

AN ELECTRONIC BROKER FOR BUSINESS-TO-BUSINESS ELECTRONIC COMMERCE ON THE INTERNET

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Distributed object standards provide a key to building interoperable applications that can run on a range of platforms. The paper describes a CORBA-based research prototype for an electronic broker in business-to-business electronic commerce. High-level IDL specifications are used to achieve interoperability between components of the electronic marketplace. The two key functionalities of the electronic broker are the ability to dynamically gather information from remote electronic catalogs and the support for negotiations through auction mechanisms. The paper discusses the functionality and the design of the electronic broker and gives an overview of current extensions of the prototype. As application-level interoperability is a crucial precondition for many brokerage services, we put special emphasis on electronic commerce protocol standards.

Keywords: Electronic brokerage; distributed object computing; interoperability standards; electronic commerce architectures

1. Introduction

Procurement is one of the most important business functions, and it affects project expenses and quality of the final product. The proportion of income dollars spent on procuring goods and services ranges between 35% in industries like printing and publishing to 90% in industries like petroleum [1]. Information technologies like the Web have the potential to radically change the way procurement is done, reducing the cost of procurement and making the entire supply chain more efficient.

Currently, much automated procurement and business-to-business electronic commerce is done between pairs of companies using technology such as EDI running over proprietary, closed systems. The context for those EDI relationships is mostly communication between companies having long-standing relationships with each other [2]. Electronic commerce and the Internet introduce a new marketplace with new models of doing business. This new electronic marketplace contains a melee of smaller companies, each one relatively unknown and together offering a bewildering array of products. Currently, no integrated and feasible way exists in this electronic marketplace

- for providers to reach customers
- for customers to reach suppliers
- to introduce new offers efficiently
- for negotiation, billing and accounting
- for creating limited electronic marketplaces

Electronic brokerage is regarded as the core concept to overcome the current limitations. The core business of brokers is to bring together buyers and suppliers in a marketplace [3], i.e. to match buyer's needs and suppliers' abilities. Electronic brokers can provide many services to facilitate this, ranging from yellow pages to catalog aggregation and negotiation support.

As brokers provide a central marketplace facilitation, where many buyers and suppliers meet, they are also in a key position to provide many value added services, which are of vital interest to the participating parties. The broker can acquire better knowledge of market demand and supply characteristics. Furthermore, since brokers participate in transactions with different customers and different suppliers, they can analyze consumer preferences across products, suppliers and industries. Some of these value-added services exploit the role of the broker as a trusted third party, while others help in automating tasks during an electronic market transaction.

This paper describes a prototype of an electronic brokerage service. In section 2 we give examples of commercial brokerage services on the Internet and describe barriers to electronic brokerage services arising from the missing application-level interoperability.

Distributed object standards like OMG's Object Management Architecture (OMA) provide a key to building interoperable applications that can execute on a range of platforms. This approach has proven successful in numerous applications where CORBA was used to glue together heterogeneous information systems. Section 3 provides an overview of CORBA-based electronic commerce frameworks.

Section 4 discusses the functionality and the design of the electronic broker in the OFFER framework. The OFFER prototype is part of a larger project focusing on brokers and electronic markets for business-to-business electronic commerce. This prototype uses pre-defined IDL standards for the communication between application components. The electronic broker in OFFER assists the user in two main ways. First, it helps search in electronic catalogs of suppliers; second, it provides auction mechanisms to support price negotiation between buyers and sellers.

Application-level interoperability is a crucial precondition for the implementation of many brokerage services. Thus, section 5 surveys different approaches to standardize electronic commerce protocols. Section 6 describes the focus of our current research and extensions to our prototype and finally section 7 summarizes the paper.

2. Barriers to Electronic Brokerage on the Internet

This section describes well-known examples of brokerage services on the Internet and shows barriers to the implementation of these systems. Probably the most successful brokerage service on the Internet is the aggregation of product information from remote electronic catalogs [4] (so called catalog aggregation). Brokers that aggregate product information from underlying electronic catalogs face the challenge of combining all the information within a single coherent structure through which buyers can navigate readily.

In many cases the information gathering is static, i.e. the broker gathers the information to create a catalog before the user requests the information. As many markets are extremely volatile, it is important to provide a more flexible way to adapt to the frequent changes in the market. A growing number of brokers allow dynamic aggregation, where the gathering of information is done after receiving the user request.

Andersen Consulting's Bargainfinder [5] and Netbot's Jango [6] are examples of brokers supporting dynamic aggregation of product information from electronic catalogs on the Internet. *BargainFinder* was the first so called shopping agent for on-line price comparison. It requests its price from each of nine different merchant Web sites using the same request a Web browser would make. Although it was a limited prototype, BargainFinder offered many insights into the issues involved in price comparisons. For example, a third of the on-line merchants accessed blocked the price requests (see [7] for a broader review).

Jango searches for products that meet specified criteria and displays hits within a table that permits extensive evaluation. Clicking an attribute name sorts the alternatives on that attribute, permitting an elimination-by-aspect approach. Jango solved the blocking issue by having the product requests originate from each consumer's Web browser instead from the Jango site. Currently, it is part of the Excite search engine. BargainFinder and Jango are only two examples of a large number of Internet brokers offering catalog aggregation for various domains. BotSpot [8] gives a more comprehensive overview about various kinds of Web bots (commercial, search or shopping bots) and their URLs.

As a catalog aggregation service has to communicate with various participants in a marketplace, high-level interoperability between these systems is a crucial precondition for their implementation. Unfortunately, current Web-based technology makes the implementation of these systems very difficult. Web-based electronic catalogs format their CGI requests and HTML outputs in vastly different and often changing ways, each of which must be processed differently (see also [9]). Moreover, these formats change quite often. Writing and maintaining a program that keeps track of the various queries and parses the resulting HTML files individually is a cumbersome task. Jango relies on a collection of intelligent "Information Adapters" to identify and retrieve relevant information from Web sites in order to answer consumer queries. The Information Adapters deploy various artificial intelligence techniques to cope with the changing CGI and HTML formats and perform the translation. These approaches do not provide the solid and scalable brokerage infrastructure we need for Internet commerce.

The lack of interoperability standards between electronic commerce applications leads to high costs for the broker, as procuring from sixty heterogeneous suppliers requires sixty different accommodations. This is one of the greatest obstacles to the widespread establishment these brokerage services. Currently, there is a proliferation of different approaches to establish interoperability standards in the field of electronic commerce. These approaches are ranging from document-centric standards like Internet-EDI to API-based standards, trying to define the interfaces of electronic commerce systems.

3. Electronic Commerce based on Distributed Object Technology

In this section we focus on research approaches to build electronic commerce applications on top of OMG's Object Management Architecture (OMA). A basic idea of these approaches is to achieve interoperability between electronic commerce components through the standardization of their interfaces in OMG's Interface Definition Language (IDL).

The combination of distributed object computing and the ubiquity of the Internet can serve as a basis for powerful commercial applications. Especially the combination of OMG's CORBA and Web standards led to a flood of research projects and new products. CORBA [10] provides interoperability of objects across networks in a heterogeneous environment. CORBA supports high-level language bindings, as it separates an interface from its implementation and provides language-neutral data types. It supports polymorphic messaging as well as run-time metadata for describing all interfaces known to the system. Moreover, the Internet Inter-ORB Protocol (IIOP) provides an efficient, state-preserving alternative to HTTP.

On the other hand, object frameworks are a successful new concept in software engineering [11]. They are almost complete applications, designed to be reused in a number of applications. Various examples show the widespread use of this concept for graphical user interfaces or ERP applications [12][13]. The idea is to standardize interfaces of generic electronic commerce components and have third party vendors implementing these components. This has led many domain experts to claim that CORBA-based object frameworks for Internet commerce will solve many of the problems of Web-based electronic commerce systems [14].

Several research projects are already developing CORBA-based object frameworks for electronic commerce. OMG's Electronic Commerce Domain Task Force (ECDTF) is working on the standardization of generic facilities needed in electronic commerce. ABS (Architecture for Information Brokerage Services) is one example of approaches in this field. Athanassiou et al. [15] provide a detailed analysis of brokerage and base their work on ODP-RM, TINA-C and OMG concepts. COSMOS [16] is a promising new project trying to develop a generic contracting service for business transactions on the Internet. Technically it uses advanced telecollaboration and mobile agent technologies, incorporating CORBA standards and Java technology.

OSM (Open Service Markets) [17], an already finished EU ACTS project, was very proactive in OMG's ECDTF and developed tools to enable an open electronic trading market based on OMG's OMA. The project defined a framework for global electronic commerce and virtual trading market systems and proposed an Electronic Commerce Reference Architecture for OMG's ECDTF. The Reference Architecture provides an overall framework of required electronic commerce components and describes a good overview of facilities needed for building electronic commerce applications.

The Reference Architecture can be seen as a roadmap for future OMG standardization in this field and contains also high-level facilities for catalogs, brokerage and agencies. Unfortunately, the Reference Architecture provides only a high-level description for the Brokerage Facility and so far there has been no Brokerage Request For Proposals (RFP). The high-level description of the Brokerage Facility introduces two specific interface requirements, namely recruiting and forwarding, which correspond to the respective concepts of searching and advertising.

4. OFFER – A Broker-centered Object Framework

OFFER is a research project focusing on electronic brokerage services for business-to-business electronic commerce on the Internet. OFFER defines high-level IDL interface standards to achieve interoperability between the electronic broker and other components on the marketplace.

To illustrate the ideas and to learn more about brokerage in a distributed objects environment we implemented a prototype of a CORBA-based object framework for electronic brokerage. An objective of the project is to provide knowledge about the functionality of the required software components, their granularity and the interaction between them. The business model consists of suppliers, customers and electronic brokers. Suppliers and electronic brokers offer services, which can be accessed over the Internet and which are procured by customers. The OFFER electronic broker (e-broker) assists the user in two main ways. First, it helps search in remote electronic catalogs (e-catalogs) of suppliers; second, it provides auction mechanisms to support price negotiation between buyers and sellers.

The OFFER prototype is implemented entirely in Java using Visigenic's VisiBroker ORB as a distribution mechanism. It comprises several Java applets, which communicate via IIOP with the e-broker and the remote e-catalogs implemented as CORBA servers. The products traded in the market are books, as they are easy to describe and to categorize. The interfaces of these services are described in OMG's Interface Definition Language (IDL).

4.1. Broker-assisted Search in Electronic Catalogs

This section outlines the workings of a broker-assisted search over remote catalogs (i.e. dynamic catalog aggregation) using the OFFER framework. Suppliers offer an e-catalog to the customer; suppliers can also register with the e-broker. Hence, a customer can search for a service either directly in the e-catalog of a supplier or can use the e-broker to search in all the e-catalogs of all the suppliers, which are registered with this broker. We specify a standard IDL interface for the e-catalogs of a supplier and for the e-broker. Each supplier is responsible for implementing this interface; the implementations can be in any CORBA-compliant language such as C++, Java or Smalltalk. The e-broker IDL provides a `search()` operation, which allows a customer to find a service with the e-broker and it supports an operation called `getSupplierProfiles()`, which allows CORBA clients to receive information about the suppliers that are available through the e-broker. Other CORBA components, on top of those available, can easily create value-added services by the e-broker.

An important requirement is the ability for new e-catalogs to register with the e-broker. The broker can either maintain its own database of registered e-catalogs or it can use the services of an Object Trader. The OMG Trading Object Service became a CORBA standard in mid-1996 [18]. It defines several functional interfaces (Lookup, Register, Link, Admin and Proxy). The Lookup interface, for example, lets the user discover objects based on the properties and services they provide. Via the Register interface one can register (export) or unregister (withdraw) new services with the trader. In our case, the e-catalogs act as exporters, advertising a service offer (consisting of name, location and several other properties) with the trader.

The electronic broker acts as an importer, querying a list of references to actually available e-catalogs according to certain constraints. The references can be used afterwards to send a `search()` message to these electronic catalogs and evaluate the results (see Figure 2). Some Object Trader implementations provide even the possibility of querying dynamic properties of an exporter at the time a query is made. The advantage of using an object trader is that the e-broker can rely on an already standardized and well-understood service for the registration of new e-catalogs. Deployment of an Object Trader is especially useful in environments, where it is already an established service.

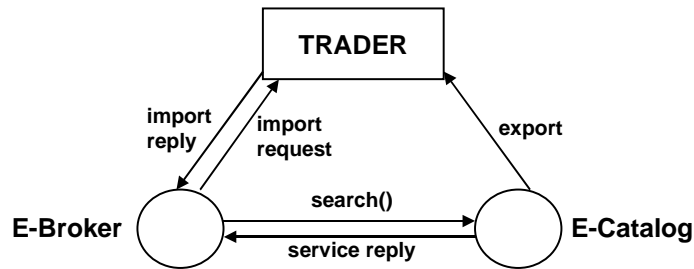


Figure 1. Deployment of an Object Trader

There are several advantages to using the CORBA-based approach over CGI-based implementations. CORBA 2.0 provides IIOP, an efficient state-supporting protocol on the Internet. As already mentioned, CORBA separates the interface from the implementation. Thus, a CORBA-based e-catalog can change its implementation without requiring the e-broker to rewrite its interface. This is an advantage over current client/server systems, in which the API is often tightly bound to the implementation and therefore very sensitive to changes (see a more detailed discussion in [19]). Nevertheless, a precondition for this infrastructure is that all suppliers of a certain market agree on a predefined interface standard for their e-catalogs.

4.2. Broker-assisted Negotiation Support

An e-broker provides a centralized market place, where many buyers and suppliers meet. Hence, the e-broker is well-situated to offer various kinds of negotiation mechanisms to buyers and sellers. Unfortunately, there do not exist solid bargaining algorithms. Bargaining strategies between a buyer and seller are extremely complex. They frequently evolve over time, and often require shrewd judgements about how much information to reveal, when not to be truthful, how many issues to involve, and which sequence of counterproposals to use. It's a fuzzy science at best [20], and efforts to either program strategies into software agents [21], or to have agents learn good strategies [22][23] are not robust enough for commercial applications. Hence, automated negotiation is still in its infancy, and primarily in extremely controlled conditions at research laboratories.

In order to achieve solid negotiation support within the OFFER e-broker, we replaced the buyer/seller negotiating session with an economic mechanism: the auction. The strategy issue collapses into the single dimension of bid formulation. The software agents can now afford to be "dumb:" they need only know the auction rules and submit a bid. In the Vickrey auction, truth-telling is the dominant strategy, and hence optimal bid

formulation is extremely simple. For many other auction types, optimal bidding strategies are only slightly more complex. This approach moves much of the “cleverness” from the software agents into the market mechanisms instead. In addition to solving the strategy problem, an auction also solves the ontology problem (the item is successfully described at the outset and cannot change during the course of the auction).

Table 1. Auction Rules, Winners, and Optimal Strategies

Auction	Rules	Outcome	Optimal Bidder Strategy
Sealed Auctions			
<i>First priced sealed bid</i>	Bidders submit a single sealed bid before deadline	Winner is highest bid at bid price	Shade bid a bit below true willingness to pay
<i>Vickrey</i>	Bidders submit a single sealed bid before deadline	Winner is highest bid at second highest price	Truthtelling
<i>Sealed double auction</i>	Bidders and sellers submit a single sealed bid before deadline	Auctioneer determines a single market-clearing price and matches buyers and sellers	Truthtelling
Open Auctions			
<i>Dutch</i>	Auctioneer calls out descending price; bidder calls out a bid	Winner is first bidder to call out, at bid price	Shade bid a bit below true willingness to pay
<i>English</i>	Bidders successively raise bids for item until single bidder remains	Winner is last bidder remaining, at price of second-highest bidder	Bid up until true willingness to pay, then drop out of auction (truthtelling)

Table 1 shows the rules, outcomes, and optimal bidder strategies for some major auction schemes. Each type of auction has special advantages and is suitable for special needs. A sealed auction is one in which a prospective bidder doesn't know about his competitors' bids. An open auction is one in which a prospective bidder knows some information (such as price and number of other bidders) about his competitors' bids. For more rigorous discussion, see [24][25][26]. Because the auction is a mechanism that is suitable for electronic commerce applications, there has been a large and relatively immediate commercial success using online auctions to negotiate price between a single seller and several buyers. Auctions on the Internet have been successfully run by Onsale [27], eBay [28], and several other companies [29]. The e-broker in the OFFER framework implements an English, a Vickrey and a First Price Sealed Bid Auction.

4.3. Design and Implementation Issues

For the design of object frameworks it is crucial to identify the so-called "hot spots." These are exchangeable components, which should guarantee the flexibility of the framework in future applications [30]. Well-designed frameworks provide reusable architectures with flexibility in the right places. As shown above, different auction mechanisms are best suited to different situations. For future applications of the framework it is important to handle these mechanisms flexibly and provide easy extensibility. We achieve this through abstract coupling of the EBroker class with the Auction class (shown in Figure 2).

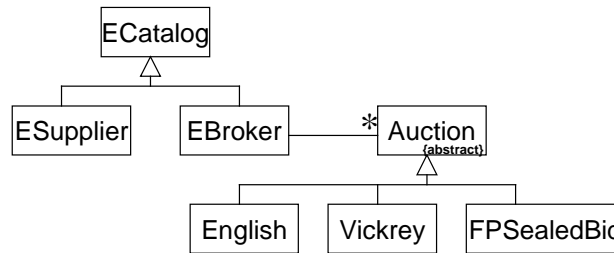


Figure 2. Abstract Coupling of Classes (UML Class Diagram)

All auctions announce their commencement and the item(s) for sale, as well as a possible reserve price and minimum bid increment. A sealed auction has a publicly announced deadline, and will make no information about the current bids available to any future bidders until the auction is over, at which time the winner(s) is (are) announced. An open auction will make information about current bids available to any future bidders until the auction is over, at which time the winner(s) is (are) announced.

One can open an auction with the e-broker operation `startAuction()`. Currently this can be either an English, a Vickrey or a First Price Sealed Bid Auction, which are described in Table 1. Through polymorphic messaging, the operations of the appropriate type of auction are triggered afterwards. For example, different auctions, closed via `stopAuction()` will compute the winners in different manners. Moreover, an English Auction has additional operations like `getCurrentBids()`, to get a market overview or `getElapsedTime()`, to show how much time is left after the last bid until the auction closes.

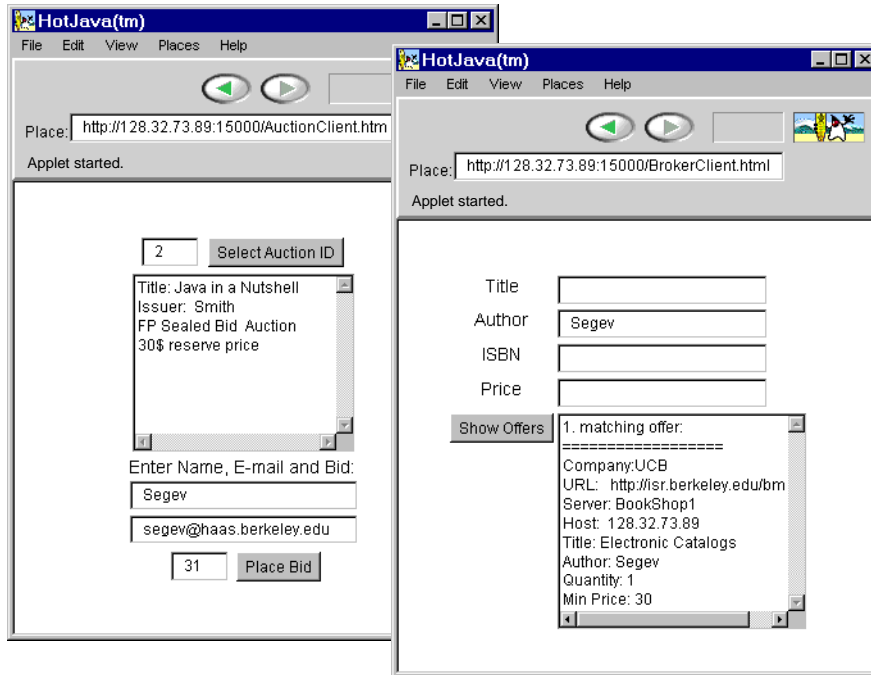


Figure 3. Screenshot of the e-broker user interface

In our implementation we left out the Dutch auction, as it is strategically equivalent to a First Price Sealed Bid Auction. Currently, anybody can start an auction or participate in an auction. Figure 3 shows a screenshot of parts of the current user interface.

5. Electronic Commerce Interoperability Standards

Application-level interoperability of electronic commerce systems across the Internet is a key issue for the implementation of electronic brokerage services. Standards for protocols, documents and interfaces are crucial to achieve interoperability for inter-organizational systems. Currently, we see a proliferation of electronic commerce standards. The following sections survey different approaches and their impact on the implementation of commercial brokerage services.

5.1. Interface Standards for Electronic Commerce Components

The OFFER prototype uses high-level IDL interface standards to achieve interoperability between electronic commerce applications (e.g. between e-catalogs and e-broker). Many examples show that CORBA technology is very useful in gluing together heterogeneous information systems within an organization [31][13]. Also the prototype we implemented works very efficiently as long as everyone in the marketplace adheres to the predefined IDL interfaces and uses a CORBA-based system. In order to achieve interoperability on an electronic marketplace, these interfaces have to be standardized and adopted by all participants.

OMG's ECDF (see section 3) tries to standardize interfaces of CORBA-based electronic commerce components. The ECDF reference model (see Figure 4) is composed of three principal groups, namely low level electronic commerce services including profile, selection, payment and certificate services; commerce facilities including supporting service management, contract and related desktop facilities; and finally, market infrastructure facilities covering catalogue, brokerage and agency facility.

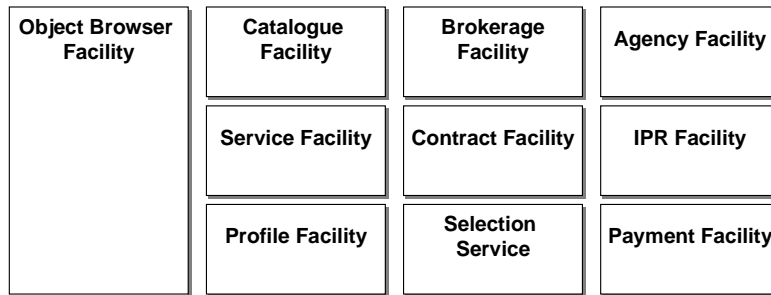


Figure 4. OMG ECDF Reference Architecture

Unfortunately, standardization in OMG's Electronic Commerce Domain has been fairly slow. It is quite difficult to establish interface standards on which all participants of a certain market agree. Moreover, requirements for higher level electronic commerce facilities like brokers and catalogs can be very heterogeneous across different industries, which makes their standardization even harder [32]. So far there have only been RFP's for low level electronic commerce services in the OMG Electronic Commerce Domain.

5.2. Document-centric Interoperability Standards

Many other approaches try to standardize electronic documents used in a business transaction. Some of the first approaches in this direction originated from an Internet Engineering Task Force (IETF) workgroup covering EDI (EDIINT), which has recommended standards for interoperable electronic data interchange over the Internet. Member companies have demonstrated exchange of documents over SMTP using the Secure MIME (S/MIME) protocol. Two draft standards have been proposed: MIME-based secure EDI, and EDIINT functional specifications.

Many companies have applied Internet-EDI in business-to-business electronic commerce. The problem with EDI standards like ANSI X.12 or UN/EDIFACT is that start-up and support costs are very high, due to their inherent complexity of the standards. For small and medium-sized enterprises this has often been no solution. Moreover, EDI standards do not integrate very well with the ubiquitous Web infrastructure.

Many new approaches use XML as an underlying basis. Created and developed by the W3C XML Working Group, the eXtensible Markup Language (XML) version 1.0 is derived from the widely used international text processing standard SGML (Standard Generalized Markup Language, ISO 8879:1986). Intended for use on the World Wide Web, XML retains SGML's basic features - vendor independence, user extensibility, complex structures, validation, and human readability - in a form that is easier to implement and understand than established EDI standards. XML is emerging as the de-

facto standard for many Web-based languages like RDF (Resource Description Format) and PICS (Platform for Internet Content Selection). Thus, several industry approaches like OTP (Open Trading Protocol) [33] or OFX (Open Financial Exchange) [34] define XML standards for various electronic commerce domains.

5.3. Broker-support for Multiple Standards

From a conceptual point of view both approaches are only slightly different. API-based approaches like OMG's IDL standards define the interface of components, which accept a set of data and return another set of data. Document-centric approaches define the set of data to be exchanged in form of electronic documents. On the one hand, the OMG approach is promising, as it bundles language-independent IDL interface standards with the powerful features of CORBA-based distributed applications (see section 3). On the other hand, the document-centric standards described in the previous section can be handled by a wider variety of platforms existing on the Internet, as they do not pose any particular requirements for the applications (e.g. to be a CORBA application).

As long as no standard has gained considerable market dominance, these differences are less of an "either/or", but more of a fact that has to be considered when implementing a commercial brokerage service on the Internet. Brokerage services will probably have to "understand" several standards in order to compete on the marketplace. Several new developments already provide services, which provide the possibility to translate between those different standards. For example, WebBroker (see <http://www.w3.org/Submission/>), which falls under the W3C HTTP-NG Activity, represents an attempt to unify interface technology used in existing distributed object systems like OMG's CORBA, Microsoft's DCOM, and JavaSoft's RMI but is based on XML, HTTP/1.1 and traditional CGI technology. It can be used for describing and exchanging structured messages between software components on the Web.

6. Current Directions

The OFFER project has undergone several changes. Currently, the original prototype is re-implemented in some parts and extended based on Oracle's database and CORBA-based Web Application Server. In parallel the functional scope of the investigation has been expanded to include a wider variety of brokerage services ranging from negotiation support to trusted third party services and other supporting services like billing, accounting and decision support.

A major emphasis is placed now on the negotiation support. The OFFER prototype described in section 4 provided standard auction mechanisms like the Vickrey, English and First Price Sealed Bid auction to support negotiations. One of the greatest deficiencies of current auction implementations is that they only automate negotiations on a single dimension of a good or service. However, in many business-to-business procurement situations, negotiation on multiple attributes is the case. People do not only negotiate on the price, but also on credit terms, terms of delivery and certain features of a product.

Negotiation support systems (NSS) provide some interesting approaches to the area of multiattribute negotiations. A NSS is a software program which is especially geared towards helping human negotiators make better decisions and negotiate more productively, and is a step towards automated negotiation. While NSS are quite powerful

tools, and can often make negotiations more productive than would be possible without them, they are far from able to support automated negotiation on their own. NSS require constant human input, and both the initial problem setup and all final decisions are left to the human negotiators.

In OFFER we take a different approach and support bidding on multiple attributes of a deal. We combine decision analysis tools with competitive bidding mechanisms in order to achieve a more powerful negotiation support. The requisitioner defines preferences in form of a utility function. Then suppliers try to submit bids that best satisfy the requisitioners preferences. The bidding process is performed in an open-cry manner in order to foster competition among suppliers. However, it can also be conducted in a sealed bid fashion.

In order to get more tangible results, we work together with purchasing managers in the food industry and try to build a specific brokerage solution for food wholesale. An electronic broker in this field should on the one hand allow multilateral negotiation with numerous small and medium-sized enterprises on several attributes of a good, and on the other hand aggregate the bids of several suppliers into a package for the buyer.

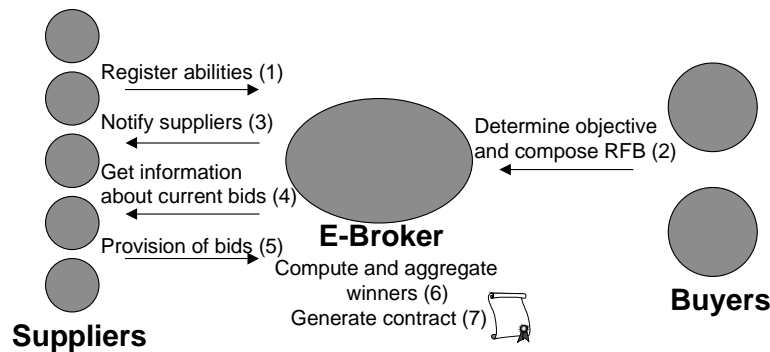


Figure 4: Broker-supported Negotiation in the Food Industry

Figure 4 shows the main steps during the broker-supported negotiation process in OFFER. Buyers have to register their abilities with the electronic broker (1) in advance. The requisitioner specifies a request for bids (RFB) and submits it to the broker (2). The electronic broker notifies suppliers with corresponding abilities (3) and collects their bids. The suppliers can compose a bid out of the RFB. A client-side tool helps in composing a winning bid. In an open-cry auction it is important that the client can query not only the RFB but also information about other bids (4), which is provided anonymously. The bidding (5) can be conducted according to various auction schemes (open cry, sealed bid). After the auction closes, it computes the winning bids and aggregates them into a package for the buyer (6). In this market multi-unit bids are divisible, i.e. a bidder is also willing to sell smaller quantities of the good. After the winning bids are determined, the electronic broker compiles a digital contract (7). We investigated different decision analysis techniques, which we use to define the buyers' utility function [35] and are implementing these mechanisms in our prototype, in order to extend the basic functionality described in section 5.

7. Conclusions

Electronic brokerage is an emerging field and many business, legal, organizational and technical aspects still have to be resolved. In this paper we described a CORBA-based electronic broker. We used high-level IDL specifications to achieve interoperability between the electronic broker and other components on the marketplace. Interoperability standards are an important step for the creation of new electronic marketplaces. Protocols and product taxonomies provide ways to communicate buyer's needs and suppliers capabilities. We described design and functionality of the brokerage infrastructure and provided an overview of different electronic commerce protocols, which can be used for the implementation of commercial brokerage services.

Electronic brokers and marketplaces have to provide mechanisms to match buyers' needs and suppliers' capabilities. In our initial prototype, we provided search in remote electronic catalogs and auction mechanisms to support multi-party negotiations. Our current research focuses more on negotiation support as the most dynamic form of matching buyers and suppliers on a marketplace. In particular, we investigate new forms of competitive bidding on multiple attributes and see how we can deploy these in business-to-business procurement. This phase of the project is done jointly with the electronic business group of the IBM T. J. Watson Research Center, New York and a large Austrian food retailer.

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