Plug and Play Components for Global Supply Chains

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Abstract

This paper introduces the concept of an electronic trade scenario as an aid to the management of (global) supply chains, and other forms of international, business-to-business electronic commerce. The problem addressed is the following. Competition demands that trade transactions be handled efficiently and securely. However, the same competitive environment also demands flexibility, and the ability to re-design the supply chain as conditions change. Current advances in electronic document technologies, notably XML schemas, ebXML, offer new possibilities for generic, resusable component software at the level of document specifications. Here we address the additional challenge of supporting the rapid re-engineering of the process specifications for the supply chain. For this, we focus on the component technologies for electronic trade scenarios: generic, reusable models of the entire trade transaction. They are stored in a on-line repository, where each member of the supply chain can download the transaction component for their role in the transaction. We describe a CASE tool, called **InterProcs**, which provides a graphical modeling internface for supply chain process specifications at several levels of abstraction, including Unified Modeling Language (UML) and Documentary Petri Nets (DPN). Once specified, **InterProcs** auotmatically produces an operating prototyping of the supply chain transaction model. In this paper we address the additional step to production implementation of the prototype supply chain model using distributed component technology. Because we are concerned with open standards, we focus specially on the Java 2 Enterprise Edition (J2EE) platform.

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Keywords

Global supply chains; electronic trade scenarios; electronic trade procedures; documentary petri nets; UML; EDI, XML schema, ebXML, component architectures; J2EE

1 Introduction

Electronic linkages to support in global supply chains are typically implemented using Electronic Data Interchange (EDI), which provides a standardized format and structure for business documents in electronic form. More recently, XML technology has emerged which allows for electronic document structures to be represented more generically (XML schemas, ebXML), enabling for instance browser-based Internet software to be developed.

This provides improved flexibility, especially for simple transactions with only a few document exchanges. However, in more complex cases such as global supply chains, the process specification of the transaction needs also to be explicitly addressed, engineered, and analyzed. In these cases of international trading, as many as 20 different trading partners may be involved, we upwards to 60 different documents. Moreover, the parties include not only other companies, but also a variety of governmental agencies involved in the regulation of import and export. In many cases, the transaction costs of dealing internationally are double or triple those for domestic trading, ranging from 7-10 % of the total transaction value. (On a global scale, this is an added cost of over two trillion dollars per year.)

In this paper we address re-engineering of global supply chain processes, using models called electronic trade scenarios. These techniques offer a means of reducing the transaction costs of global supply chains, while yet providing increased flexibility to quickly modify and re-configure them in response to changing market conditions. The basic idea is to separate out those aspects of the electronic transaction that are not relationship specific, and represent them in the form of trade "scenarios" that are more generic and re-usable. These electronic trade scenarios can then be made available via publicly accessible repositories, that are under, for instance:

a. proprietary control (e.g. a major manufacturer)
b. controlled by an industry or sector organization (e.g. insurance industry)
c. controlled by a local or regional sector, e.g. a port authority
d. made globally available, e.g. by the International Chamber of Commerce (ICC), or United Nations.

A modeling and prototyping environment, called ***InterProcs***, is presented that includes a graphical design interface for electronic trade scenarios, which automatically generates functioning prototype transaction models that operate locally or in distributed fashion over the Internet.

The focus of this paper is how these prototype scenarios are translated into production level implementations. In the past, this typically involved large amounts of reprogramming. However, the newly emerging component technologies offer the promise to weave new production supply chain software based on commericially supplied vendor components, minimizing the re-development time and costs. In this paper we examine these aspects of component architectures for global supply chains in more detail.

2. Electronic Trade Scenarios

An electronic trade scenario is a computational component that controls the document flow and related constraints and rules for a trade transaction. It also contains specifications for the electronic documents[1] used in the transaction. An electronic trade scenario may be a complete, automatic generic solution for a certain type of trade transaction. As such, it may be downloaded from a public repository by the trading parties, and executed immediately.

The deployment of electronic trade scenarios is normally assumed to be done by means of a repository that is publically available to the trading community. Each party (role) in a trade transaction, whether done repetitively or only once, may obtain the electronic transaction sub-procedure for their role by downloading from this repository, as shown in Figure 1.

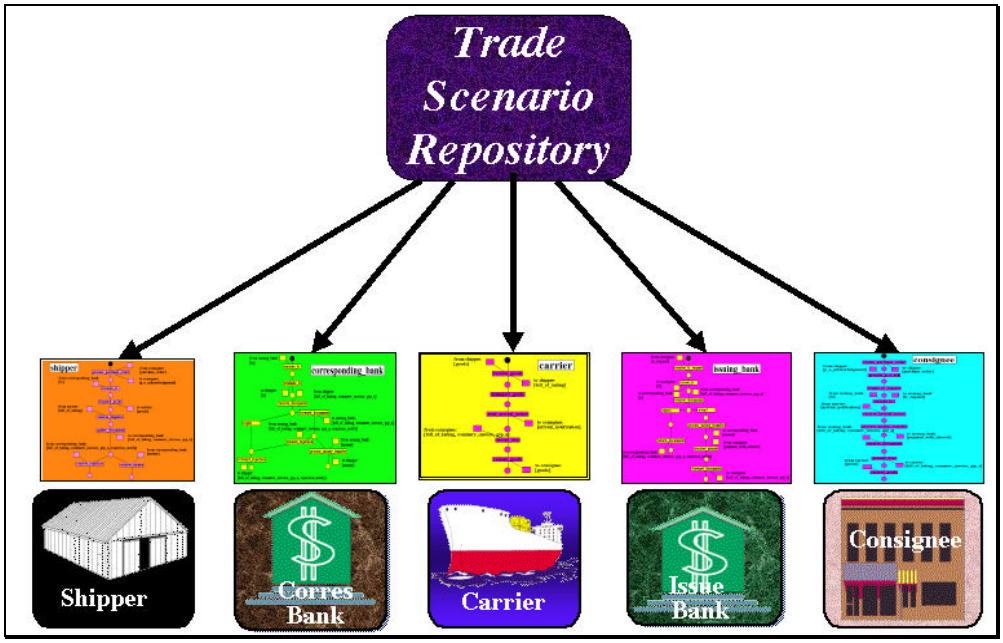

Figure 1. Parties downloading from electronic trade scenario repository

3. Formal Representation of Trade Scenarios

A basic issue for this project is how electronic trade scenarios should be represented (a.) from the modeler's perspective, and (b.) from a computation (inferential) perspective. In the course of our prior research, we have examined a wide number of such representations, including state-transition diagrams, marked graphs, event nets, event grammars, the event calculus, process algebras, temporal and dynamic logics. Eventually, we found Petri Nets [Petri, 1962; Peterson, 1981; Aalst, 1992] to be the most appropriate representation for capturing the temporal/dynamic aspects of electronic trade scenarios, offering both a graphical representation (for modelers) and a formal basis for the verification of various properties (computational). In addition, Petri nets have become popular in a wide variety of problem domains where sequence, contingency and concurrency of activities need to be modeled. This wide acceptance facilitates the training and understandability for electronic trade scenarios. However, Petri nets by themselves offer only a temporal framework for knowledge

[1]Electronic documents might use different kinds of syntax, for instance ANSI/X12 EDI, UN/EDIFACT, XML/EDI, FLBC. An electronic trade scenario might be narrowly defined to assume one specific electronic document syntax, or be more general, to accept different kinds of syntax.

representation. For that reason, we have found it necessary to add various extensions to the Petri net representation, making it more appropriate for the modeling of trade scenarios, what we call Documentary Petri Nets (DPN's). The actions represented in a DPN can include the sending or receiving of a document, goods or funds, or the expiration of a deadline [Lee, 1992; Bons, Lee and Wagenaar, 1995; Lee and Bons, 1996].

Each party (role) to the contract has a separate DPN graph, indicating its actions in the overall transaction [Wrigley, 1992]. While DPN's are used in this project as the representation for trade scenarios, we allow for the possibility that better representations may later be found. While the prototyping environment (explained below) is built using this representation in its graphical interface, the underlying computational representation is actually predicate logic (not seen by the modeler), which enables us to support a wide variety of alternative modeling representations.

4. Design Tool: InterProcs

A tool has been developed to support the design and prototyping of electronic trade scenarios, ***InterProcs*** [Lee, 1992; Lee and Bons 1996; Lee, 1999]. To design a documentary petri net (DPN), the user interacts using a graphical interface. This graph is then compiled into an internal (object-based) representation. This supports the capability of simulating or actually executing these trade procedures.

The simulation mode allows the designer to verify the DPN model, and as well demonstrate it to users and clients. This can be done locally, or over the Internet.

The architecture of these electronic trade scenarios assumes that they will be distributed among multiple, distant parties. Thus, the trade procedure is a collection of separate sub-procedures, one for each party to the transaction. The coordination among these role procedures is done exclusively by the electronic documents they exchange.

5. Modeling Example

Many global supply chains involve sea transport. Even in this aspect by itself, the transaction model may be quite complex [UN/ITPWG].

Following is an example electronic trade scenario for import/export, based on procedures used at the Port of Rotterdam. This model was developed (by R. Bons) based on the Port of Rotterdam Executive Game [Wagenaar, 1992; Wrigley, Wagenaar, and Clarke, 1994], developed at Erasmus University, which in turn was based on analysis and interviews conducted at the Port of Rotterdam itself. It is important to keep in mind that each of these snapshots is the graphical display of a separate computer program, operating on the local machine of each of these parties, essentially a distributed software system for the transaction. Each of the party's role scenarios is downloaded from a central site (the 'transaction provider'), in this case probably the port authority, and is immediately executable. In short, it is "point and click" installation of EDI capability.

The diagram Figure 2, following, is called an Overview Graph. It summarizes all of the document flows among the parties, but omits the details of the sequencing of these flows (sequential order, contingent branching, concurrency). These detail aspects are contained in the DPN diagrams for each role.

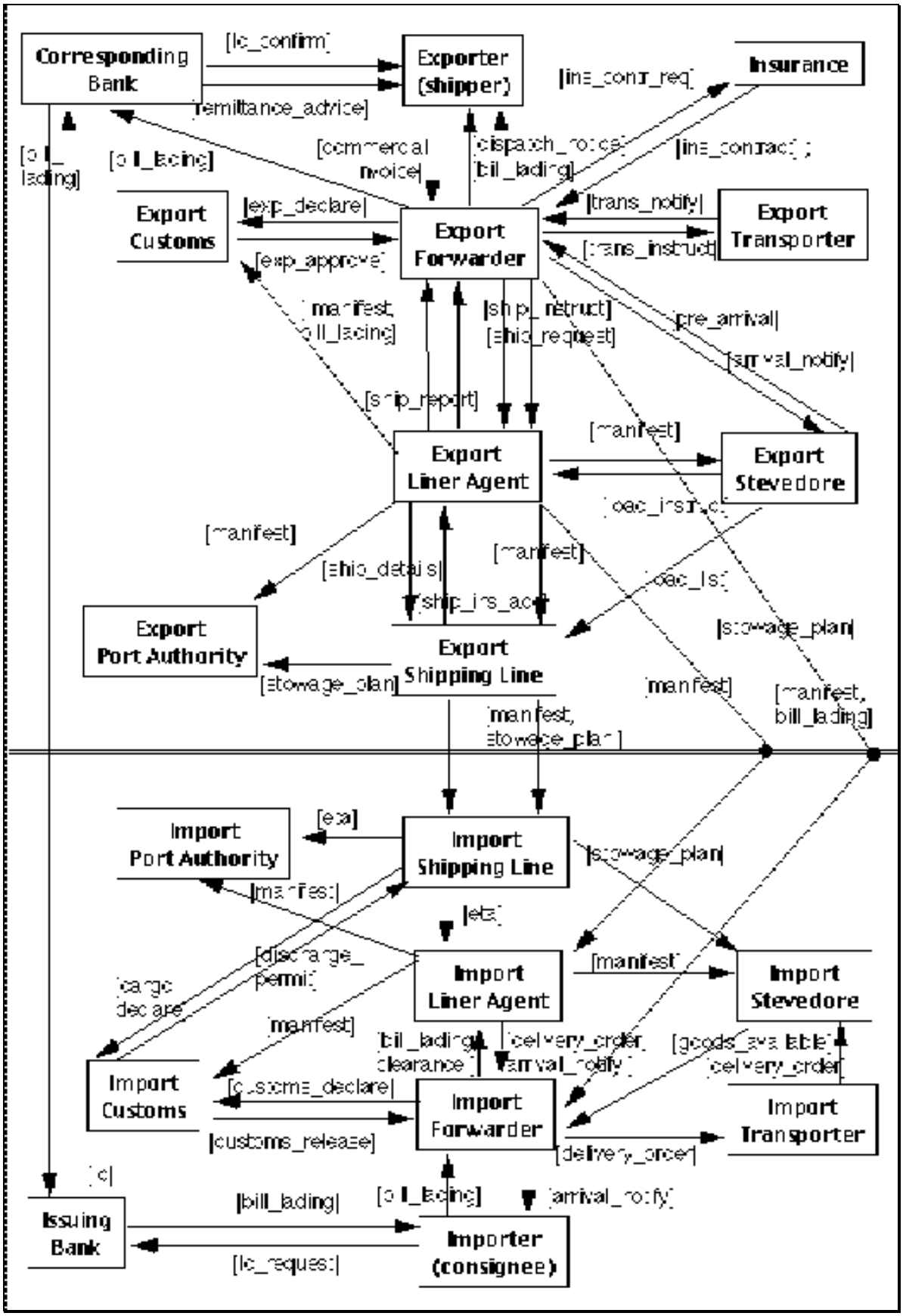

Figure 2. Overview Graph for Import/Export

In Figures 3-5, we present the Documentary Petri Net (DPN) models for three of these roles: the exporter, the export liner agent, and the export liner agent. (Because of space limitations, only these few could be shown.) We remind the reader that while the procedure is shown graphically, each of these DPN's is actually a separate computer program (in Java), that operates independently at each of the parties' locations.

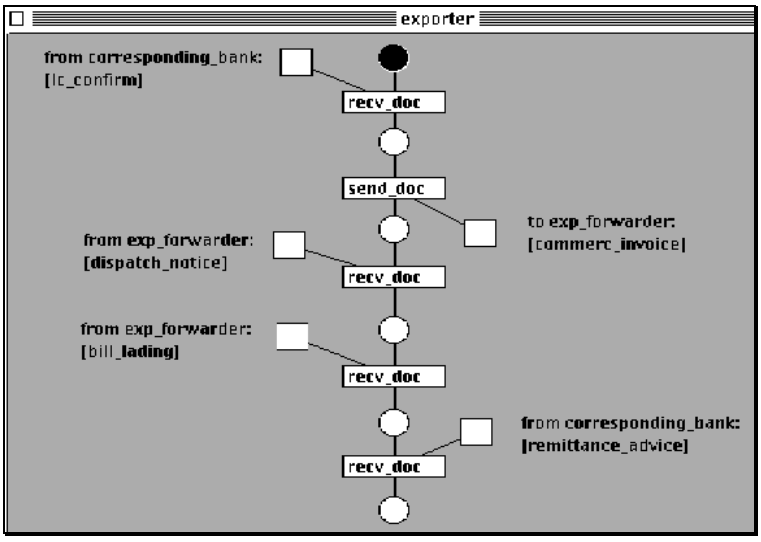

Figure 3. DPN for Exporter

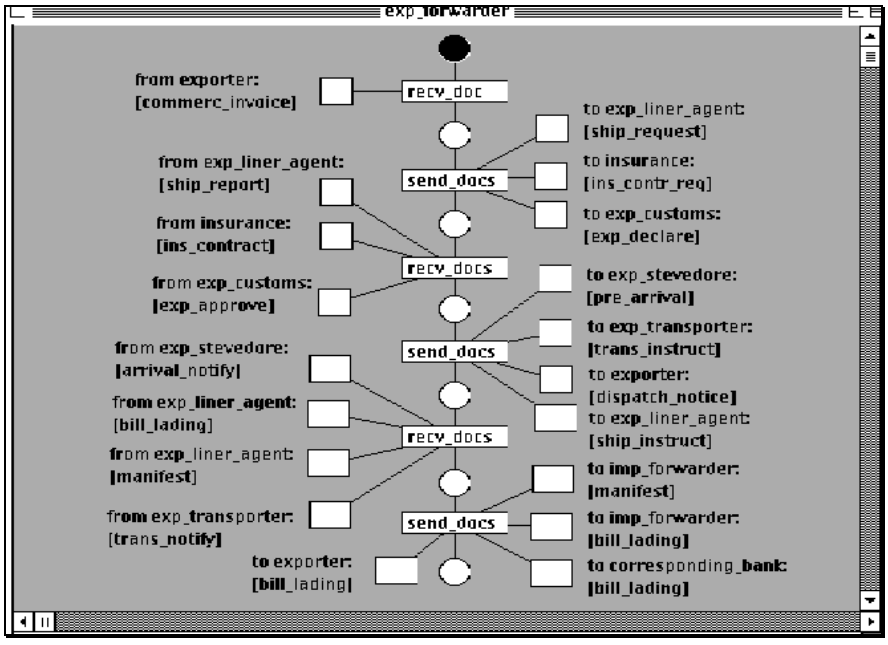

Figure 4. DPN for Export Forwarder

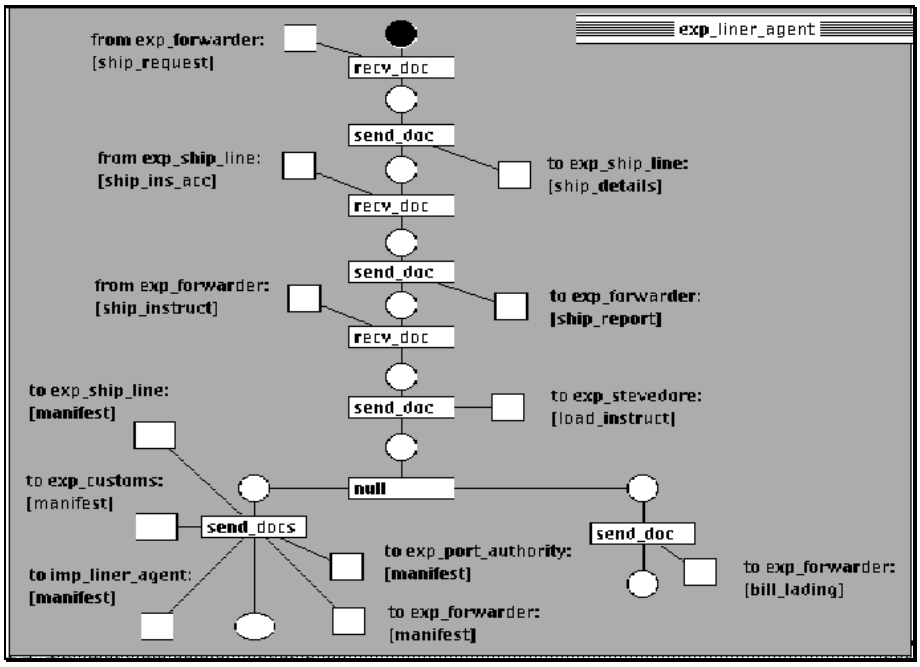

Figure 5. DPN for Export Liner Agent

6. Component Architectures for Global Supply Chains

A key challenge remaining is how these downloadable, generic trade procedures will interface to the specific, and often idiosyncratic aspects of the local application software of each of the parities. A possible solution for this is in the growing popularity of application packages, e.g. those of Baan, SAP, that replace ad-hoc data processing software with off-the-shelf parameter-driven solutions. A by-product of this approach is that these installations have uniform interface by which their applications may communicate with the outside world. Unfortunately, these solutions are (so far) vendor specific. What is needed is more of an "open systems" approach for application integration. Such an approach is gradually emerging in what is coming to be known as "component-based architectures". While this is emerging on several fronts, such as CommerceNet, MicroSoft, the leading innovations (at present) appear to be from a consortium (including Sun, IBM, Netscape, Oracle, BEA, and others) focusing on specifications for components based on the Java programming language and CORBA (a standard for intercommunication among computational objects, possibly written in different programming languages):

"A component is a reusable software building block: a pre-built piece of encapsulated application code that can be combined with other components and with handwritten code to rapidly produce a custom application ... An application developer should be able to make full use of the component without requiring access to its source code. [Thus,] customized business solutions can be assembled from a set of off-the-shelf business objects" [Thomas, 1997, pp 5-6].

A current initiative known as "Enterprise Java Platform" directly addresses the problems of production-level implementation of ***InterProcs*** models, providing "a standard set of application programming interfaces (API's) to a core set of enterprise-class infrastructure services, including life cycle, naming, remote invocation, messaging, transactions, database access, and management." [Thomas, 1997, p. 9]. The component approach seems to be an emerging solution for interfacing to EDI documents as well [Harvey, Hill, Schuldt, Martin, Thayer, Raman and Webber, 1998]. Rather than being simply data structures, document

components will be objects that can dynamically communicate their data contents in a variety of syntactic forms (obtained via object inheritance). Ultimately, these document components will be made available via global repositories, available for applications worldwide.

7. Summary, Conclusions

The concept of an electronic trade scenario was introduced as a potential solution to "open" electronic commerce -- trade among parities that have no prior trading relationship. The vision is that these trade scenarios would be stored in a publicly accessible electronic library (perhaps a "global repository" maintained by an independent international organization), and downloaded loaded by trading parties as needed for a particular trade. The Documentary Petri Nets (DPN) representation was presented as a candidate representation for such trade scenarios. The ***InterProcs*** system was presented as a prototyping environment to support the design and execution of such trading systems using this DPN representation.

The focus here was the generation of global supply chain scenarios as object-oriented components for assimilation within emerging business component architectures, to support plug-and-play installation of trade scenarios into production transaction systems.

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