Coupling Object-oriented EDI with XML/EDI for Internet-based Electronic Business Implementation*

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Abstract

Traditional EDI technology is mainly used among large businesses because the effort to implement an EDI solution is considerable. Internet technology is recently becoming as one of the cornerstones of business and provides a lightweight platform for small and medium enterprises to implement EDI applications for electronic business. This paper proposes a six-phase process for implementing the Internet-based electronic business applications. We provide a link between OO-edi business models and XML/EDI deployment to form a systematic implementation process. Moreover, for dealing with the semantic heterogeneity, we employ an ontology-based mechanism to improve the degree of interoperation between electronic business systems. Therefore, the EDI applications based upon the Internet platform can be more flexible and agility.

Keywords: electronic data interchange(EDI), electronic business, UML, XML, ontology.

1 Introduction

Electronic Data Interchange (EDI) is the computer-to-computer interchange of formatted business documents. It is one of the most powerful tools available to businesses enabling them to electronically transmit purchase orders, invoices, shipping notices, and other business documents that used to be sent in paper format. The potential benefits of using EDI are measurable and include reduced lead times, lower inventory levels and associated carrying costs, fewer lost or incorrect orders, and increased responsiveness to customers, suppliers, and vendors[9]. There are two commonly used standards in EDI, the American National Standards Institute ASC X.12 and UN/EDIFACT[1] standards. The latter is commonly used in Europe and Asia, while X.12 is most often used in North America. Each standard defines EDI documents and the information contained in them in great detail. Unfortunately, EDI technology at present is mainly used among large businesses or where a dominant actor can establish conventions. For small and medium enterprises(SME), and where the communication between partners is not very frequent and intensive, EDI has had less success. The main reason is that the effort to implement an EDI solution is considerable. Another reason is that the parties wishing to exchange business data through EDI usually have to enter into bilateral agreements.

Traditionally, there are two methods of implementing EDI: (1) through a direct computer-to-computer link between two business organizations, (2) through a third party network. The Internet is recently asserting itself as one of the cornerstones of business, with more and more Internet based projects coming to life. It is shaping up to change the way that almost all forms of commerce are conducted. The advent of this ubiquitous communications medium is beginning to have a profound effect on all industry and regulatory sectors as evidenced by the number of organizations that now can be accessed via a public web address. While business-to-consumer (B2C) services are well established there is now an increasing emphasis on the application of Internet technologies to support business-to-business (B2B) services, through the provision of online information and trading services. Today it is accepted that Internet technology is going to change the international situation, production, culture, economical aspects and daily life significantly. Widely pervasive and technically dynamic, this momentum represents the dawning of the digital revolution.

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[1]The United Nations Rules for Electronic Data Interchange for Administration, Commerce and Transport

The international EDI community has developed OO-edi over the past few years as an implementation neutral framework for the future architecture of EDI[1]. XML/EDI has also recently emerged as the implementation and deployment method of choice for next generation of electronic business facilitation via the Internet. This paper shows how these two technologies can be coupled and integrated to develop the Internet-based electronic business applications. We propose a six-phase process for implementing the Internet-based electronic business application. Starting with object-oriented modeling, then identifying data sets, developing DTD for XML/EDI, validating, exchanging, and processing the EDI messages, as well as integrating EDI with applications, we may provide a link between OO-edi business models and XML/EDI deployment.

This paper is organized as follows. Section 2 presents the concepts of Open-edi and the role of object-oriented technology in EDI framework. The coupling architecture of OO-edi and XML/EDI, ontology supporting for XML authoring is given in section 3. Section 4 describes the implementation process of the Internet-based electronic business applications. Section 5 contains concluding remarks and future research directions.

2 Object-oriented EDI

2.1 Open-edi Concepts

Open-edi is an ISO/IEC vision of what EDI should be. ISO/IEC 14662 identifies a baseline for the development of Open-edi scenarios and their implementation[1]. Open-edi assumes a generic approach to standards development, enabling organizations to establish relationships quickly and easily. In principle, once a business scenario is agreed upon, and implementations conform to Open-edi standards, there is no need for prior agreement among trading partners other than the decision to engage in the relationship. The field of application for Open-edi is the electronic processing of business transactions among multiple organizations within and across business sectors.

In order to fully appreciate this concept one can examine the Open-edi Reference Model shown as Figure 1. The model identifies the standards required for the inter-working of organizations, through interconnected IT systems. It is also independent of IT implementations, business content or conversions, business activities, and organizations.

More specifically, the Open-edi Reference Model describes two views of any business transaction, the Business Operational View (BOV) and the Functional Service View (FSV). The BOV addresses the

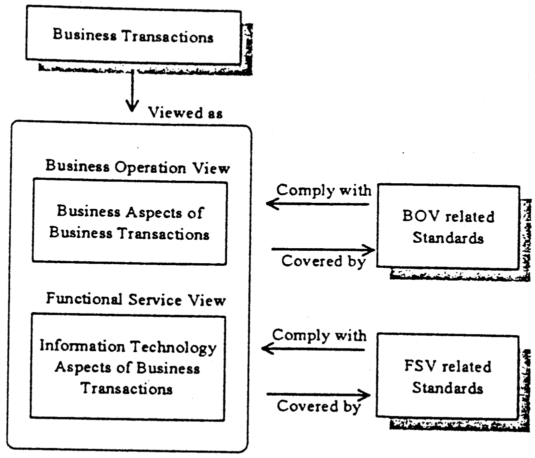


Figure 1: Open-edi Reference Model

semantics of business data as well as the rules for business transactions. The FSV addresses the supporting IT services, meeting the more mechanistic aspects of functional capabilities, service interfaces, and protocols.

The intention of Open-edi is that the formal specification according to the reference model shall be used as follows[7].

- to document the roles of the parties in carrying out the business transactions, such that joining a scenario in effect can be considered to constitute an agreement with the other parties.
- to partially automate the enactment of the business transaction, by automatic generation of code from or interpretation of the formal specification, and by selection and automatic configuration of software components.

However, the reference model is far from this goal, and does in fact not prescribe any specific modeling formalism.

2.2 TWMG's Efforts

The economic advantages of Electronic Commerce (EC), including EDI, are widely recognized and are expanding into numerous areas of business and administration. To date, the majority of implementations have occurred within large, multi-national companies. A variety of reasons, including cost, complexity, and security issues, have limited SME adoption of these techniques. However, today's exponential technology advances, increased demand for information systems which can keep pace with evolving technology, and SME involvement in global trade combine to create a powerful marketplace demand.

As a means of responding to this need, UN/CEFACT's[2] Techniques and Methodologies Working Group (TMWG) and ASC X12's Strategic Implementation Task Group (SITG) have joint forces to develop a single international next generation EDI standard. In doing so the primary objective has been to deliver quality processes, procedures, and tools necessary to manage standards development and maintenance over the entire life cycle. As much "out of the box" thinking as possible has been used in evolving this work by placing an emphasis on reengineering business processes and simplifying the rules that exist between trading partners.

In many instances today emphasis is placed on automating an "as is" process. However, by transforming the emphasis to a streamlined, more efficient process at the beginning of an automation initiative, considerably more productivity can accrue. Therefore, significant opportunities can result from the use of modeling techniques to identify data requirements and flows associated with a process, and object-oriented technology provides one of the more powerful alternatives to identify and convey common business information. The underlying assumption is that models unambiguously reflect information interactions and lend themselves to a clear understanding of what must be provided in any standards design process. Likewise, common business objects are essential building blocks from which application developers can create affordable software representing sharable business scenarios, which can keep pace with evolving business and technology needs.

There are three actions that can improve current EDI[5]. The first two, improving the technical base documents and improving the standards development process could easily be implemented. However, those changes will only result in limited improvement not addressing all of the issues. In order to address all the issues one must investigate new methods that may result in a new way to do EDI. Some of opportunities accrue with the use of modeling techniques to identify data requirements and data flows associated with a particular business process. Object-oriented technology provides one of the most powerful alternatives to identify and convey common business objects and data needed to perform the functions within a business application.

[2] United Nations Centre for the Facilitation of Procedures and Practices for Administration, Commerce and Transport

2.3 Role of Object Oriented Technology

Object-oriented technology is essentially a methodology for organizing data in ways that echo how things are put together and relate in the real world. An object is a reusable, self-contained component of a business information model. It has characteristics (known as attributes) and activities and functions (known as methods). An object knows whom it is, what it does, and how it relates to other objects.

Industry is now turning to the use of object-oriented technology as the most viable solution to the software development problem. Through the use of common business objects we see opportunities to lower costs and hasten the introduction of new software applications. Objects provide the ability to encapsulate data and methods within a representation of program components. In turn, they permit faster application development, easier maintenance, and reduced program complexity. The use of object oriented architectures permit applications acquired from different sources and installed on different platforms to freely exchange information. As quickly as industry is turning to the use of object-oriented technology, it is just as quickly evolving to a discriminator in the positioning of application software in the marketplace. There is very little interoperability between common business applications because the basis for information exchange, e.g., business objects, is predominantly proprietary in nature.

In order to overcome this situation, there must be a common source of object development. A number of issues are resolved by developing and attributing international standards body status to object class libraries. Objects provide the capability to encapsulate much of the knowledge we now store in implementation guides. This facilitates the focus we maintain on the BOV by documenting our knowledge and expertise related to the business process. Interoperability objectives are satisfied in that software developers do not require the development of proprietary objects to support the business models. Cost objectives are met because software developers are not required to develop the business process knowledge needed to develop software applications. Lastly, software developers can focus on product variations (e.g., look and feel) as the means to differentiate themselves in the marketplace rather than focusing on the underlying business process and data requirements.

An object oriented approach to EDI development is, therefore, a "process-driven approach" i.e., when a trading partner looks at another trading partner, what is seen is a common (subset) process, and potentially "extensions" that are unique to a trading partner that are spelled out in a published "scenario". These extensions (often needed for internal or competitive reasons) also become easier to implement than the traditional data driven approach.

3 Harmony between OO-edi and XML/EDI

XML is a simplified metalanguage, derived from SGML, emerging as the standard for self-describing data exchange in the Internet applications. XML's power derives from its extensibility and ubiquity. Anyone can invent new tags for particular subject areas, defining what they mean in document type definitions (DTD) Content-oriented tagging enables a computer to understand the meaning of data, including a number represents a price, a data, or a quantity[6].

UML is rapidly becoming the language of choice for object-oriented modeling in general. UML models have a strongly defined semantics, but perhaps at the cost of being a bit too concretely interpreted for analysis[3, 7]. In addition, UML and CORBA fit well together and so it is natural to use CORBA for the communication part. To use UML for modeling and traditional EDI messaging for communication would require reinterpretation UML models. We therefore adopt UML for modeling, and CORBA for the middleware permitting communication between the Open-edi parties.

3.1 Combining UML and XML

Using the combination of UML and XML as tools we can provide a link between the OO-edi business models and XML/EDI deployment. Figure 2 shows the framework of this concept in practice. There are several components that enable the linking process and each component provides part of an inter-related whole, and also part of requirements for XML/EDI deployment.

OO-edi allows design of object messages in XML as well as UN/EDIFACT messages. We utilize UML to achieve a top-down, process model driven approach to design the generation of EDI applications. UML models allows the specification of messages that could be expressed in either; (1) smaller information bundles that are representative of the object messages in an interaction diagram, or (2) larger, nested messages that are analogous to UN/EDIFACT. Either type of message could easily be communicated in XML syntax.

The UML model approach and XML schema are complementary. Since XML Schema also provides rich data typing that is available in UML, UML models also are expressed in XML Schema. Figure 3 shows an example of a simple UML class and resulted XML data document. The object management group's XML metadata interchange (XMI) document could easily be converted to XML Schema or directly from the modeling tool itself if the tool supported the export. Artifacts that would be converted to XML Schema would be based on UML class diagrams, including the data typing, inheritance, and aggregation based within the class diagram. In addition, XML Schema documents could be imported directly or by conversion to XMI for import into UML modeling tools. Reuse of new and existing XML or even SGML information allows the integration into a cross-industry model via a repository. This will allow the standardization on common semantics, or linking of semantically equivalent items, and standard interfaces across domains, collectively guaranteeing interoperability across these domains.

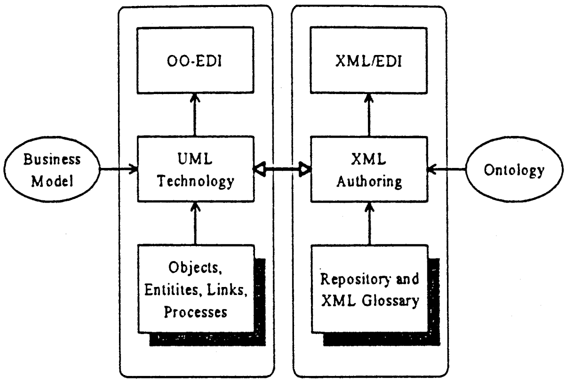
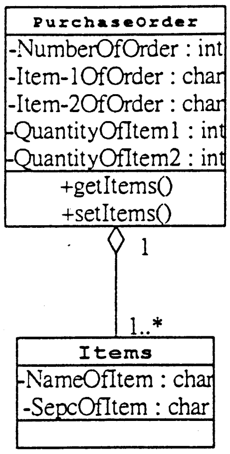


Figure 2: Coupling OO-EDI and XML/EDI

The repositories in XML/EDI provide the means to define the presentation of existing EDI standards code and element dictionaries, EDI transactions, and XML based documents with document type definitions. Repositories also contain new components that enable the complete definition and representation of a business system in an electronic format. We may capture and describe all these components using XML Glossary. Hence, each repository contains XML Glossaries, and these allow the storage and retrieval of the appropriate components. For a detail description and design of the Repository approach, please refer to [2].

3.2 Ontology Supporting

The main purpose of ontology is to enable communication between computer systems in a way that is independent of the individual system technologies, information architectures and application domain. The key ingredients that make up ontology are a vo-



(a)

```
<Class><ClassName>PurchaseOrder</ClassName>
    <Attribute>PurchaseOrder.NumberOfOrder</Attribute>
    <Attribute>PurchaseOrder.Item-1OfOrder</Attribute>
    <Attribute>PurchaseOrder.Item-2OfOrder</Attribute>
    <Attribute>PurchaseOrder.QuantityOfItem1</Attribute>
    <Attribute>PurchaseOrder.QuantityOfItem2</Attribute>
    <Opention>PurchaseOrder.getItems</Operation>
    <Opention>PurchaseOrder.setItems</Operation>
</Class>

<Class><ClassName>Items</ClassName>
    <Attribute>Items.NameOfItem</Attribute>
    <Attribute>Items.SpecOfItem</Attribute>
</Class>
```

(b)

Figure 3: (a) A simple UML class (b)Resulting XML data document

cabulary of basic terms and a precise specification of what those terms mean. The term "ontology" has been used in this way for a number of years by the artificial intelligence and knowledge representation community, but is now becoming part of the standard terminology of a much wide community including object modeling and XML[10]. Ontology is more than a taxonomy or classification of agreed terms. Ontology provides a set of well-founded constructs that can be leveraged to build meaningful higher level knowledge. The terms in ontology are selected with great care, ensuring that the most basic (abstract) foundational concepts and distinctions are defined and specified. The terms chosen form a complete set, whose relationship one to another is defined using formal techniques. It is these formally defined relationships that provide the semantic basis for the terminology chosen.

In the Internet-based applications, such as agent-based systems, the adoption of a shared ontology allows agents to simultaneously interoperate without misunderstanding, retain a high degree of autonomy, flexibility and agility[6, 10]. An ontology-based approach has the potential to significantly accelerate the penetration of electronic commerce within vertical industry sectors, by enabling interoperability at the business level, reducing the need for standardization at the technical level. This will enable services to adapt to the rapidly changing online environment.

XML is widely predicted to improve the degree of interoperation between agents on the Internet. Yet XML does not address ontology and provides only a syntactic representation of knowledge. For this reason, many Internet commerce initiatives are developing taxonomy to support XML-based interoperation. These developments mostly focus upon the identification of standard "tags", and not the underlying ontology. Interoperation is therefore dependent upon each trading partner agreeing to use particular tag sets and using these consistently. It is not clear that this strategy will achieve the degree of interoperation and flexibility.

We believe that an ontology-based mechanism integrated with XML/EDI shown as Figure 2 will enable greater agility and flexibility in the business models. It may also reduce the need for organizations to adopt common infrastructure and implement domain-specific standards. Spontaneous and organized commerce between trading partners will be more viable.

4 Implementation Process

We propose a systematic process for the implementation of Internet-based electronic business applications shown as Figure 4. The process covers an overall life cycle of system development and consists a number of phases that can be viewed as the activities for model's coupling and integrating: (1) modeling business processes, (2) identifying data sets, (3) developing DTD or XML schema, (4) generating XML pages or documents, (5) validating, exchanging, and processing message, and (6) integrating EDI with applications . We describe the basic concepts and functionality of each phase as follows.

Phase I: *Modeling business processes.* Modeling is a means of decomposing business processes into their more generic components. It pro-

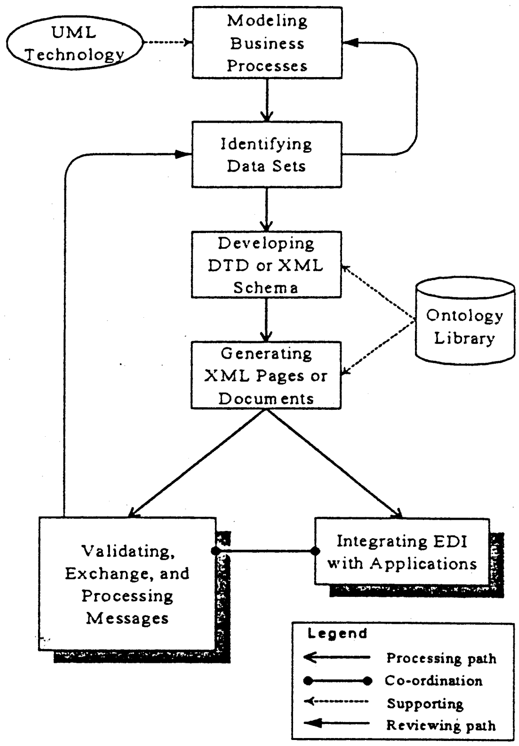


Figure 4: Implementation process

vides a consistent means for representing the essential capabilities, properties and aspects of the process and excludes all extraneous details. Models provide the interface specification that enables non-standard data, internal to a business process, to be mapped and translated to a representation of standardized data.

The role of modeling in next generations standards development will be to act as the mechanism for developing unambiguous business processes (a domain) by providing detailed insight into the concepts of process behavior analysis, architecture design, and implementation. At lower stages of decomposition, models will also identify objects and their interactions, the data needed by the processes, and the rules under which objects operate and interact. As described in Section 3, we adopt UML as an integrated suite of modeling techniques. The results of modeling process will play as a foundation for data sets identification.

Phase II: *Identifying data sets.* Identification of data sets for electronic business transactions will often be the responsibility of industry associations and various standardization bodies such as UN/EDIFACT. Whereas existing EDI definitions are primarily concerned with the way in which a set of fields forms a message, the concepts required for XML/EDI are based more on the definition of independent classes of information that can be combined together with other classes of information to form interchangeable messages. One of the advantages the accrues from XML/EDI's ability to subclass fields is that such fields can be developed interactively using information supplied from more than one location. Once information has been captured, and used to create an instance of the relevant class of data, it should not be necessary to recreate the information each time that is required. The requirement is that business processed this information reference the point at which the data was originally captured, such as the address associated with the purchase order for the items.

Phase III: *Developing DTD or XML Schema.* Messages that pass between systems will typically conform to a previously agreed XML document type definition or schema that formally describes, in terms interpretable by both humans and computers, an internationally accepted message type[8]. XML DTD can be developed by:

- international standards bodies wishing to develop standardized sets of interchangeable data.
- industry associations wishing to develop agreed procedures between members.
- a company wishing to supply information to a number of suppliers or customers.

Phase IV: *Generating XML pages or documents.* An XML/EDI electronic business message may consist a number of pages or documents, a pointer to the DTD, any definitions required in the internal subset of the DTD, as well as entries for each of the fields required for the message. We associate with ontology library shown as Figure 4 to assist dealing with the understanding of domain-specific tagging terms. In addition, we also permit entities and attributed that are defined in the external subset to be redefined in the internal subset. This facility allows XML/EDI users to develop locally significant subclasses, i.e., domain-specific web pages and documents.

Phase V: *Validating, Exchanging, and Processing message.* A validating XML document instance processor (known as an XML parser) to ensure they contain all required elements form the specified data set, and that the fields are in the required sequence can validate XML/EDI messages.

Data captured in XML/EDI messages can be exchanged in several ways such as: (1) in the form of an XML file interchanged using the HTTP protocol or its derivatives (secure HTTP), (2) in the form of a multiparty Internet e-mail message, (3)in the form of an EDI message that is created by processing the XML file at source using a special conversion program.

The way in which a received message would be processed depends on which of the available methods for exchanging messages was chosen. If the message was received in a format that provided the XML/EDI message generated by the originator, the XML Style Language(XSL) can be used to associate different processes with individual element classes. Therefore, the elements can be processed by one or more local processors[8].

Phase VI: *Integrating EDI with applications.* Almost any applications capable of importing and exporting ASCII text should allow integration of an EDI product. Since EDI is not normally a part of the application itself, most EDI vendors provide rather extensive facilities to interpret the output of an application and convert it into EDI, also being flexible while generating output.

While planning the implementation, it is vital to consider what processing will be done to permit receipt of function acknowledgments(FA) and matching to the original document. Periodically, these audit trials can be scanned for unmatched transactions and the trading partners can be notified of a problem.

5 Conclusions

This paper has presented a systematic process for implementing Internet-based electronic business applications. We couple object-oriented modeling technology with XML to form an integration characteristic for system development. Moreover, for dealing with the semantic heterogeneity, we employ an ontology-based mechanism to improve the degree of interoperation between electronic business systems. Therefore, the EDI applications based upon the Internet platform can be more flexible and agility.

EDI systems are not only technical devices used on the operational level on business transactions, but they imply considerable organizational as well as strategic challenges and chances that have to be taken into account by management in order to exploit the potential benefits[9]. The future of electronic business will undoubtedly deploy the aforementioned technologies as starting blocks and evolve to more advanced technologies as part of the ongoing digital revolution. Some further research issues might include the constructing of reusable common business objects, building the semantic data element directory to provide for multilingual extension and the basis for a standardized XML "tagging" methodology.

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