for companies of all sizes including small and medium enterprises (SMEs). The supply chain partners need to collaborate in order to better align supply and demand forecasts and to have a joint strategy in case of exceptions to realize the "the network is the business system" vision. The first prerequisite to have a collaborative supply chain planning is sharing information on the supply chain visibility, individual sales and order forecast of companies, current status of the products in the manufacturing and distribution process, and the exceptional events that may affect the forecasts in a secure and controlled way. Knowledge is the main instrument to drive and support collaboration: there needs to be knowledge-oriented inter-enterprise collaboration between supply chain partners which necessitates the interoperability between the enterprise systems.

There are various standard initiatives addressing the standardization of communication in exchanging the supply chain planning information in different domains, such as RosettaNet [RosettaNet], Open Applications Group Integration Specification [OAGIS], Chemical Industry Data Exchange [CIDX] and GS1 eCOM [eCOM]. Hence when companies involving in more than one supply chain need to exchange the planning information across multiple domains, an interoperability problem rises to be addressed.

Additionally, in order to be used effectively, this inter-enterprise collaboration process should be integrated with the underlying intra-enterprise planning business processes of the companies, and also with the underlying legacy applications handling the company planning activities such as enterprise resource planning (ERP), material requirements planning (MRP), advance planning system (APS), warehouse and inventory management systems. However integration is costly, especially for SMEs who have limited resources. Rather than all-in-one integration,

interoperability solutions should be accessible to SMEs: SMEs need to be agile, flexible and should be able to collaborate with various business partners, however with their limited resources they cannot afford integration costs with all of the partners.

To address the abovementioned problems, this paper describes the approach of a Semantic Interoperability Service Utility Framework for achieving the semantic reconciliation of the planning and forecasting business documents exchanged between the companies according to different standards. This work is a part of ICT-213031-iSURF (An Interoperability Service Utility for Collaborative Supply Chain Planning across Multiple Domains Supported by RFID Devices) project which is supported by European Commission.

2 Relation to Existing Work

Universal Business Language (UBL) aims to develop a common vocabulary for use in exchanging business documents using XML syntax [UBL]. UBL is the product of the international efforts lead by Organization for the Advancement of Structured Information Standards (OASIS). Reuse of well-understood, standardized patterns in documents makes business processes easier to implement, manage, and improve. Thus UBL provides a library of reusable component schemas such as Address, Price and a set of document schemas such as Order, Invoice. All UBL schemas are defined using the XML Schema Definition (XSD).

Even though businesses share a lot of common data requirements, they operate in different industry, geopolitical, regulatory contexts and they have different rules and requirements for the information they exchange. In response to these needs, UBL provides a Customization Methodology that describes how UBL components are to be modified for contextual needs through XSD derivation operations. Following UBL Customization methodology, most UBL implementations prefer using tailored UBL schemas instead of using the standard library.

Current UBL solutions, however, do not address the documents related to collaborative planning of enterprises. Therefore, there is a need for customizing the available UBL components and creating UBL collaborative planning documents. Nonetheless, even after the created UBL Planning documents are used as a common denominator in the transactions exchanging planning data, since the requirements of different business domains for planning data differ, it is reasonable to expect from user communities to customize UBL schemas according to their needs. UBL customization process enables the communities to create customized document schemas; however it does not handle the interoperability between these customized document schemas. For this reason as communities prefer using customized standard schemas, it becomes harder to maintain the interoperability within the UBL community. That is, the UBL community gets clustered into smaller communities using different customizations and cannot communicate directly with others.

On the other hand, in 2001, VICS (Voluntary Inter-industry Commerce Standard) Collaborative Planning, Forecasting, and Replenishment [CPFR] Committee developed and published an object model for XML specifications for CPFR messages, which was approved by VICS Board of Directors. Subsequently, the VICS model has been incorporated into EAN.UCC System XML Messaging Standard which is a broader, global specification. The model is based on UML; most of the classes are references to EAN.UCC XML classes. Forecast, Forecast Revision, Product Activity, Performance History, Event, Exception, Exception Criteria and Item Information Request are some of the message types that have been covered. The XSD's of the message types are published and are freely accessible. Later on the CPFR XML message types are enhanced by GS1. Efforts resulted in eCOM planning message schemes based on CPFR message types.

As also outlined by CPFR, there are various domain specific standard initiatives addressing the standardization of communication in exchanging CPFR related information like OAGIS defining Business Object Document specifications (BODs) for demand and supply schedules (forecasts), RosettaNet in the electronics domain, CIDX in chemistry industry and GS1 defining a global

standard for electronic business messaging. [Kabak, Dogac, 2008] presents a detailed survey about the analysis of the electronic business document standards.

Current approaches, including CPFR address collaborative planning within a single industry. However in real business life, the case that partners from different industry domains need to collaborate in sales and production planning is not rare. For instance a car manufacturer is in continuous interaction with partners form textile and chemistry industry. In each industry domain, different messaging standards, and business document standards are adopted based on the requirements of the domain. When collaboration needs to be achieved across domains, a severe interoperability problem emerges.

Consider the supply chain partners presented in Figure 1, which are involving in several supply chains and therefore in need of collaborating in more than one CPFR Network. It may be possible for a company to stick to a data exchange standard within the scope of a single CPFR Network. For example Company A conforms to RosettaNet as a part of RosettaNet community in Figure 1. However for Company A to be able to communicate with other companies in different CPFR Networks which may be conforming to different data exchange standards such as OAGIS or EDIFACT (EDI for Administration Commerce and Trade), there is a need for a flexible interoperability solution.

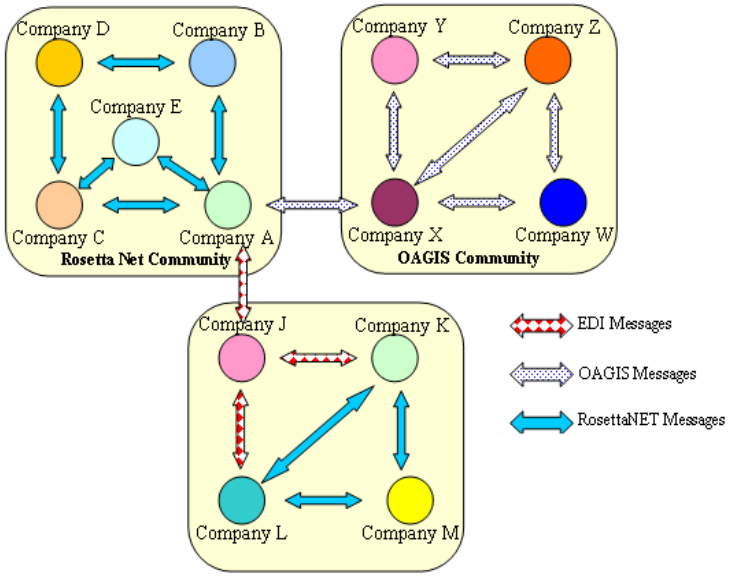

Figure 1 Interactions between different CPFR Networks

Finally, for legacy system integration, Service-Oriented Migration and Reuse Technique (SMART), proposed by Software Engineering Institute at Carnegie Mellon University, is an initial approach to the identification and analysis of issues in migration to services [Lewis et al. 2005]. It helps organizations analyze legacy systems to determine whether their functionality can be reasonably exposed as services in an Service Oriented Architecture (SOA). Another approach, Salvaging & Wrapping Approach (SWA) [Sneed, 2006], involves a three-step procedure for creating Web services from legacy code. These are extracting the legacy code, wrapping the extracted code and making the code available as a Web service. IBM SOA strategists believe that it is not enough to consider only process/service integration, but also the integration at the end-user interface. They believe application connectivity, process integration, information integration and a build-to-integrate development model must also be considered [Channabasavaiah, Holley, 2006]. SAP developed NetWeaver; a Web-based, open integration and application platform and foundation for enterprise SOA [SAP, 2008].

Existing approaches mainly demand context sensitive solutions for migrating legacy applications to service orientation. In fact, they propose merely a back-end integration based on reverse engineering and architectural reconstruction of source codes. However, such context sensitive

attempts are not practical enough for enterprise scale legacy applications and they cannot be generalized easily.

3 Research Approach

One of the goals of iSURF project is creating an interoperability platform in order to enable the exchange of planning data between enterprises and especially across domains. The interoperability platform of iSURF is named iSURF Interoperability Service Utility (iSURF ISU). Interoperability should be regarded as a service that users can utilize anywhere and anytime they need. Therefore, iSURF ISU is projected to be a highly dynamic and flexible building block of the system which is envisioned to robustly respond to the user requests. The main functionality of iSURF ISU is to perform the semantic mediation of planning documents across enterprises through a common denominator, OASIS UBL documents. In order to achieve this goal, a number of steps have to be taken that are addressed by the iSURF ISU.

UBL itself does not include planning documents; therefore first of all, by customizing the available UBL components, UBL Document Schemas for collaborative planning data should be created. Since the requirements of different industry domains differ, iSURF ISU provides a semantic UBL Customization Tool for enterprises to customize UBL components based on the requirements of their industry domain.

Additionally, iSURF ISU aims to provide a machine processable, ontology based mechanism that can express the structure and the semantics of UBL components together with their correspondences in different customized versions. Our early finding regarding this mechanism has been presented in [Yarimagan, Dogac, 2008]. In the architecture, iSURF Component Ontology for UBL provides a formal representation of components. While the UBL documents are customized to industry domains through the iSURF semantic UBL Customization Tool, the customizations are represented in reference to the iSURF Component Ontology.

The infrastructure of iSURF Interoperability Service Utility can be seen in the Figure 2. The most critical building block in iSURF ISU is the semantic mediator. Since UBL customizations of partners in the supply chain are independent from each other and might be industry specific; different planning document structures are created in each enterprise through the iSURF semantic UBL Customization Tool. Thus, semantic mediation of these planning documents is

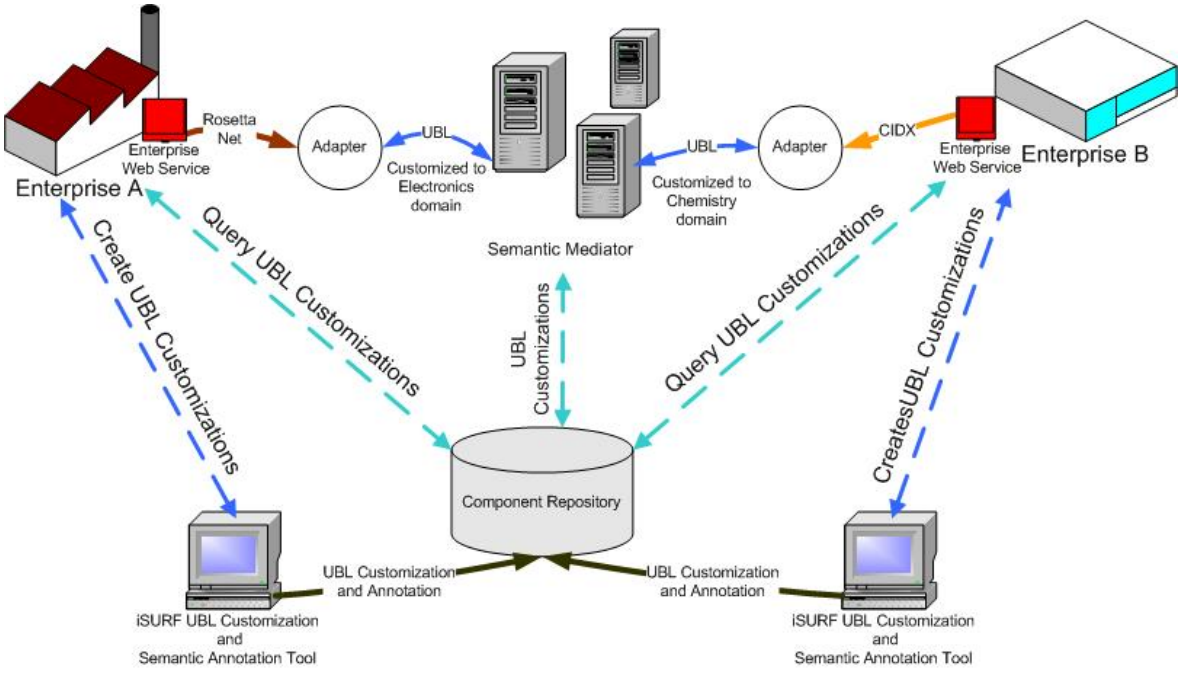

Figure 2 iSURF Interoperability Service Utility Architecture

necessary for interoperability. In order to provide semantic interoperability and mediation, iSURF ISU has the capability of translating UBL documents of one enterprise to another. In the semantic mediation of UBL documents, iSURF ISU is planned to employ intelligent algorithms and description logic reasoning services by exploiting the semantic annotations made in the UBL customization phase. In order to avoid the bottlenecks of the centralized architectures, iSURF ISU is designed to perform semantic mediation on a distributed architecture in which the tasks are distributed among multiple servers for balancing the workload.

In addition to these, a semantically enhanced repository is available in the architecture for publishing customized UBL components. This repository has two functionalities. First of all, customized UBL components are stored in the repository. These components can be checked out by the enterprises which leverage reusability of the components. Furthermore, the iSURF semantic mediation tool is able to access the customized UBL components that are semantically annotated through this repository.

In the architecture, web services are used for the communication between the enterprises for document exchange. Achieving the communication via web services facilitates platform independence for the enterprises in the supply chain. Existing services of the enterprises is designed to be exposed as web services so that the legacy applications will not have to be re-implemented or modified. Furthermore, the web service operations are to be semantically annotated to facilitate discovery of the services.

The objectives of iSURF ISU architecture is enumerated in the subsections below.

3.1 Definition and Customization of UBL Collaborative Planning Documents to be Exchanged

In order to leverage knowledge oriented collaborative planning, enterprises have to be able to exchange planning data creating a Virtual Organization. Currently, the planning data is being exchanged among enterprises through various standards, for example, “OAGIS ShipmentPlanningSchedule”, “RosettaNet 4A4 Planning Forecasting”, or “CPFR Forecast Revision”. iSURF ISU extends UBL to define common semantics for exchanging planning data across multiple domains. Firstly the planning documents to be used in the iSURF pilot application should be selected and common UBL documents should be created for collaborative planning based on CPFR guidelines. Once the UBL planning documents are generated, the customization based on the requirements of the end users can be defined.

3.2 Creation of Semantic UBL Customization Tool and Customization of UBL Documents for Multiple Application Domains

The document types to be exchanged between the Virtual Organization constituents are to be UBL compliant, in order to provide a uniform medium for interoperability service.

Enterprises (large and small) need to be provided robust and comprehensive software tools in order to generate their own UBL customizations according to the requirements defined in the objective above. The customizations are tracked by representing them through the UBL Component Ontology semantically. In this architecture, created custom UBL components are stored into the ebXML (Electronic Business XML) registry/repository and are semantically annotated by using ebXML registry semantic mechanisms to facilitate their discovery. This annotation also enhances reusability of components for further UBL customizations.

For the enterprises that already employ existing planning data standards (OAGIS, CPFR, RosettaNet) specific adapters facilitate the conversion of the standard documents to UBL. For other enterprises, software tools facilitate the conversion of their proprietary format to UBL or generating their custom UBL documents from scratch.

3.3 Interoperability Service Utility Development

In iSURF architecture, interoperability facilities are planned to be provided as a service through iSURF ISU, which means the parties can utilize these interoperability services as they need, anywhere and anytime.

Interoperability of planning documents is enabled through semantic mediation of UBL documents which are customized for different domains. Exploiting the semantic annotation of the UBL customizations performed in the objective above, intelligent algorithms, description logic reasoning facilities are included in order to achieve semantic mediation of UBL documents customized for different business contexts automatically.

In the iSURF Interoperability Service Utility, the goal is creating a generic semantic mediation mechanism based on UN/CEFACT (The United Nations Centre for Trade facilitation and Electronic Business) Core Components methodology, enabling the mediation between different industry standards such as OAGIS, CIDX, RosettaNet, GS1 and so on. In iSURF project, the focus is on planning documents; however the methodology and the tools will be applicable to define and automate the mediation for other set of business documents.

3.4 Tools to Wrap Legacy Applications through Web Services

iSURF Interoperability Service Utility is designed to allow companies of different sizes and technical levels be able to collaborate through their existing technologies and standards.

Semantic mediation of customized UBL documents to one another to achieve interoperability are performed through iSURF Interoperability Service Utility. Moreover, interconnection of enterprise information systems with the collaborative planning environment is also addressed by wrapping legacy applications as web services. Therefore, the trading partners in the planning environment are not limited to use UBL or any specific solution within their internal systems in order to collaborate with each other.

For this purpose, iSURF ISU architecture also includes a generic tool which allows wrapping existing proprietary applications as semantically annotated Web services. In this way companies are enhanced to share their internal planning, scheduling and forecasting data from proprietary systems through semantically enriched web services. This enhancement also allows companies to semantically relate their proprietary messages to the customized UBL planning documents which are used in the Interoperability Service Utility in order to provide interoperability between trading partners.

4 Findings

The purpose of iSURF ISU can be regarded as creating Virtual Organizations for establishing semantic infrastructure for the interoperability of enterprise applications across multiple domains, in order to achieve planning data exchange as presented in Figure 3. OASIS-UBL is the standard employed as the common denominator in iSURF Interoperability Service Utility architecture since UBL is considered as the Lingua Franca for common business information and it is the first XML representation of UN/CEFACT Core Component Methodology. This iSURF Interoperability Service Utility is expected to enable the companies to extend their collaborative planning processes to a wider community: they will be able to engage in planning relationships with companies in different industry domains.

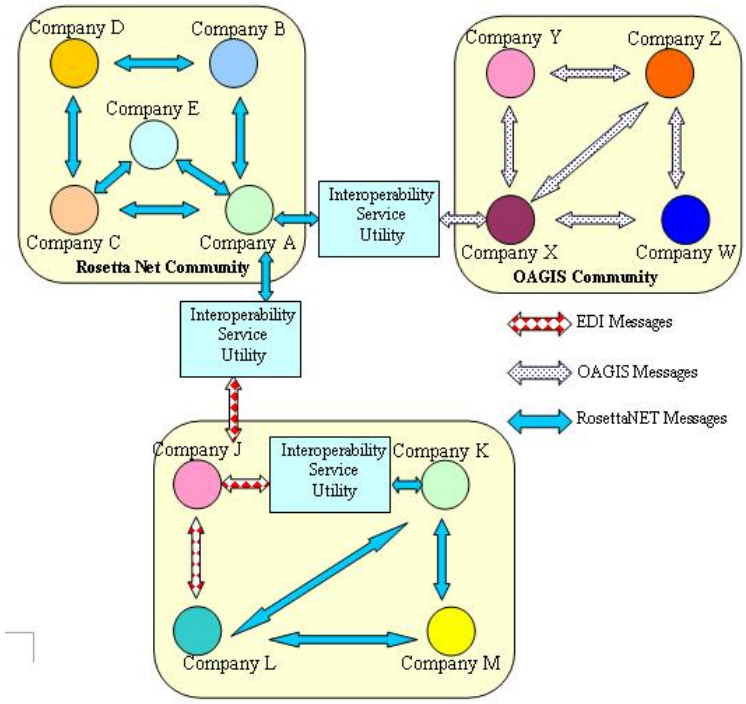

Figure 3 Interactions between different CPFR Networks with Semantic Mediation

The pre-identified list of documents to be exchanged during the planning process can be listed as follows according to the CPFR guidelines:

- Forecast document for the projected demand of an item.
- Forecast Revision in order to propose a set of changes to a forecast.
- Product Activity which provides product movement observations such as point of sales.
- Performance History which is a collection of performance metrics such as sales growth, forecast accuracy, etc.
- Exception Notification which represents variation of metrics in the forecast documents and the real values.
- Exception Criteria defines threshold for variances on which exceptions should be triggered.
- Event describes a promotion, inventory policy change or other planned events.
- Item Information Request requests information on product activity, forecast or performance data when it is not automatically sent.

The pre-identified core processes in a planning environment are:

- Collaboration Arrangement Development
- Joint Business Plan Creation
- Sale Forecast Creation
- Sale Forecast Exception Identification
- Collaboration on Sale Forecast Exceptions
- Order Forecast Creation
- Order Forecast Exception Identification
- Collaboration on Order Forecast Exceptions
- Order Generation

In the architecture, customized components are stored and shared through semantically enriched repositories. Semantic mediation of customized UBL documents to one another to achieve interoperability is performed through iSURF Interoperability Service Utility.

Collaborative supply chain planning mechanisms should offer no technical or economic barriers for trading partners, large or small. In this respect, comprehensive sets of user friendly software components directly addressing the SMEs should be provided.

As an outcome, iSURF ISU enables SMEs to customize, create and store their UBL components; mediate data between their proprietary formats, standard formats in different domains such as OAGIS, GS1 eCom, CIDx, RosettaNet and customized UBL and expose their services as web services for inter enterprise collaboration.

5 Conclusion

Existing approaches do not address the interoperability problem across multiple domains and the migration of legacy systems into a SOA environment is a major research challenge with a significant economical impact. Interoperability Service Utility of ICT-213031-iSURF project funded by European Commission is expected to achieve collaborative planning and forecast across multiple industries by enabling the customization mediation of planning messages across different industry domains. In other words the planning messages that may be represented in OAGIS, CIDX, GS1 eCom, RosettaNet are mediated semantically across different industry domains. In order to provide semantic interoperability and mediation, iSURF ISU makes use of iSURF Component Ontology for UBL providing a formal representation of components.

Web services wrap the legacy applications, in order to achieve interoperability with the collaborative planning environments. For the enterprises already having planning document formats (such as CIDX, RosettaNet etc. or any proprietary format), special UBL adapters facilitates for the enterprise to convert the planning documents to the customized UBL documents. For the other enterprises; tools are to be provided to enable them to create UBL documents from the scratch. As a result, the SMEs, most of which do not have an existing message format, or do have to involve in more than one supply chain planning process in different domains will have chance to join collaborative planning in a supply chain which will result in reduced forecast error and increased sales.

References

CIDX, Chemical Industry Data Exchange, WWW page. http://www.cidx.org, accessed 05.03.2008.

CPFR, WWW page. http://www.vics.org/committees/cpfr/, accessed 27.02.2008.

eCOM, WWW page. http://www.gs1.org/productssolutions/ecom, accessed 05.03.2008.

Kabak, Y; Dogac, A. A Survey and Analysis of Electronic Business Document Standards. Submitted for publication, 2008.

Lewis, G; Morris, E; O'Brien, L; Smith, D; Wrage, L. Software Engineering Institute, "SMART: The Service-Oriented Migration and Reuse Technique, (CMU/SEI-2005-TN-029), 2005.

OAGIS, Open Applications Group Integration Specification, WWW page. http://www.openapplications.org, accessed 06.03.2008.

RosettaNet, WWW page. http://www.rosettanet.org, accessed 06.03.2008.

SAP, NetWeaver Open Integration Platform, WWW page. https://www.sdn.sap.com/irj/sdn/developerareas/netweaver, accessed 05.03.2008.

Sneed, M. H. Integrating legacy Software into a Service oriented Architecture. IEEE Computer Society, 2006.

UBL, WWW page. www.oasis-open.org/committees/ubl, accessed 04.03.2008.

Yarimagan, Y; Dogac A. A Semantic based Solution for the Interoperability of UBL Schemas. Submitted for publication, 2008.