# Tendering Process Model (TPM) Implementation for B2B Integration in a Web Services Environment

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## Abstract

*Improvements can be made for tendering processes to solve B2B interoperability and integration problem by means of Web services technology. In this paper, we detail our tendering process model (TPM) based on Web services with SOAP messages exchange in XML format to improve inefficient manual or semi-automated tendering process. Adopting TPM, seeking ideal tender-supplier couple (TSC) with a business-to-business (B2B) application is illustrated as a real example to find best tender for suppliers and best quotation for tenders respectively. The approach discussed in this paper is a novel application in tendering process of logistics industry and is beneficial to stakeholders involved.*

## 1. Introduction

Logistics covers fields like supply, procurement, order, purchase, delivery, and tendering. With its growing popularity, the efficiency is much impaired in long-term if the problem of integration and interoperability in tendering processes cannot be solved.

The problem discussed in this paper is solved with the help of technology advancement. Over the past several years, Web services have been expanded to become more and more popular for application development, mainly due to its competitiveness in applications integration [8]. Web services technology offers a unify platform for both *business-to-business* (B2B) and *business-to-business* (B2C) communications. The goal of the Web service paradigm is to overcome some of the main drawbacks of traditional business-to-business applications that, in most cases, result in complex, custom, one-off solutions, not scalable, and costly and time consuming. Some benefits of adopting Web services are that they are platform and vendor independent, since they are based on a set of standards, they provide a means for convergence disparate business functionalities [1], they make easier to deploy business applications for trading partners, thus resulting in a significant reduction in total cost of development.

Unlike traditional client-server models, such as a Web server or webpage system, Web services do not provide the user with a Graphic User Interface (GUI). Instead, Web services share business logics, data, and processes through a standardized programmatic interface across a network. The applications interface with each other, but not with the users. Application developers can then add the Web service to a GUI (such as a Web page or an executable program) to offer specific functionalities to users. Besides, Web services distributed computing model application-to-application communication over the Internet is realized [2]. For example, a tendering application could communicate via Web services programmatic interface with an inventory application that specific items need to be reordered.

Tendering processes are complex. A typical one involves lots of business procedures such as tender specification preparation, tender advertisement, tender aggregation, tender evaluation, tender awarding, contract monitoring, etc. Besides, a tendering system often needs to communicate with other systems such as supply, order, purchase, procurement, and even account to complete its procedures. The total number of stakeholders involved can be numerous, and it is crucial for them to interoperate smoothly with one another through a programmatic interface written in a common language. Ideally, a well-suited tendering process model should be designed making use of this language to provide a framework for all stakeholders to follow strictly, so that application-to-application communication over the Internet in an organized manner becomes possible.

For instance, in a traditional paper-based bidding process, after a tender is released, suppliers must provide quotations of detailed goods or service information to tendering system so that they can be ranked by certain tender requirements before the tender contract is finally granted after selection. However, this tender bidding and contract granting process is not automated. This results in wasting a significant amount of human effort and time in the tender business procedures, such

Proceedings of the 40th Annual Hawaii International Conference on System Sciences (HICSS'07)
0-7695-2755-8/07 $20.00 © 2007 IEEE
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as preparing and responding to electronic tender document via cumbersome procedures like filling in web-base form or e-mail tender documents. Furthermore, the possibility of tendering process interruption is extremely high because of unavoidable human attention. A tendering process model (TPM) for structuring the business workflow and a standardized protocol for stakeholders' application-to-application communication over the Internet is therefore crucial.

Based on our earlier experience in developing e-Negotiation support with a meta-modeling approach with Web services [2], we apply and extend it for tendering processes. The rest of the paper is organized as follows. Section 2 discusses some background information about this topic like tendering process procedures. Section 3 reviews related work. Section 4 describes the architecture and implementation method for tendering process model (TPM). Section 5 illustrates with a real example of matching tender-supplier couples (TSC) adopting this model. Section 6 concludes our paper with discussions of the advantages of our approach and our continuing research work.

## 2. Background

Prior looking depth into a tendering process let us introduce the stakeholders involved.

### 2.1. Stakeholders

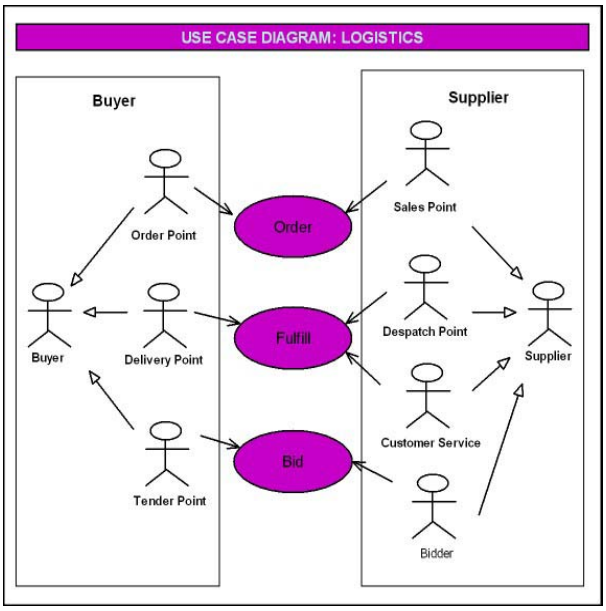


*Figure 1. Stakeholders Involved in Logistics*

Figure 1 shows some of the related parties in logistics. '*Logistics*' refers to the ways in which how goods can be moved or supplied and it involves various business processes such as order, delivery, purchase, or tender. '*Bidder*' refers to a person who provides an offer to do some work at a certain price. '*Supplier*' refers to any natural or legal person or public entity or group of such persons and/or bodies, which offers on the market, respectively, the execution of works and/or a work, products or services. '*Tender*' refers to a statement of the price one would charge for doing a job. '*Contract*' refers to a formal agreement, having the force of law, between two or more people or groups. '*Quotation*' refers to the calculated cost of a piece of work. '*Procurement*' refers to the act of getting possession of goods. This paper focuses only on the tendering process because its implementation for B2B integration with Web services has not been extensively studied before.

### 2.2. Tendering Process

In general, no matter paper-based or computerized tendering process, both of them begin with a needs analysis, followed by supplier selection, tender invitation and ending with contract awarding and contract monitoring.

**Need Analysis -** Before a tender is issued, the responsible Contracting Authority (CA) ensures that it researches the needs of end-users to make sure that the tender specification meets these needs.

**Supplier Selection** - CA carries out their own supplier search for smaller contracts, or use pre-negotiated contracts of buying groups without tendering. Suppliers may even approach these buying groups separately to enquire about opportunities to supply.

**Tender documents -** usually called an Invitation to Tender (ITT), which contains the following sections:

a. Introduction
   -Background information of the tender
b. Tender Conditions
   -Legal parameters surrounding the tender
c. Specification
   -Description of the supplies, service or works to be provided
d. Instructions for Tender Submission
   -Instructions for the bidders
e. Qualitative Tender Response
   -Qualitative questions designed for bidder
f. Pricing and Delivery Schedule
   -Quantitative questions designed for bidder
g. Form of Tender
   -Declaration to be signed by the bidder
h. Certificate of Non-Collusion
   -Declaration that the bidder has not colluded with any other bidder on the tender
i. Draft of Proposed Contract
   -A draft of the contract that will be signed by the successful bidder

**Tendering Procedures** - Tenders are classified as 'Restricted', 'Open,' and 'Negotiated' tenders.

**Restricted Tender** follows a two-stage process. All suppliers that have expressed an interest are sent a pre-qualifying questionnaire (PQQ). The PQQ is split into a number of sections:

a. General Company Details
b. Technical Resources
c. Financial Information
d. References

Suppliers are short-listed based on the above information, and the ITT are sent to appropriate ones. Normally, suppliers have certain period of time to respond to PQQ and ITT.

**Open Tender** allows any supplier that expresses an interest in tendering to be sent the ITT documents. The supplier simply sends a letter referring to the contract, expressing an interest, and enclosing the relevant contact details. Normally, suppliers have a certain period of time to respond to the ITT.

**Negotiated Tender** is carried out only under special circumstances, such as when a project needs to be completed within a short period of time, or there is only one supplier or contractor who has the necessary supplies or expertise, where the technical and other parameters may not be capable of precise definition and where security projects of national importance are involved.

**Award of Contract -** Most contracts are awarded on a most economically advantageous tender basis. Therefore, the evaluation may not be restricted to just the cost. A contract is awarded after evaluating a range of criteria, which are usually weighted by importance [9]. Criteria other than cost may include quality, experience, proposed payment processes, and timetable for implementation.

**Contract Award** - The CA signs a contract with the selected supplier based on the "Draft of Proposed Contract" included in the tender documents once the contract has been awarded.

**Contract Monitoring** - The CA expects to meet with the selected supplier on a regular basis to review its performance and discuss any related issues.

## 3. Related Work

Manual tendering process is time-consuming and cumbersome, often taking months of turn-around time and numerous manual procedures, which is costly for the stakeholders involved. There are several approaches existing in the marketplace.

e-Tendering is the most well-known approach [5]. It attempts to solve the problem by replacing paper-based tendering processes with electronically facilitated processes based on tendering practices to save turn-around time. However, this solution is incomplete, since the *interoperability between stakeholders remains weak*, i.e., the ability for two or more systems (or components) to exchange information and to use the information that has been exchanged is still lacking. For instance, the tendering process may not be efficient enough if buyers need to manage the tenders coming in by first storing them in one place, cut and paste data from the electronic tender documents for comparison in a spreadsheet, or make use of semi-automated evaluation tools to carry out the supplier selection process, and then reply selection result. The labour cost is raised if 7x24 operation is in need.

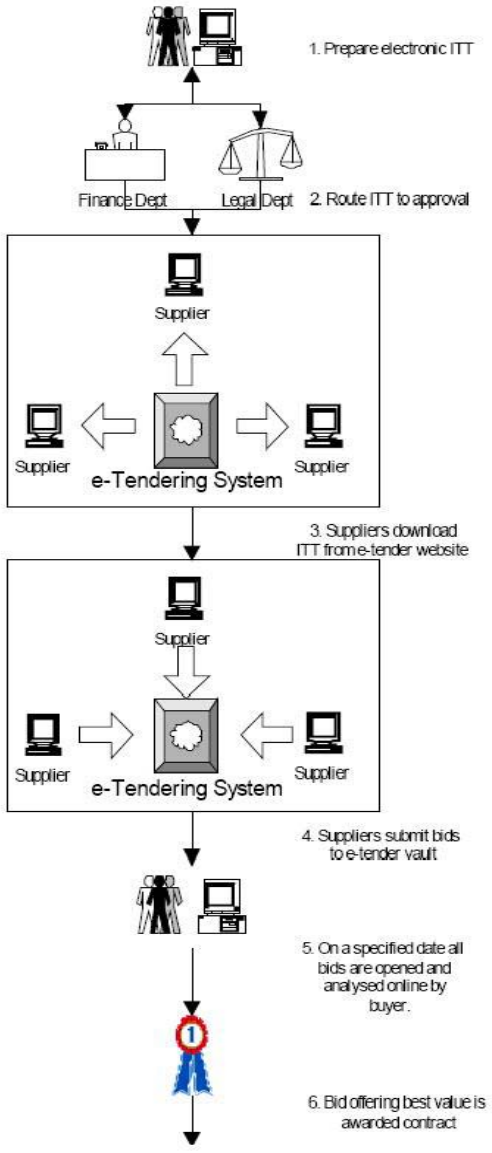


*Figure 2. Typical E-Tendering System*

This simple technical solution based on secure e-mail and electronic document management, involving uploading tender documents on to a secure Website with secure login, authentication, and viewing rules. So, the e-tendering approach is just an *electronic paperless* one, which is inadequate to solve the problem.

Figure 2 describes a typical e-tendering System involving the following steps:

1. CA staff creates the electronic ITT document online.
2. ITT document is sent to all the parties involved in the approval process such as finance and legal departments.
3. ITT is published via the e-tendering system and is available online for interested suppliers to look into details.
4. Suppliers access the e-tendering system to view the ITT via the CA's website.
5. Suppliers respond to ITT by sending their bids using secure e-mail to the e-tendering system. Security features prohibit access to any of the tender responses until a specified deadline.
6. Once the tender deadline has been reached, the CA users of the system can view the tenders and collaborate on-line to perform evaluation analysis of the submitted bids, either manually or semi-automatically by bid evaluation tools.
7. The supplier of the winning bid is notified of the award via the e-tendering system.

Tools available in the current market offer various levels of sophistication. A simple e-tendering solution may be just a simple application on a Web server, where electronic documents are posted with basic viewing rules. This type of solution is unlikely to provide automated evaluation tools. Users need to download tenders to spreadsheets and compare them manually. Such solutions can only reduce the turn-around time of paper-based tendering slightly.

More sophisticated e-tendering systems may include more complex collaboration functionality, allowing users in different locations to view and edit electronic documents. They may also include e-mail trigger process control to alert users, for instance, when a staff has made changes to a collaborative ITT, or a supplier has posted a tender.

For all the above situations, manual procedure is necessary for the execution of the tendering process. The interoperability between stakeholders is weak because of lacking in a standardized language for interfacing, and the tendering workflow seems to be unstructured.

Web services can be used to overcome these problems and realize a really efficient tendering process, reducing the time and cost significantly. Our approach automates most of the tendering process's procedures from preparing the tender specification, tender advertising, tender aggregation, to the evaluation and placing of the contract, under a structured model that has taken all business requirements into account after detailed analysis. Early adopters of Web services include several industries such as logistics businesses that may involve a set of diverse trading partners working closely together on Internet [11]. In summary, the properties of Web services can be summarized as follows:

- Loosely-coupled. Web services can run independently of each other on entirely different implementation platforms and run-time environments.
- Encapsulated. The only visible part of a Web service is the public interface.
- Standard Protocols and Data Formats. The interfaces are based on a set of XML standards.
- Invoked Over Intranet or Internet. Web services can be executed within or outside the firewall.
- Components. The composition of Web services can enable business-to-business transactions or connect the internal systems of separate companies, such as workflow.
- Ontology. Everyone must understand the functionality behind how data values are computed.
- Business Oriented. Web services are not end-user software.

As a result, a pool of Web services can provide an easier integration environment to achieve interoperability, reusability and robustness. Initial Web services-based applications are usually within businesses (behind the firewall or Intranet) in order to gain trust.

The overhead of streamlining the tendering process from start to finish requires more specific tender requirements for automatic evaluation of strict tender criteria and request responses from stakeholders to be in a particular format.

## 4. Tendering Process Model (TPM)

In this section, we introduce a model to cover different tendering procedures (open, restricted, negotiated), its architecture, model, and implementation with Web services. We illustrate our TPM with four typical kinds of tendering processes: Request To Participate (RTP), Invitation To Tender (ITT), Tender Submission, and Tender Award Notification. The business documents are specified for implementation as Extensible Markup Language (XML) documents to be exchanged between stakeholders involved. The exchange of information described in this section can be carried out through different means although Simple Object Access Protocol (SOAP) is considered as an ideal choice [3]. The models described below assume the electronic

exchange of data in a fully automated environment with application-to-application communication over the Internet.

### 4.1. System Architecture

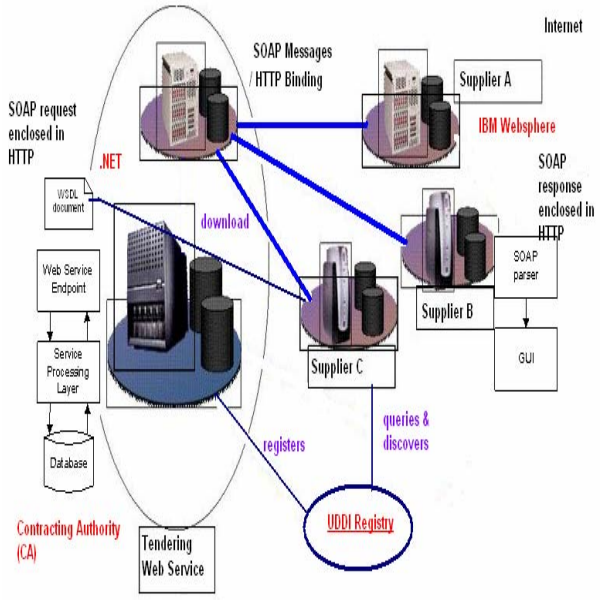


*Figure 3. Web Service SOAP Messaging Architecture*

Web service SOAP messaging architecture as described in Figure 3 has been used to improve the integration and interoperability of the tendering process.

The CA provides the tendering Web services for suppliers. The Web Services Description Language (WSDL) document has described the Web service technical details and Web service interface such as what operations it supports, what protocols is adopted, and how the data exchanged should be organized [6][14]. It is considered as a contract between the Web services requestor and the provider.

First of all, the CA *publishes* the WSDL document to Universal Description, Discovery and Integration (UDDI) registries, which serves as "yellow pages" of WSDL documents that provides a standard means for describing organizations and their services thereby allowing online service discovery [15]. Then service requestors, such as suppliers, act as a requestor entity that expects to make use of the tendering Web services for achieving its business requirements by using UDDI registries. UDDI provides the information for the matchmaking between the Web service provider and requestor. UDDI works as a discovery agency, like Web search engine such as Google.

Once suppliers *find* the tendering Web service at the UDDI registries, the suppliers gets the correspondent WSDL document and *binds* with the Web service via a SOAP message [16]. SOAP is an XML-based messaging protocol that is independent of the underlying transport protocol (e.g., HTTP, SMTP, and FTP). SOAP messages are used both by the suppliers to invoke tendering Web service, and by the tendering Web services to answer to their requests. Therefore, the tendering Web services provider (i.e., CA) receives the input SOAP message from and generates an output SOAP message to the suppliers [2][3][6]. In the next subsection, we detail how Web services can facilitate the implementation of our TPM.

### 4.2. Business Process Meta-Model

The tendering process can be classified into business procedures as below (Figure 4):

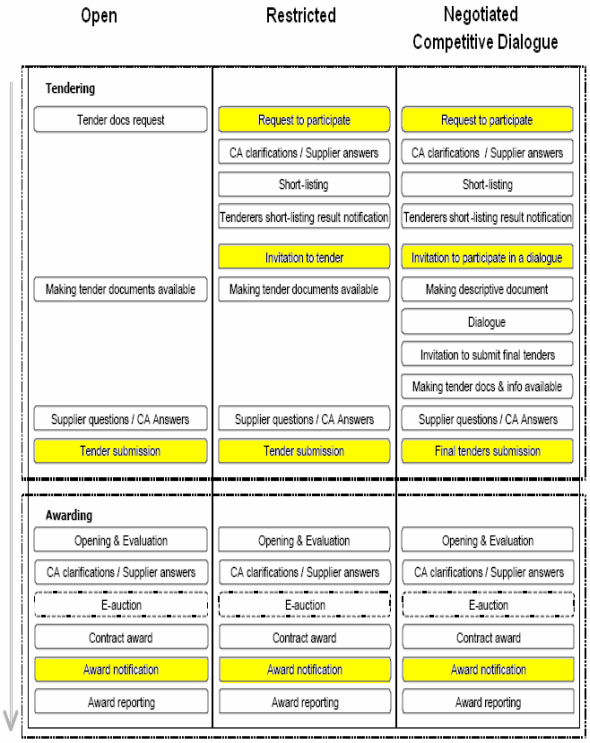


*Figure 4. Tendering Business Processes*

The tendering phase covers the preparation of an offer by a supplier in response to a call for competition, as well as its submission to and receipt by the CA. The awarding phase begins with the opening of tenders. After evaluating the tenders, a winning tender is selected and an award notice is published through the appropriate services. Suppliers are informed of the result of the selection. This model describes three of the award procedures: open, restricted, and competitive dialogue. Highlighted ones in the diagram are described with UML sequence diagrams afterwards.

Four typical tendering procedures meta-models are presented in the Unified Modeling Language (UML), which is a modeling language for visualizing, specifying, constructing, and documenting the artifacts of a software-intensive system. UML offers a standard way to write a system's blueprints, including conceptual things such as business processes and system functions, as well as concrete things such as programming language statements, database schemas, and reusable software components. Note that UML standardizes only the notation, leaving software engineers the freedom to adopt their own software development process.

### 4.2.1 Request To Participate (RTP)

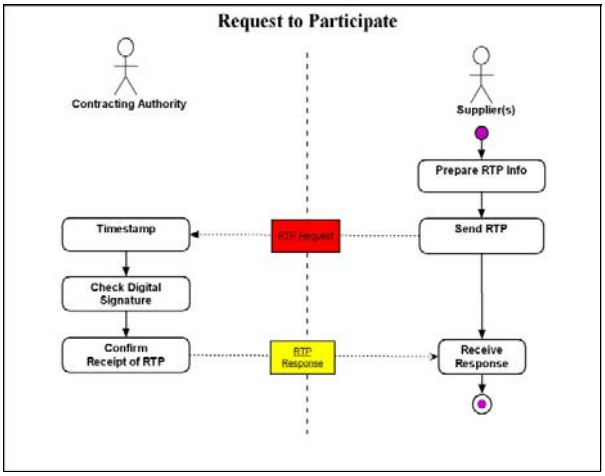


*Figure 5. Request to Participate*

Figure 5 presents a meta-model of RTP in UML [9]. In response to the corresponding contract notice, suppliers (or bidders) may request to participate by sending the required information (legal, economic, financial, and technical information) to the CA. The request is duly signed and sent to the CA. The RTP is received by the tendering platform or directly by the CA, which time-stamps it, and checks the reception date against the deadline defined in the contract notice. The supplier is notified whether its RTP is accepted.

To illustrate the implementation, the following XML business documents (SOAP messages) are designed for the *RTP* Web service:

| Messages | Description |
|---|---|
| Request to participate | Sent by a supplier to the CA to request participation. Contains all required information. |
| RTP Response | Sent by the CA to a supplier in response to a previous request to participate to acknowledge receipt of RTP. |

### 4.2.2 Invitation To Tender (ITT)

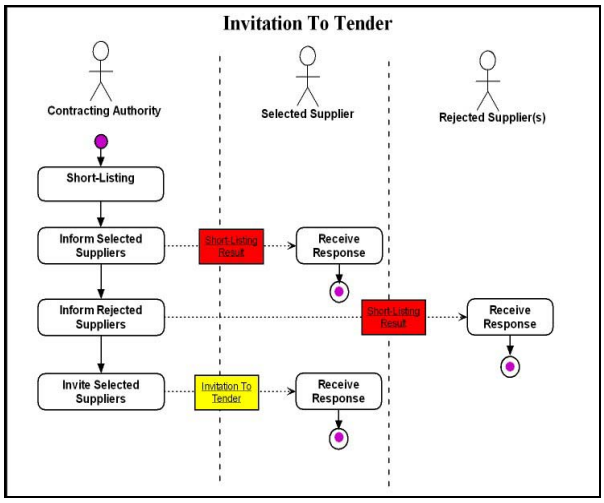


*Figure 6. Invitation to Tender*

Figure 6 presents a meta-model of ITT in UML. The CA invites some or all pre-selected suppliers to tender. This applies also in the case of a reopening of competition between several suppliers. When using a tendering platform, the CA uploads the contract documents and makes them available to the suppliers it has invited to participate or tender. The following XML business documents (SOAP messages) are designed for the *ITT* Web service:

| Messages | Description |
|---|---|
| Short-listing Result | Notification of rejected suppliers by the CA of the result of the short-listing process. |
| Invitation to tender | Sent by the CA to a supplier in order to invite it to submit a tender, after a previous request to participate. |

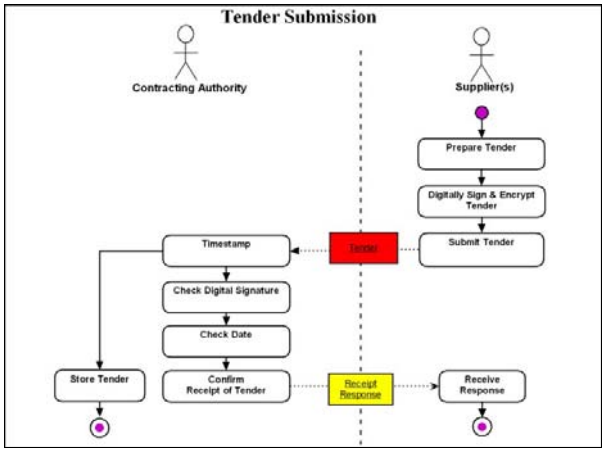


*Figure 7. Tender Submission*

### 4.2.3 Tender Submission (TS)

Figure 7 resents a meta-model of Tender Submission (TS) in UML. To submit the tender electronically, the supplier prepares its tender and then sends it to the tendering platform. The supplier may sign and encrypt it before uploading it. However, verification and evaluation of safety requirements (i.e. time stamping, signature features, etc.) constitute a separate process. Its sequencing depends on the type of security device used (PKI, PIN). Moreover, time stamping and use of the digital signature may involve interactions with third parties. These are mainly exchange at the software or hardware level that are not considered in our model and therefore, do not appear in the schema below. The submission date of the tender may be checked against the deadline defined in the contract notice. The tendering platform stores all submitted tenders in a secure vault. It issues a reception response to acknowledge receipt of the submitted tender. The following XML business documents (SOAP messages) are designed for the *TS* Web service:

| Messages | Description |
|---|---|
| Tender | Offer sent by the supplier to the CA. A tender may take the form of an electronic catalogue. |
| Reception Response | Sent by the CA to a supplier in response to a tender submitted. It acknowledges the receipt of the tender submitted. |

### 4.2.4 Tender Award Notification (TAN)

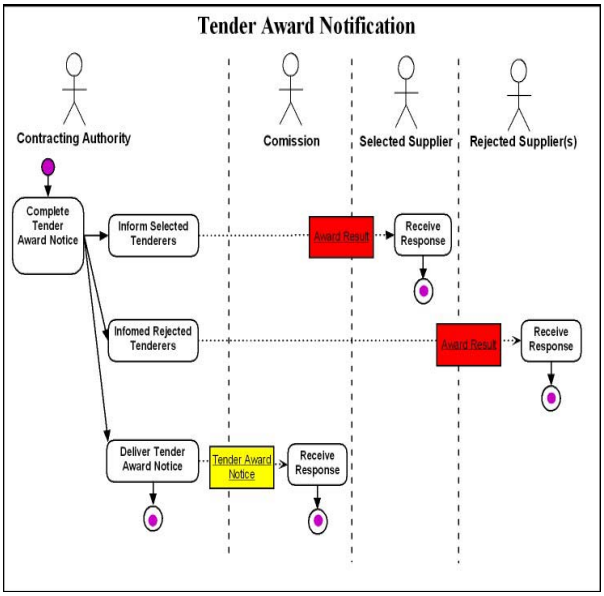


*Figure 8. Tender Award Notification*

Figure 8 presents a meta-model of Tender Award Notification (TAN) in UML. The CA must inform all participants of the result of the tender award as soon as possible, no matter the selected or eliminated suppliers. Besides, an award notice is sent out as well for publication of the tender award result. The following XML business documents (SOAP messages) are designed for the TAN Web service:

| Messages | Description |
|---|---|
| Award Notice | Sent by the CA for official publication using the corresponding standard form. |
| Award Result | Notification of the tenders by the CA of the result of the awarding process. |

### 4.3. Business Document Specifications

SOAP messages are often combined to implement patterns such as request and response for Web services. All SOAP messages are encoded using XML, which is an XML document that consists of a mandatory SOAP envelope, an optional SOAP header, and a mandatory SOAP body.

Example 1 SOAP Message Embedded in HTTP Request

```
POST /Tender HTTP/1.1
Host: www.tenderserver.com
Content-Type: text/xml; charset="utf-8"
Content-Length: nnnn

<SOAP-ENV:Envelope
 xmlns:SOAP-ENV="http://schemas.xmlsoap.org/soap/envelope/"
 SOAP-
ENV:encodingStyle="http://schemas.xmlsoap.org/soap/encoding/">
<SOAP-ENV:Body>
 <SendMessage xmlns="http://www.tender.com/Webservices">
 <InvitationToTender>
 <tenderReceptionDeadline>6-12-2005</tenderReceptionDeadline>
  <tenderSendingAddress>HKUST</tenderSendingAddress>
   <tenderLanguages>English</tenderLanguages>
  <documentsRequestDeadline>6-10-2006
   </documentsRequestDeadline>
   <documentsPrice>500</documentsPrice>
   <paymentProcedure>Cash</paymentProcedure>
 </InvitationToTender>
 </SendMessage>
</SOAP-ENV:Body>
</SOAP-ENV:Envelope>
```

Example 2 SOAP Message Embedded in HTTP Response

```
HTTP/1.1 200 OK
Content-Type: text/xml; charset="utf-8"
Content-Length: nnnn

<SOAP-ENV:Envelope
```

```
  xmlns:SOAP-ENV="http://schemas.xmlsoap.org/soap/envelope/"
  SOAP-
ENV:encodingStyle="http://schemas.xmlsoap.org/soap/encoding/"/>
<SOAP-ENV:Body>
  <SendMessageResponse
xmlns="http://www.tender.com/Webservices">
  <SendMessageResult>true</SendMessageResult>
  </SendMessageResponse>
</SOAP-ENV:Body>
</SOAP-ENV:Envelope>
```

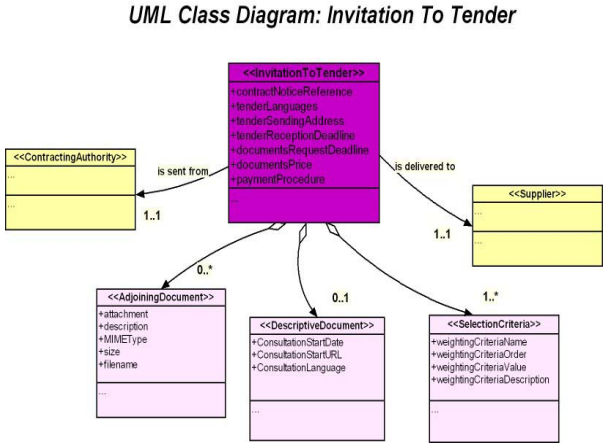


*Figure 9. UML Class Diagram: Invitation to Tender*

For business procedure discussed in section 4.2.2, the ITT UML class diagram (Figure 9) can be converted into XML specification for SOAP messages exchange between stakeholders.

## 5. Illustrative Scenario

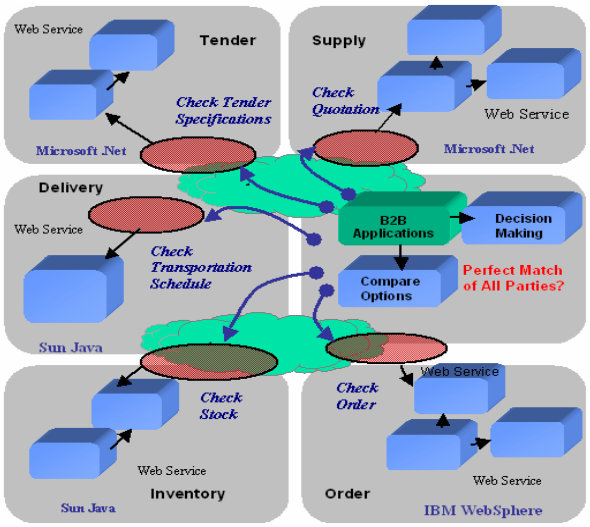


*Figure 10. Tender-Supplier Couple (TSC)*

In this section, we provide an illustrative scenario which makes use of the TPM as discussed in the previous section to integrate tender and supplier systems as depicted in Figure 10.

It is a norm for tendering systems to look for the best supplier quotation meeting tender requirements, and so it does for suppliers to look for the best tender offered price, tender-supplier couple (TSC) is the most ideal partner formed which brings greatest benefit to both of them. The degree of fitness may depend on their self-defined criteria such as cost, quality, experience, service level, past performance, delivery schedule, proposed payment processes, and timetable for implementation.

These criteria are considered as metrics for non-equally weighted average score calculation to find out the ideal TSC [9]. An ideal tenderer or supplier should archive the *highest score* among all participated competitors. An ideal TSC is identified by considering expectations of both parties fairly. We highlight the implementation procedures as follows:

(1) **Initialization** – During the invitation to tender (ITT) and tender submission procedures, stakeholders communicate with one another via an agreed schema to gather the relevant metrics-related information. The scale can be large, say, if each tenderer needs to talk with 1000 suppliers RTP. All information for the *current* metrics is stored within their own database management systems (DBMS).

(2) **Top-$N_{accept}$ List Ranking** – Non-equally weighted average score is calculated for all suppliers ($S_1 ... S_N$) based on metrics criteria. Once a tenderer ***T*** desires to find its "mates" (and vice versa), T's *top-$N_{accept}$ list* is then found, with most ideal supplier $\boldsymbol{S_{ideal}}$ which owns the greatest weighted average score ranked 1st on the list.

(3) **Ideal TSCs Identification** - Assumed that *T* accepts only the top-3 suppliers, and $S_{ideal}$ accepts only top-5 tenderers ($S_{ideal}$ considers $T_1 ... T_M$ from different angle of view metrics), *T* will first check with $S_{ideal}$ to see if *T* itself is on $S_{ideal}$ *top-$5_{accept}$ list* too. An ideal *TSC* is found if both of them are on the corresponding *top-$N_{accept}$ list*, and tender award notification procedure is executed. Otherwise, *T* checks with supplier that is ranked 2nd on *T's top-$3_{accept}$ list*. Sometimes, no TSC can be formed if *T* cannot satisfy the top-3 suppliers' expectations (i.e., *T* is not listed on any of its top-3 suppliers' *top-$N_{accept}$ list*), the tender will close without qualified suppliers.

### 5.1. Ideal TSC Identification Weighted Average Score Calculation Example

Assumed that a tenderer *T* considers 3 different metrics $M_i$ for ideal supplier selection $S_{ideal}$ from its

point of view, i.e., $M_1$: Cost of Goods, $M_2$: Location of Stocks, and $M_3$: Scale of Suppliers. Besides, *T* considers the metrics importance in supplier selection $M_1 > M_3 > M_2$. With appropriate weighting assigned for different metrics, the following table is obtained:

| **Metrics $M_i$** | **Score $X_i$** | **Weight $W_i$** |
|---|---|---|
| $M_1$: Cost | X=0: >=3000<br>X=1: 2000<=M1<3000<br>X=2: 1000<=M1<2000<br>X=3: 0<=M1<1000 | 3 |
| $M_2$: Location | X=0: Other Countries<br>X=1: US-Based<br>X=2: INDIA-Based<br>X=3: CHINA-Based | 1 |
| $M_3$: Scale | X=0: Small-Scaled<br>X=1: Middle-Scaled<br>X=2: Large-Scaled<br>X=3: Enterprise-Scaled | 2 |

| **Supplier** | **Metrics Status** | **Score** | **Weighted Average Score** |
|---|---|---|---|
| **$S_i$** | **$M_i$** | **$X_i$** | $\bar{x} = \frac{\sum_{i=1}^{n} w_i x_i}{\sum_{i=1}^{n} w_i}$, |
| $S_1$ | $M_1$=2,500<br>$M_2$=INDIA<br>$M_3$=Enterprise | X=1<br>X=2<br>X=3 | {3(1)+1(2)+2(3)}/6 =1.83 |
| $S_2$ | $M_1$=8,500<br>$M_2$=US<br>$M_3$=Enterprise | X=0<br>X=1<br>X=3 | {3(0)+1(1)+2(3)}/6 =1.17 |
| $S_3$ | $M_1$=2,100<br>$M_2$=CHINA<br>$M_3$=Middle | X=1<br>X=3<br>X=1 | {3(1)+1(3)+2(1)}/6 =1.33 |
| $S_4$ | $M_1$=1,580<br>$M_2$=JAPAN<br>$M_3$=Enterprise | X=2<br>X=0<br>X=3 | {3(2)+1(0)+2(3)}/6 =2 |
| $S_5$ | $M_1$=2,900<br>$M_2$=UK<br>$M_3$=Large | X=1<br>X=0<br>X=2 | {3(1)+1(0)+2(2)}/6 =1.17 |

**T's *top-*$N_{accept}$ list**

| **Rank R** | **Supplier $S_i$** | **Weighted Average Score** | **Top-3 Decision** |
|---|---|---|---|
| 1st | $S_4$ | 2 | Accept |
| 2nd | $S_1$ | 1.83 | Accept |
| 3rd | $S_3$ | 1.33 | Accept |
| 4th | $S_2$, $S_5$ | 1.17 | Reject |

We have *T*'s supplier selection preference (Degree of suitability): $S_4 > S_1 > S_3$. Then, T will check with $S_4$ first to see if *T* can satisfy S4 expectations to form a TSC.

With the help of SOAP messages exchange [3][6], the integrated tender and supplier systems can now interoperate via Web services. So, related information can be gathered by a B2B application to perform comparison of TSC. Figure 10 illustrates the scenario when the B2B applications try to match related parties for a TSC. This B2B interaction is facilitated through the Web services provided by numerous tender, supply, delivery, inventory, and order systems. It acts as an agent to find ideal partner from the customer viewpoint. If the request is triggered by the tender system, B2B applications invoke the Web services of other systems and take all essential factors into considerations such as tender specifications, supplier quotation, transportation schedule, stock in inventory and order fulfillment, perform comparison, and advise the ideal supplier quotation result within a short period of time. The result is the most beneficial to such tendering system as other parties can cope with. This scenario is typical for many other logistics systems. We can observe that the long turn-around time, weak interoperability and business cost problems are solved by our TPM.

## 6. Discussions and Summary

In this paper, we have presented a Web service based architecture with the SOAP messages exchange during tendering processes, including sample UML meta-models for four typical business procedures: *Request To Participate* (RTP), *Invitation To Tender* (ITT), *Tender Submission* (TS), and *Tender Award Notification* (TAN). Besides, we have illustrated a typical example application scenario, with the design a reference SOAP XML message specification for an *Invitation To Tender* (ITT) document. It is the responsibility for enterprises to implement their own Tendering Process Model (TPM) that suits their own business requirements. They should also provide reliable tendering Web services so that interoperability and integration becomes possible for B2B application-to-application communication over the Internet, which is independent of platform, technology, and tools. We have also illustrated how well Web services can fit into the picture of a distributed application in section 5.

The key advantage of applying Web services is o establish cross-organizational collaboration via existing Internet standards, supporting both human Web-based and application programmatic interactions. When both partners support Web services, a more efficient and preferred way for event passing with the publish-and-subscribe paradigm can be employed [2]. In addition, smaller business partners with varies degree of automation can still participate in these business processes manually or semi-automatically. Because of the process complexity, Web services based interactions also facilitate exception handling [3], which typically require human attention and decision.

Moreover, Web services enable external integration with e-marketplaces and brokers, expanding the opportunities of TSC and therefore businesses. Internally, Web services enables the integration of tendering proc-

esses with enterprise resource planning (ERP) and other enterprise information systems to facilitate decision support. These are under our continuing research agenda.

For other continuing research, we are looking into the integration with other logistics systems like delivery, order, purchase, and procurement. We can further customize the use of Web services as the communication channel between various logistics systems. Although only tendering process is focused in this paper, similar integration work can be done for other related processes involved in logistics to make scale-up feasible for proposed solution. The steps are similar, first of all, understand the business requirements to streamline the business procedures, design the message exchange specifications, and then set up the architecture for application-to-application communication over the Internet. The implementation approach for integration is similar to the one in this paper even though the business requirements are not exactly the same. We can foresee the possible benefits bring to the logistics industry is great.

One of the main goals of Web services is to make easier their composition to form more complex services. To this purpose, many emerging languages (e.g., BPEL44WS [12]) have been proposed for coordinating Web services into a workflow. However, the availability of such languages is not enough and many research issues still need to be faced. First, some researchers [13] have recognized that WSDL – the standard description language for Web services – is rather poor with respect to the information it can convey. In particular, service's messaging behaviors are crucial for the business process compositions. Additionally, there is a strong need of models for composing Web services, and of formal tools for driving the composition process and for analyzing the properties of the resulting composite Web services. In this respect, many techniques can be used (see [13] for an overview), which greatly depends on the description language and the composition model being adopted. However, we believe that a first key to compose Web services is the availability of a methodology for performing such a composition for TPM. This is a crucial requirement for managing the complexity of Web service composition. For this reason, we will also look into some ideas for developing such a methodology for Tendering Process Model (TPM).

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