CIFE CENTER FOR INTEGRATED FACILITY ENGINEERING

Developing Electronic Models To Support Internet Bidding

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SUMMARY

Title: Developing Electronic Models to Support Internet Bidding

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Abstract

This report outlines the conclusions of a research project to investigate the applicability of Electronics Models to support Internet Bidding. The research project incorporated field studies and interviews to document existing practice, as well as the implementation of prototype bid applications. We identified the major problems with existing practice to be lost information, costly search, redundancies, missed opportunities and inefficient document processing. Through our prototyping, we identified the difficulty for existing XML standards to support complex engineering information. The major prerequisites for AEC Internet bidding are: rating systems, industry standards, differentiation of processes, and scale.

Developing Electronic Models To Support Internet Bidding

1 Introduction

In this report, we investigate the prerequisites for Internet bidding in the AEC (Architecture Engineering and Construction) industry. This paper assumes that the reader is familiar with present AEC bid practices. We first state the goals and methodology of the research project that we undertook in 1998-1999. We then discuss the problem with the existing process. Next, we describe our implementation and analysis of a prototype bidding application. In the end of the paper, we discuss the pre-requisites for real-time electronic bidding in the AEC industry.

2 Background

Bidding in the AEC industry involves information flows between several actors including owners, architects, designers, contractors and subcontractors. The bid process is comprised of activities such as publication of request for bids, formulation of bid-packages, interpretation of drawings and specifications, cost estimations and submittal and acceptance of bids. Today, paper documents constitute the primary means for the exchange of detailed bid information. Bid process automation, in contrast, will require computer interpretable models of business documents and the information flows that occur during detailed project bidding.

To date, business-to-business electronic commerce has been limited by the following factors:

1) Agreement on standard protocols to describe business documents has been restricted to relatively simple business forms. Implementations have, therefore, concentrated on solutions that support commodity transactions represented, for example, by Electronic Data Interchange (EDI) transaction sets for billing invoices.

2) The cost to customize EDI solutions for the exchange of complex information has been high. Large initial investment has also created barriers to competition, since the cost of switching between suppliers and customers increases. Systems have therefore, been implemented for highly capitalized manufacturing environments with mass production of standard articles (for example, the automotive industry).

In contrast, the AEC industry requires sharing complex, detailed information between relatively small organizations for single unit production. Thus, the industry has been slow to adopt traditional electronic commerce solutions.

Nonetheless, emerging technologies for Internet-based I-Commerce systems promise to:

1) Provide a means for representing and sharing complicated engineering information.

2) Use standard communication and business language protocols that reduce investment costs.

Therefore, our premise is that I-Commerce systems will be able to add value to the business processes in the AEC-industry. We have chosen to study in detail the application of I-Commerce to bidding, a key AEC business process.

3 Goals and Methodology

The main goal of the study was to investigate how Internet Technologies could support the modeling requirements of bidding in the AEC industry. In order to fulfill this goal, we identified two sub-goals as prerequisites. First, the existing process would have to be mapped out. Secondly, the representation requirements for information had to be identified.

In order to fulfill the goals listed above, we researched along 3 separate axes.
First, databases and the Internet were searched to understand the status of the different technologies and the efforts in ecommerce in the AEC and other industries.
Secondly, we studied the existing bid process through observation and interviews. In order to understand how bidding is carried out today, we studied an ongoing construction project in California. We interviewed contractors, subcontractors and architects in order to understand the decision and communication processes of bidding. We also performed field studies of the activities in the war room of a general contractor during a competitive bid process. In addition to this, we interviewed solution providers.
Our final research methodology was prototyping to understand how existing Internet technologies could support the modeling requirements of a bid process.

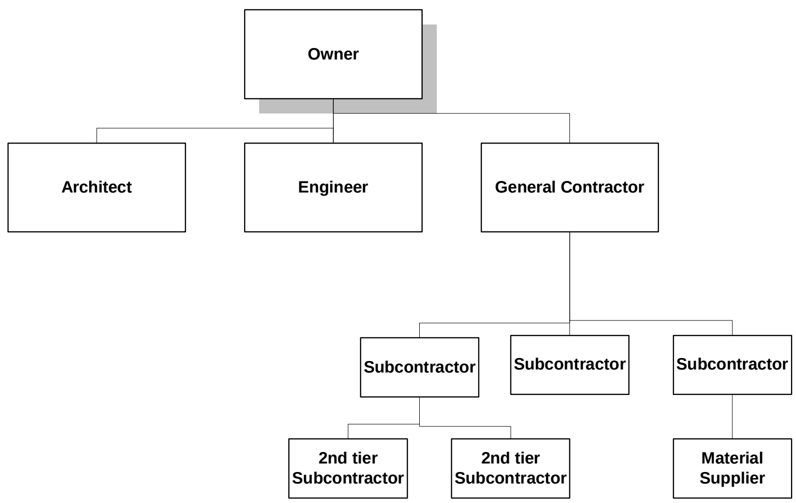


Figure 1 Typical Organization of construction project

4 The Existing Bid Process

4.1 The Overall Process

Bidding in the construction industry is a complex process that involves several different participants and a multitude of activities. First, there is the owner, the client in need of a new building. The owner hires an architect to carry out the architectural design and an engineer who provides the technical design of the building. The architectural and technical designs and specifications then serve as a basis for general contractors that bid to construct the building. The general contractor does not perform all the work himself but hires in turn subcontractors to carry out the majority of the jobs. The subcontractors hire in turn second-tier subcontractors and material suppliers.

The bid process involves the whole supply chain, as the general contractor demands bids from subcontractors and suppliers, which are aggregated to the final bid from the general contractor to the owner. It should be mentioned that as many different general contractors bid on one project, one subcontractor is likely to bid for subcontracts from several competing general contractors.

Since each project is unique and at the same time complex, there is a large amount of uncertainty concerning the final financial outcome of a project for the different

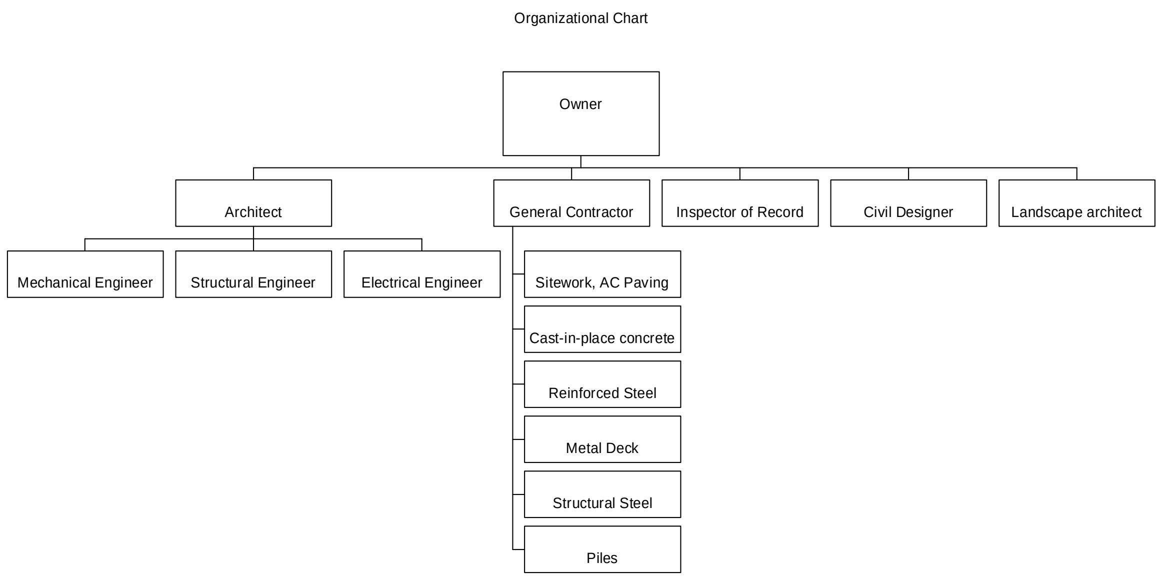


Figure 3 Organization of project studied

participants, something that makes the task of cost estimation harder and more important.

Figure 3 shows the project organization at the time of the mobilization. It shows that some architects and designers were hired directly by the owner, while the architect hired others. The subcontractors listed are the most important ones. In this project, the general contractor hired all subcontractors.

4.2 Bid process at a Californian General Contractor

We have studied the bid process at a Californian general contractor. We have identified 5 major activities as listed below. This discussion will cover all of these activities but primarily focus on two activities, "Determine bidders" and "Select Winning Bid", which will be studied in detail.

4.2.1 Decide whether to participate or not

When a general contractor receives an invitation to bid, the first thing to do is to decide whether to participate or not. To do this, senior management and engineers study the drawings, specifications, the type of project along with historic cost and profitability data in order to make a quick "ball park" estimate of the profitability of the project. This decision necessitates that the general contractor also assesses the quality of the owner and the architect with whom the general contractor would have to work closely if awarded the project. Other constraints on the decision are whether the general contractor has the necessary resources available, whether the project is located in an area where the general contractor is active, and, finally, an estimation of the likely number of competitors, which implies the likeliness of being awarded the contract.

4.2.2 Breakdown Work

Given that the general contractor has decided to bid on the project, the next step is to break the project work into parts that can be subcontracted. At this stage, make or buy decisions are also made as the general contractor decides which work can be performed in-house. In theory, it may be more rational to wait with this decision until all the bids from the subcontractors are collected. But, given the amount of work that is put into the composition of each bid by the subcontractors, a general contractor who wants to keep his industry reputation will want to guarantee that this work has not been done in vain.

4.2.3 Determine bidders

The process of determining which subcontractors are qualified to participate in the actual bid process is described in detail below.

4.2.4 Perform Cost Estimation

The general contractor will also want to perform cost estimation to determine the cost of the work that is performed in-house and to be able to verify the bids from the subcontractors. This is a process that demands deep technical knowledge and experience, but at the same time requires a lot of manual, and often-tedious labor to extract quantities and other technical information from the drawings and specifications.

4.2.5 Select Winning Bid

Which bid is finally selected by a general contractor depends on 1) the perceived qualities of the bids respectively and 2) the relative importance of these qualities. In our study, we have identified three major selection criteria: price, ability to meet schedule, and completeness of scope of work.

4.3 A detailed study of two processes

In this section, we will describe in detail two critical parts of the bid process: the determination of bidders and the selection of the winning bid.

4.3.1 Determine bidders

The general contractor determines which subcontractors will be allowed to bid on the project. The general contractor wants to make sure that only qualified and serious candidates will bid on the project. The reasons for this are twofold:

1.) The process of composing a bid is time consuming and costly for the subcontractors. The general contractor therefore wants to guarantee that all bids that are received are considered seriously. Otherwise, a subcontractor would be reluctant to bid on any future project.

2.) The general contractor has to allocate resources to the evaluation of each bid and will therefore want to reduce the number of bids to a manageable level.

The process of determining potential bidders can in turn be divided up into three steps. Each step reduces the number of potential subcontractors.

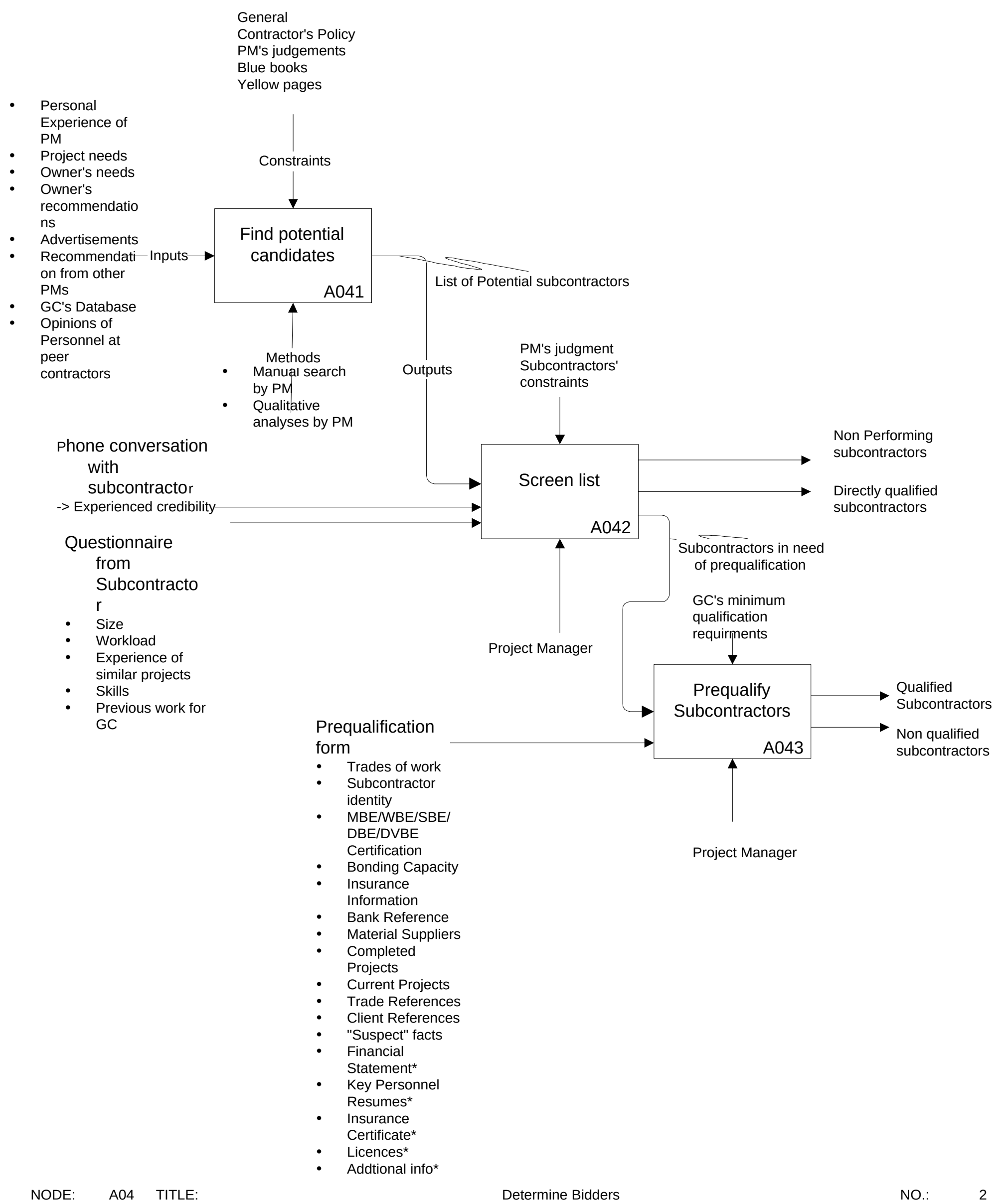


Figure 4 Determine Bidders

4.3.1.1.1 1) Find potential candidates

The general contractor first wants to find all potential subcontractors that could bid on the project. This is done using information from a variety of different sources. The project manager will have his/her own knowledge about potential candidates; other managers within the same organization will have opinions and recommendations. The owner will sometimes have wishes in terms of technical specifications or the favoring of locally or minority owned businesses. Other inputs are advertisements, the general contractor's database of subcontractors (in our study it consisted of a list by trade of subcontractors that the general contractor had worked with in the past), bluebooks and catalogues of local contractors. The project manager manually evaluates all names that he receives, using his experience and trade knowledge, and also checks with peer project managers (both within his own and other organizations) to find out what their experiences of working together with a certain subcontractor are. Another constraint on the evaluation of potential candidates is the specific demands of the subcontract. In our study, the project was in the health care sector and the general contractor therefore sought subcontractors who had experience working in this field. As we will see, the rigorous investigation of all possible candidates in this initial stage results in fewer subcontractors being disqualified in the two subsequent steps.

4.3.1.1.2 2) Screen list of potential candidates

The next step for the general contractor is to screen the list of potential subcontractors. This process involves phone conversations with the subcontractor, during which staff at the general contractor (primarily the project manager in our study) fills out a questionnaire over the phone, in order to find out whether the subcontractor is willing and able to do the job. The questionnaire covers items such as, size and bonding capacity[1], current and future workload, experience, and also the subcontractor's interest in participation. It should however be emphasized that it is not only the actual data, but also "the way of answering the questions" that goes into the assessment of the subcontractors. The subcontractor's ability to appear serious and credible over the phone is thus an important input to the process. The answers to the questionnaire also lead to further investigation from the general contractor. If the subcontractor has worked on a project, the general contractor sometimes checks with the other project participants, especially if they can be found within their own organization. There are three possible outcomes from this screening process:

i) The subcontractor is deemed to be *non performing* or unavailable. This is the case for subcontractors that are too small, who are not interested in participating, whose workload is too great, or whose specialty does not match the type of job demanded. Only a small fraction of the subcontractors fall into this group.

ii) The subcontractor is judged to be a potential candidate but further verification is needed. The subcontractor is then sent a "pre-qualification form" to be filled out. This serves as a means for obtaining more information and also has a legal aspect

[1] Bonding capacity: A guarantee from a financial institution which guarantees that the work will be fulfilled, even in case of the potential bankruptcy of the subcontractor.

to it, because it forces the subcontractor to write down the answers given in the phone conversation.

iii) The subcontractor is judged to be qualified and is invited to bid without any further procedure. Subcontractors in this category are typically firms with a high reputation in the trade and/or have worked successfully with the general contractor in the past.

4.3.1.1.3 3) Pre-qualification

Those subcontractors from whom further information is demanded are sent a "pre-qualification form". This form covers bonding and insurance information, safety record and workload. It also asks the candidate to name bank references, second tier subcontractors, material suppliers, and clients of past and current projects. These references to personnel within other organizations can lead to phone calls from the project manager, especially if it is someone he/she knows. The pre-qualification form can be judged as a checklist where the subcontractor should pass a threshold of criteria for each of the items. However, there is room for explanations where the subcontractors can give reasons for their inability to live up to a certain criteria. There are two possible outcomes of the pre-qualification:

i) The subcontractor is deemed to be non-performing and is left out of the process.

ii) The subcontractor is judged to be qualified and will be invited to bid along with the subcontractors who directly qualified in the screening process.

4.3.2 The selection of the winning bid

The second critical activity that we have chosen to study is the selection of the winning bid. When the general contractor has received the bids, they are processed in order to select the best one. The main selection criterion is price but also the fulfillment of the scope of work and the assessed ability to meet schedules are important. The process can therefore be divided up into four parts as follows:

4.3.2.1 Check Scope of Work

The project manager, with the aid of the project engineers, checks that the bids fulfill the scope of work as specified in the drawings, specifications and the inclusions as specified in the bid package. This activity can be seen as a screening process where the bids with a non-satisfactory scope are disqualified.

4.3.2.2 Assess ability to meet Schedule

Time is critical in construction, as in many other industries. The important difference between construction and traditional mass-producing manufacturing industries is the unique nature of a construction project and the dependencies of a large number of independent organizations. This makes delays frequent and costly. Often the general contractor's contract with the owner stipulates economic incentives for finishing the project on time. The ability to do so depends on the performance of the subcontractors whose work is often interdependent, meaning that the delay in finishing one subcontract could jeopardize the schedule for the entire project. This is especially true if the subcontract is on the critical path of the project. The project manager uses his judgment to determine whether a subcontractor has the ability to meet the schedule. The judgment is based on the performance of the subcontractor on earlier work for the general contractor and also on their reputation in the market. If the project manager is uncertain concerning a subcontractor, he will call to check some of the people for whom the subcontractor has worked earlier.

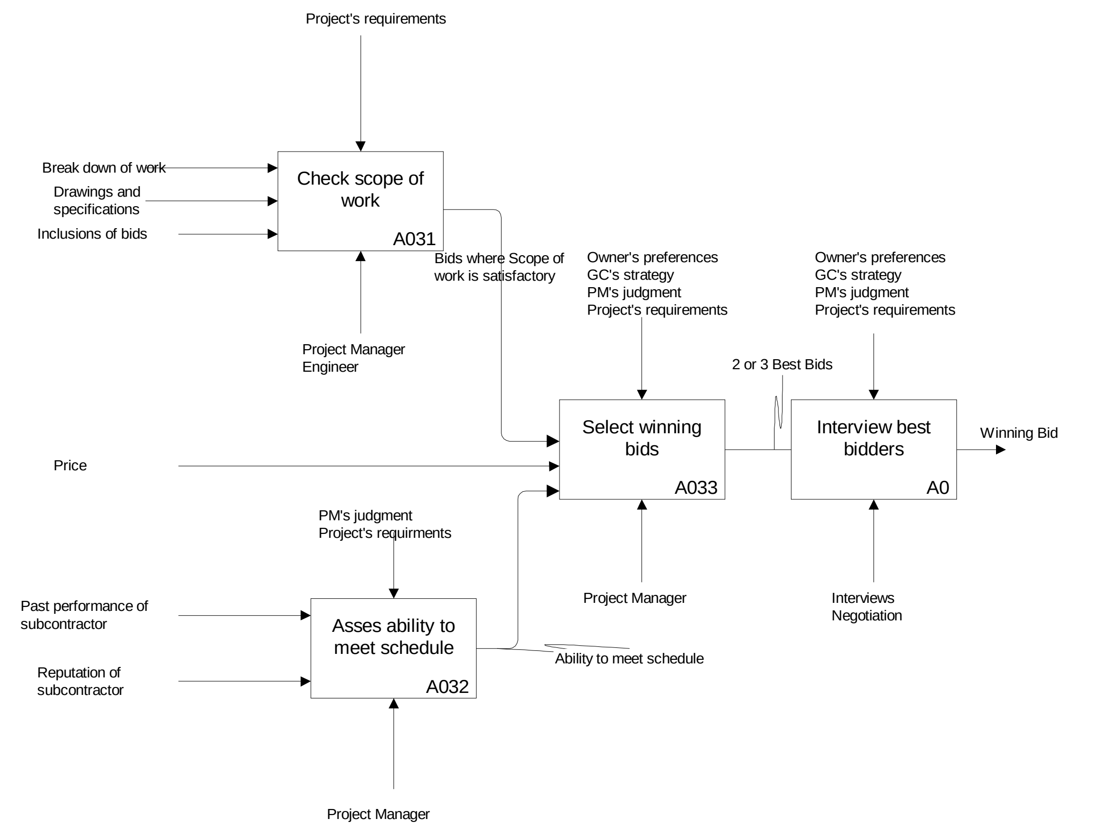


Figure 5 Select Winning Bid

4.3.2.3 Select the best bids

Out of the bids that are judged to perform concerning both scope and schedule, the 3 bids with the lowest prices are chosen. Price is "what is most important", as one project manager says.

4.3.2.3.1 Interview with 3 best bidders

To ensure that the contract is awarded to a subcontractor that will perform, the 3 lowest bidders are asked to meet the general contractor for an interview. The outcome from these interviews is the decision of which subcontractor that will be awarded the contract. This way, the project manager can form a judgment about the subcontractors' capability and likelihood to cooperate. The project manager can also ensure that the subcontractor has indeed understood what it takes to build the job. A subcontractor, who has overlooked or misinterpreted a detail of the specifications, may bid low but is likely to issue change orders as it faces the reality of the project. The owner can also have some input into the decision process. On the project we studied, the general contractor presented the low bidders to the owner for additional input concerning locality, health standards and minority issues. The final selection is therefore a trade-off between the project manager's intuition about the performance of the subcontractors and the subcontractors' bid amounts, in combination with the owner's needs. If two bids are very close, it is likely that he will choose the one whose performance he judges to be more certain, as when they have worked together in the past. If the difference in price is high, he may on the other hand go for the more risky alternative.

4.4 A competitive bid process

The research project also incorporated two field studies of the activities in the bid room during a competitive bid project. We were fortunate to be allowed to be present in the bid room during the last critical two hours before the bid. The two projects we studied were both public projects in California.

4.4.1 Background

The law in California stipulates that a public project should be awarded to the lowest responsible bidder. The bidder should then present the owner (a public agency) with a bid consisting of a number and a list of all subcontractors whose work surpasses 0.5% of the total cost of the project [1]. The government wants the subcontractor list in order to prevent bid shopping. (This is when a general contractor, after having been awarded a contract, goes back the subcontractors and informs them that unless they lower their bids they will be replaced by others who can do the job for less.)

4.4.2 Organization in the war room

The composition of a bid room is complex procedure that requires quite a large organization. It includes the following functions:

4.4.2.1 Chief Estimator

The chief estimator is in charge of coordinating the bid process. He decides when to enter the bids on the computer and to send the final bid to the owner. Another responsibility is to advise the other estimators in their negotiations with the subcontractors. It is also his responsibility to make the final decisions regarding which subcontractors to include, and how much profit and overhead to add to the bid to the owner.

4.4.2.2 Senior Estimator

The senior estimator is responsible for coordinating along with the chief estimator. For all items, which do not require a separate analyst, he checks that the incoming bids' scope of work corresponds to what is required. If there is any relevant exclusion, he judges how much to add in order to make up for it. Since he is the person that knows the jobs the best, he also assists the specialty estimators and helps the chief estimator in managing the process.

4.4.2.3 Specialty Estimators
For work items that are complex and comprise a substantial part of the final sum, the general contractor has specialty estimators that communicate with the subcontractors. On one of the jobs that we studied, specialty estimators were assigned for the electrical, dry walls, and HVAC work packages. On the other job studied, there were more specialty estimators employed. Some of them sat in their own rooms and then came in to tell their results in terms of name and price.

4.4.2.4 Estimator
To help the senior estimator out in the communication with the subcontractors, a second estimator is employed.

4.4.2.5 Computer Operator
A PC computer with an Excel spreadsheet is used to keep track of the list of bidders. One person is responsible for entering the best bids for each work item. The computer then generates the total sum along with the names of the listed bidders.

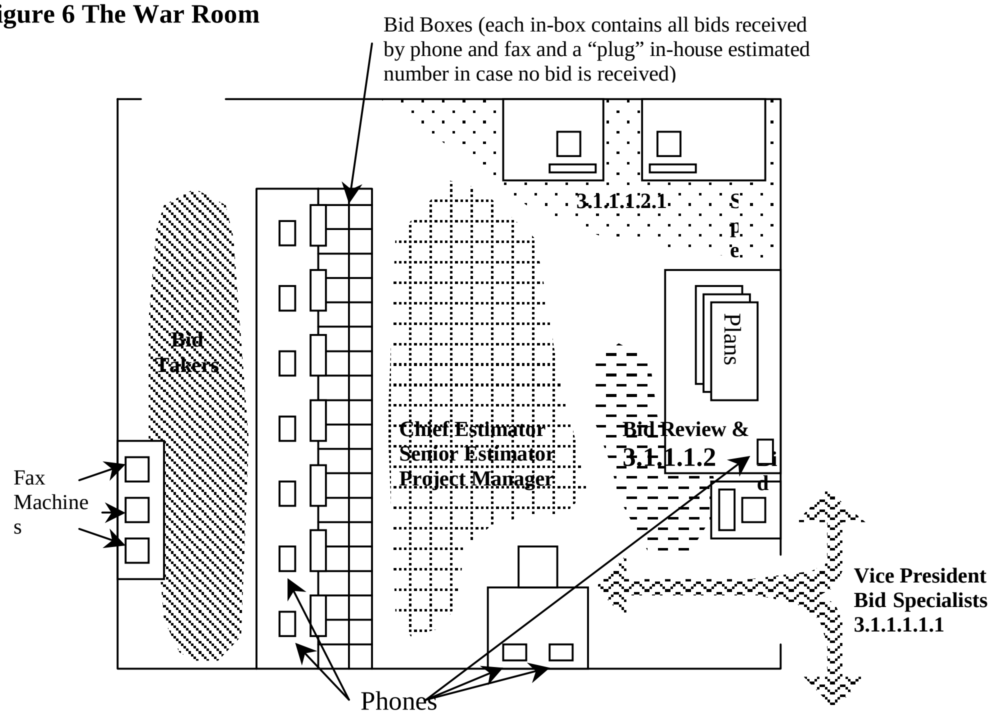
4.4.2.6 Project Manager
On the two jobs that we studied, the would-be project manager of the project was in charge of the communication with the deliverer of the bid.

4.4.2.7 Deliverer
At the owner is a representative of the general contractor ready to hand over the bid. He has the signed bid documents with only the final bid and the list of subcontractors waiting to be filled in. He is equipped with two mobile telephones to ensure that the communication works.

4.4.2.8 Bid takers
During the final hours of the bidding, 3 or 4 telephone operators are responsible for answering the calls from the subcontractors and noting their bids. Often, the subcontractors have already faxed a scope of work and only call to adjust the price as the bidding is coming closer to an end. The bid takers place the bids in bid boxes where they are picked up and checked by the senior estimators. The bid takers also administer the fax machines where other bids are arriving.

4.4.2.9 Other participants
During our field study, we also noticed some other people becoming more or less involved in the process. During one process, the vice president of the company passed by to see how the bidding was going. Other curious employees also showed up during the last stage of the process. We also observed secretaries from the central office coming in with bids that had been faxed to the main fax machine.

Figure 6 The War Room



4.4.2.10

4.4.3 Activities prior to the bidding

Prior to the actual bidding, the senior estimator responsible for the job has worked through the bid documents that the general contractor has received from the owner and divided the job into work items. For each work item, he calculates a “plug” cost, which is the benchmark cost that is used to judge the incoming bids. If no bids are received for a work item, the “plug” cost is used in the bid and the general contractor hopes to find someone who can do the job once it has been awarded the contract by the owner.

The drawings and specifications are available for the subcontractor in a plan room in the general contractor’s office. In the plan room is a copy machine to enable the subcontractors to make copies of the drawings.

The general contractor invites potential subcontractors to bid on the project. On the project we studied the general contractor used the Bidfax system to identify potential bidders. Bidfax is database of contractors that is linked to a fax system. The general contractor can search for subcontractors and the system then automatically generates faxes that invite the relevant candidates to bid on a job. In the case we studied, the senior estimator searched the Bidfax system using “specialty” and “localization” as criteria. Personal judgment was then used to add and delete names to the list that the system had automatically generated. Most of the subcontractors who wanted to bid on the project then faxed back to confirm their participation.

4.4.4 Observations about competitive bidding

4.4.4.1 In this section we will comment on some of the observations we made during our study of competitive bidding in the AEC industry.

4.4.4.2 Bidding throughout the supply chain

The bidding involves not only the owner, the general contractors and subcontractors, but also the material suppliers. The subcontractors need the price quotes from the material suppliers in order to compose their bids to the general contractor. The material suppliers are afraid that the subcontractors will try to bargain and therefore wait until the very last minute to submit quotes. The subcontractors can then only submit their bids to the general contractors and not try to negotiate with the material suppliers.

4.4.4.3 Informal negotiations

It is considered unethical to reveal the bid of a subcontractor to a competitor. On the other hand, it is to both parties interest to do so. The subcontractor wants to make sure that it is the lowest bidder and the general contractor wants to have as low a bid as possible. The result is some kind of encoded conversation of the type:

> General contractor: “ I can't tell you how you’re doing.”
> Subcontractor: “What about $X?”
> General contractor: ”Well, you have to go down a bit.”

During our field study, we observed a very late incoming bid for the dry wall package. The incoming bid was at $576,000 compared to the $580,000 of the previous lowest bid. When asked, the estimators agreed that the subcontractor probably had found about the competitor's price from a general contractor.

Another complication to consider is that there are often close links between some subcontractors and general contractors. In one case, we observed an electrical contractor that gave a 30% lower price to a general contractor with whom it was associated than on bids associated with other general contractors. This was decisive for the outcome of the entire bid process.

4.4.4.4 Decision making

On a competitive job, price is the overall decision criterion. Normally the general contractor chooses the lowest bidder given that it satisfies a number of constraints. Some bidders are, for example, non-performing and therefore disqualified. The problem is that, if a bid is “unrealistically” low, a general contractor may be forced to accept it since otherwise it may not be awarded the contract from the owner because some other general contractor will include this low bid. The general contractor knows that there is a big chance that this low bid will lead to change orders and costly conflicts and can only hope that these costs can be passed on to the owner.

Many bids include exceptions and the general contractor must then calculate how much the bid must be raised to compensate for the exception. The problem is that some exceptions are ambiguous (such as: "No exotic materials") and introduce more uncertainty for the general contractor. In some cases, these ambiguities can be cleared up through phone calls, but given the time pressure inherent in the process there is often no time for such calls.

4.5 Evaluation of the Existing Bid Process

In our study of the existing bid process in the AEC industry, we detected a number of strengths but also several problem areas.

4.5.1 Strengths

4.5.1.1 Contextual Background Sharing

The intense information exchange that takes place between the project manager and the subcontractors enables the different parties to evaluate each other's qualifications respectively. An AEC-industry transaction involves uncertainty and all the possible outcomes cannot be taken into account in a contract. The losses that occur if the general contractor hires a non-performing subcontractor will normally not be compensated for in the contract. By carefully screening and interviewing the final candidates the project manager is able to judge the ability of the subcontractors. A potential steel-contractor that does not seem to realize the potential problems associated with the job will therefore be likely to disqualify itself in the view of the general contractor.

4.5.1.2 Flexibility

Transactions in the AEC-industry require contractual adaptability [2]. Goodwill and trust are therefore key elements of a successful transaction. By spending time on communicating with the different parties and through the use of rich communication tools such as face-to-face communication, the parties believe that they can better asses whether goodwill and trust will characterize the future relationship.

4.5.1.3 Building Personal Relations

Another key element to ensuring a good will and trust is establishing good personal relations between the persons that work together on the project. These are often the same persons who carry out the negotiations between the general contractor and subcontractor (project managers in the respective organizations). The contracting stage can therefore be a forum for building these relations. Problems during the construction process will then be solved easier, since the parties already know each other.

4.5.2 Problem Areas

4.5.2.1 Lost Information

Information is likely to be lost in a manual bid process. The most obvious example is the faxes with bids that got stuck in the fax machine, as we observed during one of our field studies. Another example is how knowledge is lost within the organization. Data about the performance or existence of potential subcontractors who could bid on the project will not always reach the decision-makers unless there is a system in place for capturing and transferring this information. Today, the data gathering process is often informal. One reason for this is that the high workload prevents project managers from spending time entering data in a knowledge management system, but it is also due to the fact that the information is often hard to formalize.

4.5.2.2 Redundancies

Redundancies are another problem of today's bid process. Data, such as bidding information, is entered or written down first by the subcontractor, then read by the general contractor and finally entered into the general contractor's information processing system. Another example is drawings and specifications that are generated by the architect using a computer, then printed out on paper by the architect, only to be entered again in the contractor's cost estimation applications. These entering, reentering and reading activities represent non-value adding business processes and can also be a source of a second problem: errors. Every time information is read or entered there is a possibility of errors, given the high level of stress that is often present during a bid process. In cases where the numbers are misinterpreted, it can jeopardize the profitability of an entire job.

4.5.2.3 Costly search

Today, the search for potential business partners is a manual process. The project manager or his assistants often search data sources such as blue books, local trade journals and directories. The data they are looking for is often not very complex (name, specialty, contact information) and could easily be put into a searchable database. The search mechanism could then be automated which would save time in the information gathering process.

4.5.2.4 Production and Distribution of Documents

Document production and distribution represent substantial costs. On the project we studied, the project architect estimated the costs for the blueprints to be $1/page or around $100,000 for the project. This is substantial and corresponds to up to 0.5% of the total costs of the project. If the data distribution could be automated, it could lead to a key competitive advantage in an industry with historically low margins.

4.5.2.5 Missed Opportunities

The high costs of information gathering and processing lead to missed opportunities. A potential low bidder can be left out of the picture because the project manager did not have time to search long enough to find out about it. Also, the subcontractor themselves may not bother to participate in the framework. The simple cost benefit analysis below derived from Eccles and Park [2, 3] can serve to illustrate this phenomenon. If the costs of bidding are high as showed by the current cost curves in the diagram, the general contractor will solicit bids from fewer bidders and the subcontractor will not bother to participate unless there is high likelihood of being awarded the contract (low number of competitors).

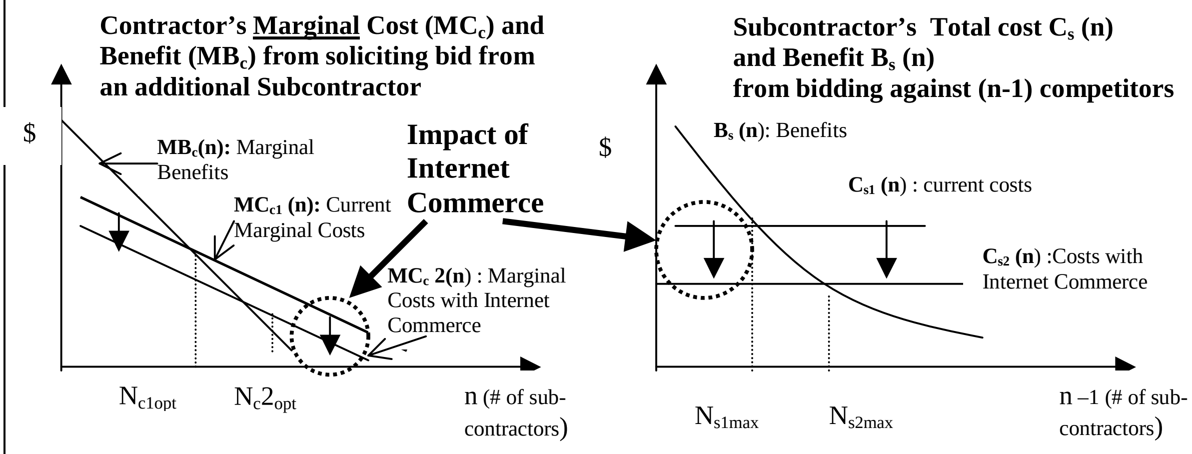


Figure 7 Impact of lower bidding costs

4.5.2.6 Latencies

Bidding is an activity with strict time constraints in the form of formal deadlines. If these are missed, losses are incurred since the parties do not obtain the best possible transaction configuration. This is critical, especially for competitive bid processes. During our field study, there were incidents of bids coming in from subcontractors after the general contractor had already sent the bid to the owners. The reason for this was jammed telephone lines and probably also unawareness of the absolute deadlines.

5 Prototypes of automated bidding

In this section, we present two-prototype applications that use electronic models to support bidding.

5.1 General Contractor Searching for Subcontractor Bids

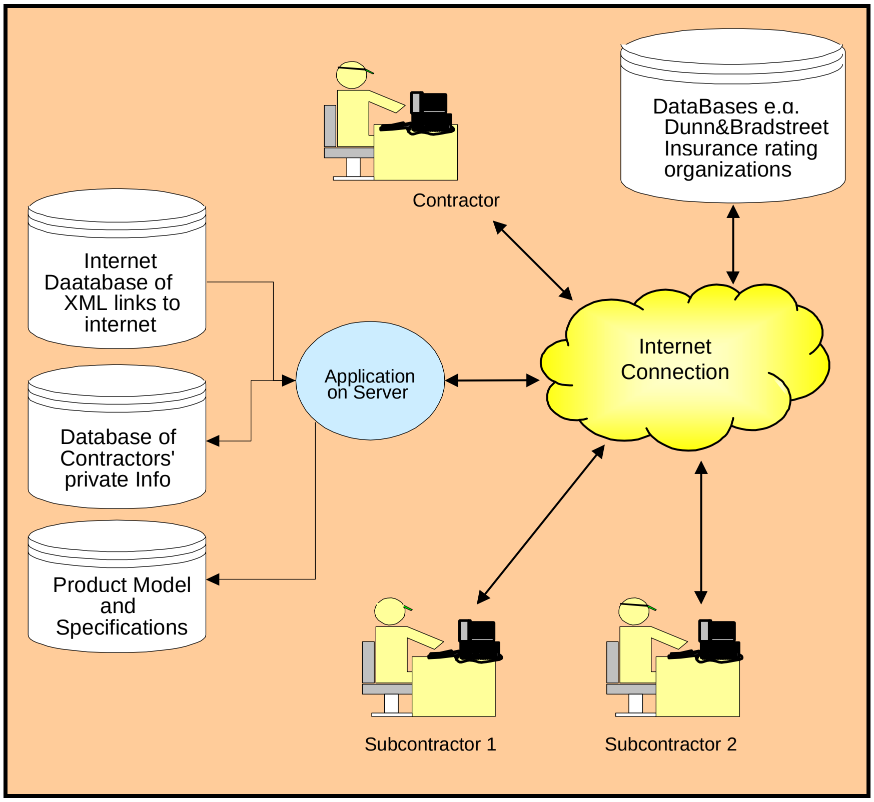
In order to investigate the requirements for a general contractor to receive subcontractor bids over the Internet, we built a prototype application. The application was based on the theoretical usage of Internet technologies such as Java, XML, VRML and HTML, however, the proof-of-concept was created using Powermodel.

5.1.1 Purpose

The purpose of the search application was to investigate web-enabled bidding. A contractor should be able to search the Internet for information, integrate it with his own in-house secure information, request bids from qualified subcontractors, and confirm and/or reject bids over the Internet. A subcontractor should be able to parse the product model and the specifications for a relevant subcontract work item and return a bid to the requesting contractor.

5.1.2 Representation

Figure 8 describes the technical representation of the prototype application. The application would be hosted on a server and the users would access it via the Internet, interfacing through their web browsers. Information used to build and update the search engine would also be accessed via an Internet connection. The application server's document management and workflow system can then manage the distribution of information.



5.1.2.1.1

Figure 8 Prototype Technical Representations

5.1.3 Reasoning

The reasoning of the application is based on the steps required to automate the bidding process. A top-level summary of the bid process is outlined in steps 1 – 3 below.

1.) A contractor searches for qualified subcontractors
    1.1) The Internet database is searched for qualified subcontractors.
    1.2) The private database is checked for matches with qualified subcontractors.
    1.3) An aggregated list of qualified subcontractors consisting of information rom both Internet and private databases is compiled.
    1.4) Contractor request bids from selected qualified subcontractors.
2.) A qualified subcontractor bids on the project.
    2.1) The qualified subs receive requests for bid along with links to project info.
    2.2) Subcontractor parses product model and specs in order to estimate costs.

2.3) Subcontractor submits bid.

3.) The Contractor receives bids and awards winner.

5.1.3.1 Internet Database

The application interacts with a database of qualified subcontractors based on shared information from several sources. This database would consist of XML links to relevant sources of information, such as Dunn & Bradstreet and insurance rating organizations. In order to create and maintain this database, a Java application would continuously search the Internet for updated information.

5.1.4 User Interface

Two different user interfaces were created for different users of the application. The primary user interface was designed to meet the needs of the general contractor who is requesting work package bids from subcontractors. The user interface for the general contractor is show in Figure 9. The general contractor first searches the Internet to determine potential subcontractors for the work package to be subcontracted. Then, based on predefined criteria within the general contractor's internal database, a short list of potential subcontractors is listed as being pre-qualified. The general contractor at this time has the opportunity to intervene and add or subtract subcontractors from the short list.

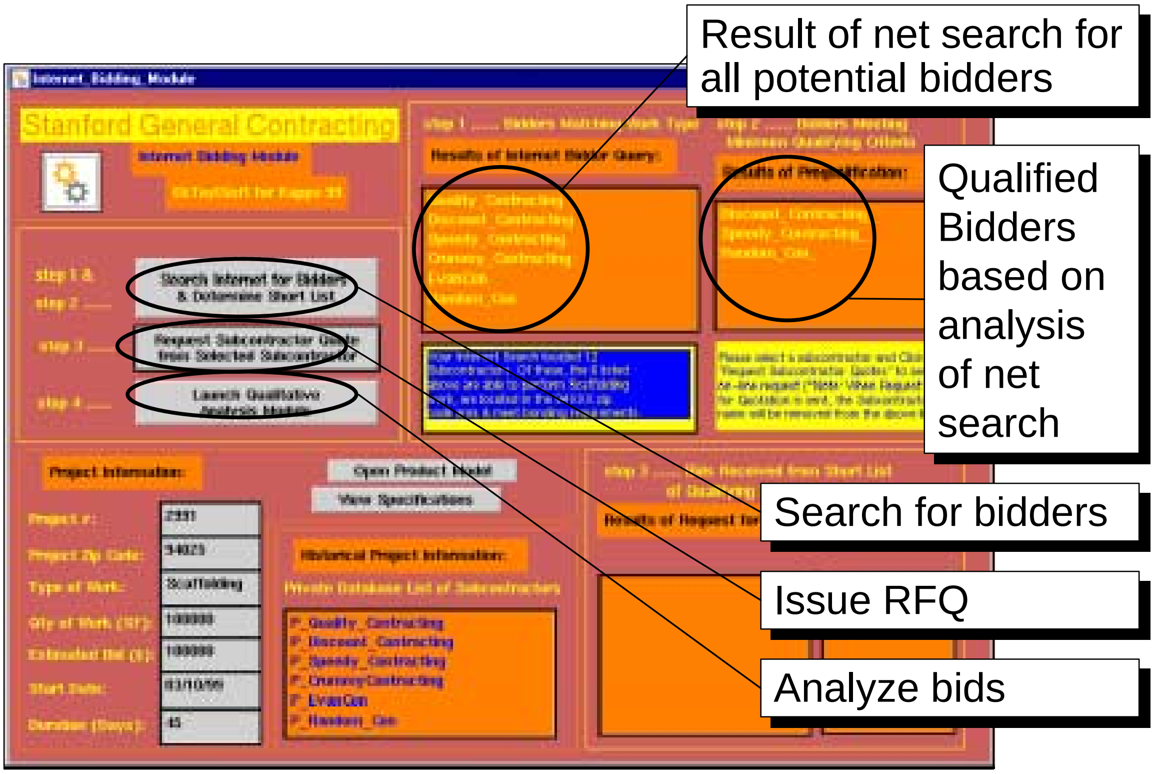


Figure 9 Bid Analysis Tool

Once the list of acceptable subcontractors is generated, the general contractor has the option to send out a request for quotation to each of the listed subcontractors. The request for quotation contains the relevant project information specific to the work package under consideration. The information about the project remains resident in an Internet-accessible database. Requests for quotations are sent using electronic mail messaging.

Subcontractors receive a request for quotation as per Figure 10 below. Using this interface, a subcontractor can parse the product model in order to visualize the work to be performed. Detailed information about the work package requirements is summarized in the "project information." A subcontractor has only to calculate their bid and enter it into the bidding interface. When the subcontractor submits their quotation, the quotations are received into the bidding interface of the general contractor. The general contractor can then evaluate the bids received from subcontractors in order to determine the lowest responsive bidder for each work package.

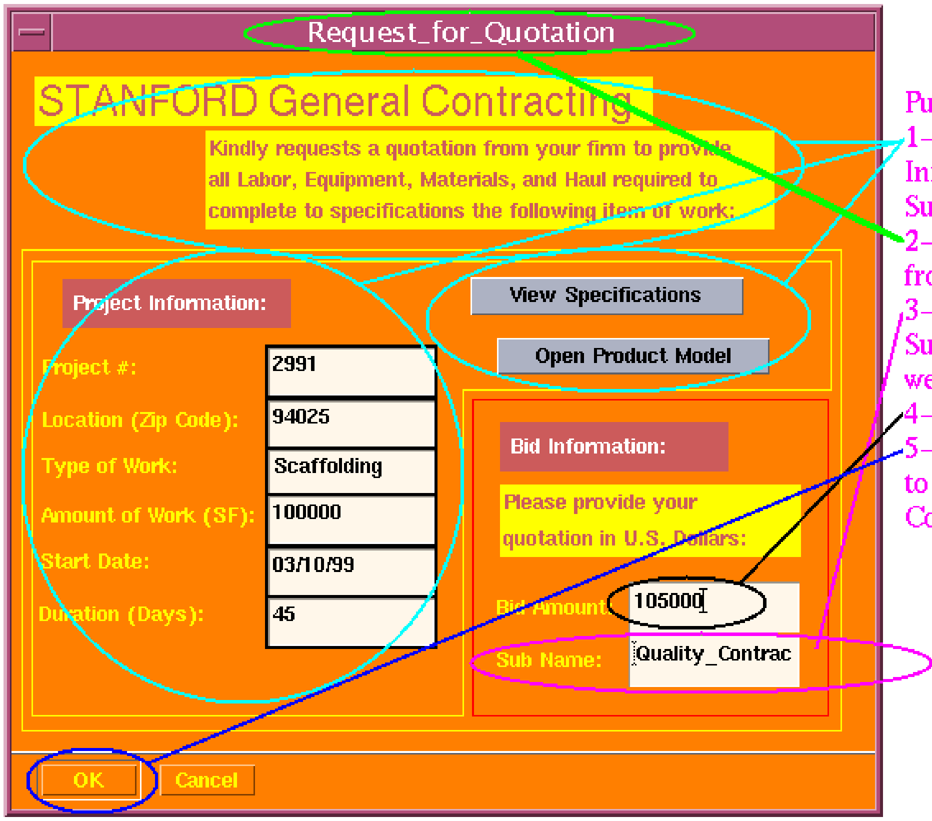


Figure 10 RFQ Tool

The user interfaces have been designed in order to maximize accessibility for AEC users without a requirement to change current business processes significantly. A user that is familiar with the operation of a web-browser should be able to master the system after a half day of training. One prerequisite is, however, that the user is familiar with terms and techniques in today's AEC bidding. A user should, for example, be proficient with 3-D CAD models in order to parse the product model in preparation of their bid.

5.1.5 Systems Interfaces

The system would be Internet compatible, meaning that the users should be required only to have a web-browser of version Netscape 4.0 or IE 4.0 (or equivalent) or more recent. The server hosting the web site will be of a type that supports accessing information from distributed databases containing content described in a consistent, standard format.

5.1.6 Test Cases

The finished system would be able to complete a bid process for a mock project of the pilot-contractor. Below is an outline of the input and constraints and the resulting output. The test case below only outlines the principle of the extended client-server application. To cover all possibilities, a more complete test case would have to be elaborated. The exact search criteria would be changed according to the needs of each individual general contractor.

Input Project Data	Project: Location Palo Alto, Type: Scaffolding Project Info Java 3D Model of project, Specs in XML format
Constraints Internet Database	D&B Sub1Bonding capacity: $100,000 Sub2: Bonding Capacity: $60,000, Skills: Scaffolding Insurance Org: Sub1 rating 1.2, Sub2 rating 1.3 McGraw-Hill: Sub1 location CA, Sub2 location CA Skills: Scaffolding
Constraints Private Database	Sub1 Cost: 100%, Qual 90%, Time 50% Sub2 Cost: 70%, Qual 40%, Time 90%
Constraints: Pilot Contractor's Search Criteria (Internet)	Location: Same state, Bonding capacity (Scaffolding): > $100,000 Insurance rating: >1
Constraints: Pilot Contractor's Search Criteria (Private)	No instance of Cost, Time or Quality < 50%
Output Shortlist	Sub1(Capacity $100,000, Insurance rating 1.2, Location CA, Cost 100%, Qual 90%, Time 50%
Output Sub1's invitation to bid	Project Information able to be parsed using web-browser
Constraints Subcontractor's (Sub1) bid	$90,000
Output bid to Contractor	Sub1: $90,000
Constraints Contractor's selection of Sub	Sub1
Output Acceptance of bid	"Bid (90,000) OK"

5.1.6.1 Conclusions from the first prototype application

Creation of this prototype bidding application highlights the need for standards for shared definition of content. This prototype assumes an open environment for shared information and the ability to access coded content about actors, pricing and product. As will be discussed later in this paper, the current state-of-the-art of XML to handle these types of transactions is insufficient. However, organizations are emerging that intend to define the types of standards that will make such a bidding environment possible (e.g., AECXML).

A further issue that came out of the above prototyping exercise was the distinction between private and public information in shared environments. The prototype assumes that information about subcontractors from, for example, Dun and Bradstreet can be accessed and integrated with internal databases to do analysis on potential bidders. This will require significant understanding on the part of contractors who develop and maintain internal databases. Further, this brings to light issues of privacy in determining exactly what information can be shared from any given database over the Internet and to what degree firewalls will protect proprietary information.

Finally, this prototyping exercise highlighted the need for trusted third parties to provide information and services with respect to information about different entities. Significant research is required to determine to what extent contractors will trust Internet technologies and each other in order to conduct bidding on-line. Nonetheless, this prototyping exercise did demonstrate that Internet-enabled bidding is possible. Future research should be conducted to extend this prototype to work towards an on-line bidding environment appropriate for the AEC industry.

5.2 Parsing of a bid package by a subcontractor

In order to investigate the feasibility of bidding over the Internet, we built a small toy model to illustrate the parsing of a bid package by a subcontractor. The model was based on Internet technologies such as Java, XML, VRML and HTML.

5.2.1 Purpose

The context is that a general contractor has a web site where subcontractors can log on to bid on different projects. In our test case, a structural steel contractor parses the information.

5.2.2 Representation

The subcontractor can choose between different projects that they want to bid on. The next subdivision is between the different work packages on the project. By choosing a particular work package, the subcontractor will see a 3D view of it. The details of each item in the work package (in this case beams, columns and concrete) are in turn represented in an XML format. The next level of granularity, the specifications, is also represented in XML with links to the GIF pictures. The specifications are, in this case, just text strings. The natural extension would be to structure them in XML format.

5.2.3 Reasoning

The application simply shows the data that the user selects. It is not an intelligent analytical application. The only search that is performed is to find the specifications that are relevant for each component. An interesting extension would be to build an analysis application in the form of an intelligent agent that parsed projects on behalf of a subcontractor in order to identify which subcontracts they should bid on.

5.2.4 User Interface

Th

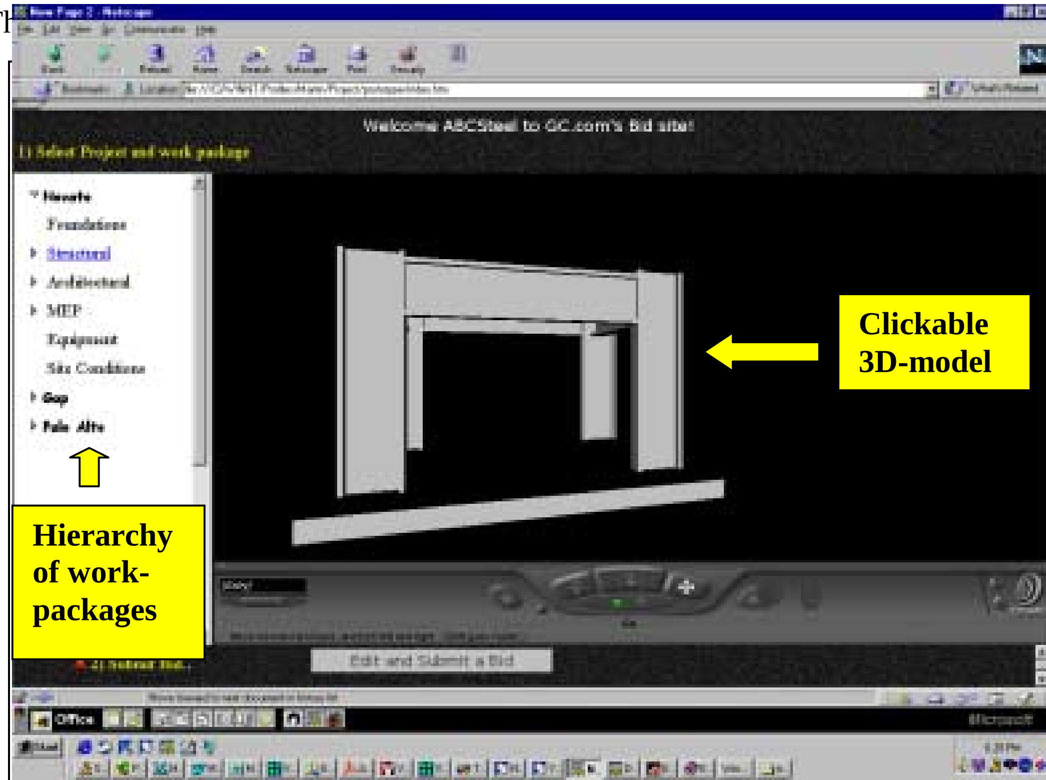


Figure 11 Bid Package Browser/ 3D Viewer

5.2.4.1 Main Menu

This is an HTML interface consisting of an expendable list where the user can choose between projects and work packages.

5.2.4.2 3D Viewer

The work packages can in turn be browsed using a VRML viewer. This gives the user the possibility to see both close ups of members and an overview of the entire job.

5.2.4.2.1 Component Information

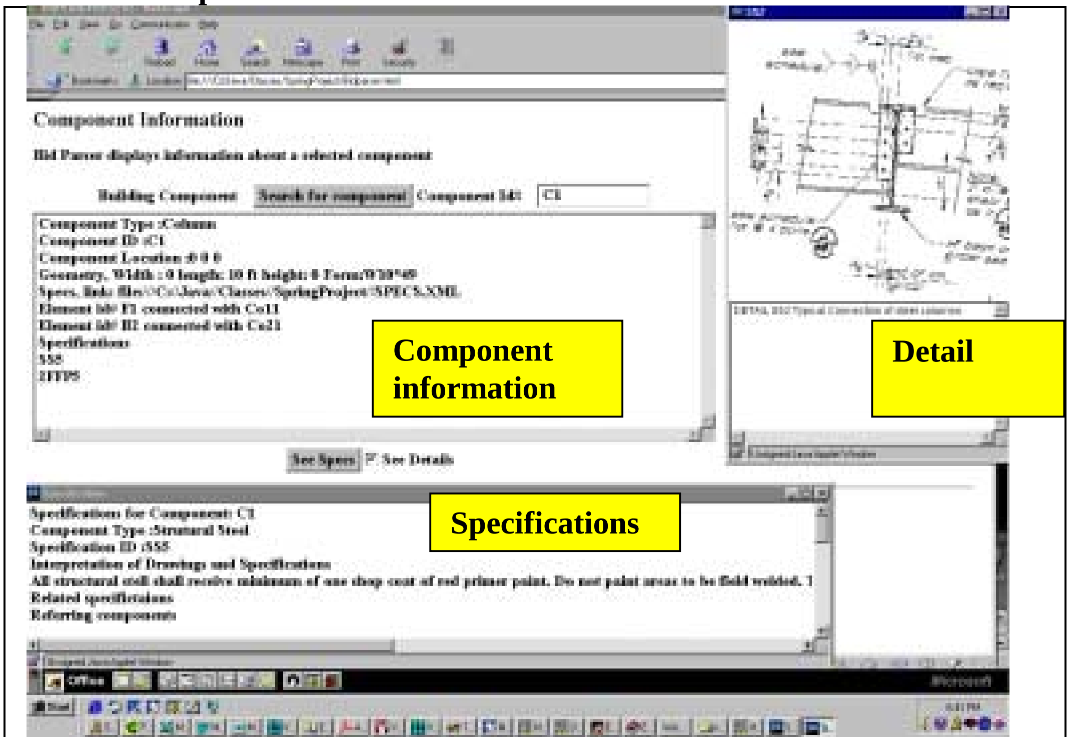


Figure 12 Component information and specifications in XML

By selecting a component the user is provided with a user interface that displays data about the component, such as width, height, type, material etc. The user can also decide to see the specifications, in which case a new window is opened showing the specification information.

5.2.4.3 Specifications

The specification information is shown as text and, if the users want, a picture of the component can also be seen.

5.2.4.4 Bid Form

In order to make the application appear interactive, we added a bidding functionality. In this case, it consists of an HTML version of today's paper based bid form.

5.2.5 Systems Interface

The solution is built in Java, XML and VRML. It is compatible with both Internet Explorer and Netscape Communicator. In order to view the 3D VRML pages, the user needs to have Cosmoplayer 2.1.1 software. The XML reader is built on Microsoft XML Parser version 1.0 that was released in 1997. Since its release, Microsoft parser has been revised on several occasions. Since the technology is not yet mature, we decided to base our application on the 1.0 platform rather than using the latest version, which would soon be updated anyway.

5.2.6 Test Case

We tested the prototype on the case of a potential contractor who wants to bid on the structural steel package of a medical building in Novato. The subcontractor wants to see the specifications and details for a steel column. The prototype behaved as it was designed to do, except for some minor bugs (such as showing two details, when only one is required).

5.3 Conclusions from building the second prototype

Building a model of an AEC structure is difficult. Even for our simple toy case, we discovered that a fairly complex model was called for. The interpretation of the information is often context interdependent. One example that requires further investigation is the integration of a product model and its specification. We chose to obtain this through the use of ID numbers that were shared between the components and their specifications. An alternative would be to view the components at different levels of abstractions, which could be obtained using objects. The specifications could then be incorporated in the product model. However, as we have pointed out, this could not be achieved using the version of XML that was available at the time of prototyping.

The obvious extension of the prototype would be to link it with the cost estimation software of the subcontractor. The power of XML is that computers can interpret it. For this to be useful, the interpretation should facilitate key AEC activities, such as cost estimation. To merely, as was done in our application, post the data to be read by humans does not incorporate the key advantages of XML.

6 Prerequisites for Bidding

In this section we will discuss some of the prerequisites for Internet bidding which we have identified as a result of our study.

6.1 Industry Standards

In order to enable flexible Internet based transactions, we recognize industry standards as one of the major prerequisites.

6.1.1 Standards needed

The different trading partners must have a means to share knowledge and information. We have identified three types of information that would have to be standardized for an entire bid process to take place over the Internet.

6.1.1.1 Transaction Information

The bid process is a series of information exchanges, which result in an agreement between two market participants. What we define as transaction information is the information that is specific to the negotiation between two parties for a given item. The most obvious example of this type of information is the bid, which in its simplest form consists of just a price and scope of work. In general, bids also include more complex items such as exceptions and addenda. In the opposite direction, from the general contractor to the subcontractors, transaction information refers to invitations to bid, qualification forms, and the rules of the bid process. Finally, the contract itself is an important example of specific transaction information.

6.1.1.2 Engineering Information (product model)

Engineering information refers to the information necessary for the construction of a subcontract. It is the information needed by the bidding subcontractors to be able to estimate the cost of the different scopes of work. The drawings and specifications along with the project manual are the paper versions of the engineering information necessary to support bidding today [4]. A lot of effort has been put into the development of a shared core model from which all the project participants can extract the information that is relevant to them. The market for cost estimation tools in North America is quite fragmented today [5]. For Internet bidding to be feasible, there is a need for a standard that supports all of these different applications and with many specialized estimating tools.

6.1.1.3 Business Information (company identity, bonding capacity)

There is also a need for information about the different actors in the market. Name, specialty of work and bonding capacity are a few instances of this type of information. It remains fairly stable and is not specific to a given transaction. One could imagine both a third party market maker that stored and aggregated this kind of information or that each market participant generated its own company profile, as is the practice today. The former scenario would have the advantage that the third party could guarantee the validity of the information.

6.1.2 Standards available

Today, there are a number of standards available both to describe and publish AEC-related content.

6.1.2.1 To describe Content

6.1.2.1.1 IFC and STEP

The International Alliance for Interoperability (IAI) developed the Industry Foundation Class (IFC) product model. The intent is that the shared IFC core model, in principle, should support views of the application data relevant for all the different parties who are involved throughout the lifecycle of a project, from the architect to the facility management [4].

While IFC is an attempt to develop a shared model, the Standard for the Exchange of Product (STEP) data represents an effort to develop integration architecture over distinct data models. For practitioners, STEP is a collection of standards called Application Protocols (APs). The APs are based on a common underlying methodology, e.g. STEP physical file format, EXPRESS data definition language. For researchers and developers, STEP is also an important source of modeling and implementation methodologies.

Arnold (1999) identifies four major deficiencies of STEP and IFC[4]. First of all, they do not support behavior very well, something that can lead to ambiguity when different applications are used to interpret a model. Secondly, they have a weak representation of state, which makes version control difficult. During a bid process, changes and updates are often made to the drawings and specifications and it is crucial that everyone bids on the same set of information. Thirdly, they are not very good at representing process, something that is important in the AEC industry where the construction process is often just as important as the finished product. Lastly, both IFC and STEP have difficulties representing context, which is crucial on complex construction projects where interdependencies are abundant. On the other hand, after having tested the IFC models on a small test case in a workshop setting, researchers have [6] concluded that IFC models worked well for representing and integrating product, work process, estimating, and scheduling information.

6.1.2.1.2 Master and Uni-format

Two systems for organizing and coding construction work have been in use since the 1970s: Uniformat and Masterformat [7]. The Uniformat tends to follow the construction of a building, while Masterformat follows the components that the building consists of. Both systems are of hierarchical nature and the information can therefore be seen at different levels of abstraction. The major publishers of construction data tend to follow the Masterformat. We foresee that either of the formats will be useful in terms of defining standards for transaction specific information, such as the different scopes of work. A major obstacle will be to deal with exceptions and addendum.

6.1.2.1.3 Standard Contracts

Standard contracts are common in the AEC industry. Both the American Institute of Architects (AIA) and the Association of General Contractors (AGC) have published standard contracts that are used to support contracting in the AEC industry. These standard contracts do, however, tend to mostly concentrate on protecting the interest of the members of the issuing organization. Nonetheless, contracts are documents and, therefore, of a relatively low complexity compared to building components. We attempted to implement a standard AIA contract in XML. This was not very hard given that the structure of the contract was rather uncomplicated. We just implemented the different subheadings of the contract in an XML DTD schema. The result is that an analysis application would be able to extract information, such as the content of a certain paragraph, to be interpreted by a human being. If one, on the other hand, wanted the entire document to be interpreted automatically, the modeling task would be much more difficult.

6.1.2.2 To publish content

6.1.2.2.1 XML

In order to build a powerful model, it is preferable to use objects. The advantage of objects is that they support inheritance. The model can then be shown at different levels of abstraction and code can be reused. Objects also have methods associated with them, which means that an object can execute a method itself, rather than having the invoking application do it. The invoking application only has to tell the object what to do instead of how to do it. The current versions of XML do not support inheritance or methods. The representation of the model of a complex structure, such as a building, would be a cumbersome task.

The International Alliance for Interoperability (IAI), which has for its scope to incorporate all AEC components and activities, instead used EXPRESS for modeling language. The software company Commerce One has developed SOX (Schema for Object Oriented XML) that aims to provide XML with the functionality of objects. Further investigation is necessary to see how SOX supports the modeling of complex AEC objects.

We have investigated the applicability of XML for publishing content. The current versions of XML work well for publishing transaction and business information The AEC-XML [8] initiative has recognized this and decided to limit their scope of work to business and transaction information along with components from standard catalogues.

6.1.2.2.2 VRML

Virtual Reality Markup Language (VRML) provides a method of representing objects in a three-dimensional viewer. The greatest advantage of VRML is the fact that it is a shared standard for publishing graphical information over the Internet. XML objects, described above, can be represented using VRML in order to give the users an understanding of how the project or work packages of the project will look.

In the second prototype described previously in this report, VRML was used in order to represent a graphical view of the XML content defined for our test case. VRML viewers support the capability to select discrete objects within the 3-D representation in order to obtain specifications and sizing information about each object. This could be extended in the future to support information about where to source materials or even to provide the interface to request bids on product model objects in an on-line bidding environment.

6.2 Infrastructure

The infrastructure requirements for the industry to adopt an on-line bidding process go beyond the simple browser requirements that are standard for many of the business-to-consumer on-line transactions today. In the fast-paced, real time bidding environment described previously in this report, it is clear that constant connectivity is a requirement for efficient bidding to take place on projects across the industry. There must be a large degree of certainty that project changes/addenda have been received and considered by all bidding parties.

Much of the above-referenced bidding uncertainty in bidding on-line could be solved by simply requiring bidders to acknowledge changes/addenda. However, last minute bid changes lead to errors and omissions, which could plague an on-line bidding mechanism if information is not accessible and quickly used ubiquitously. Liability issues, therefore, make solution providers hesitant to provide this functionality. If it could be proved that a contract was missed because of a bad connection or a software bug, the solution provider could be sued.

A further infrastructure requirement to enable on-line bidding is an acceptable, legal framework for on-line bidding. Bidders need to be authenticated and there needs to be a level of certainty that bids are coming from the parties named on the submission. Today, legal issues are still in the process of being defined for Internet commerce. Just as fax documents took several years to become legally binding, it will take time for the legal ramifications of exceptions to be determined by the courts. Even today, these issues are being challenged in courts. For example, the European union recently decided to recognize electronic signatures as being equivalent to signatures on paper.

In all likelihood, third parties will emerge that take on the "trust" role in order to alleviate potential legal issues described above. These market makers will play an "infomediary" role that allows buyers and sellers to transact. It is likely that these players will emerge as new businesses because of the appearance of bias if any single contractor or subcontractor would emerge in this role. These third parties will need to provide some measures that contractors can use to evaluate trust issues when dealing with new contractors/subcontractors. A further possibility would be for existing independent organizations (e.g., AGC, ABC) to play the role of the trusted third-party intermediary, since they already contain detailed information about contractors and understand the industry.

The applications necessary to transact on-line commerce in the AEC industry will need to be created as well. Some companies are currently emerging that are beginning to provide hosted applications that allow parts of the bidding process to be conducted on-line. One possibility is that niche providers that specialize in the AEC domain will provide the platform for construction bidding (e.g., BidFax, Buildpoint, Buzzsaw). A further possibility is that larger e-commerce infrastructure portals with more developed standards (e.g. CommerceOne) will provide the functionality for bidding in the AEC vertical industry.

6.3 Rating System

During bidding in the AEC industry today, there is informal sharing of information, such as the performance of subcontractors. Project Managers at competing general contractors call each other to check the capability of subcontractors that they consider to hire. This arrangement reduces the inherent uncertainties associated with highly asset specific market transactions. For consumer-to-consumer commerce, Internet auction models have gained substantial popularity. Internet auctions such as EBay enable transactions between private individuals [9]. The items sold are often very differentiated and hard to judge and the sellers are anonymous. Trust is therefore a prerequisite for Internet auctions and, to increase trust, they have created a rating system for buyers and sellers. In this system, the market participants rate each other after each transaction. The buyer will give the seller a good rating if it received the items in a good condition. In this section, we want to discuss some of the issues that come up when investigating whether a rating system could be used for business-to-business transactions in the AEC-Industry.

Williamson[10] identifies the pair of factors “opportunism and small number” as one of the causes of asset specificity. The number of actors in a business-to-business environment is much fewer than for consumer-to-consumer transactions and, since the actors are not anonymous, there is room for opportunism. One of the assumptions behind the EBay ranking model is that the ranking one market participant gives its transaction partner does not influence the rater. The buyer of a PEZ-dispenser from the anonymous seller “Blue Moon” has no incentive to give “Blue Moon” a rating that deviates from “Blue Moon’s” actual performance. In a market where the market participants’ identities are known and it is possible that a rating would impact the rater itself, it is not evident that such a business model would work. Take for example a general contractor and a subcontractor that work together on a project. At the end of the project, there may be a disputed change order from the subcontractor. One scenario would be that the general contractor agrees to rank the subcontractor high given that the subcontractor forgets about the change order. This would cost the general contractor nothing and benefit the subcontractor. The opportunity for this to take place increases if there are personal relations between the managers in the two organizations, which is generally the case in construction. Both parties would then be better off, but the other participants in the market would lose since they would have distorted information. If this scenario was repeated frequently enough, the entire rating system could become dysfunctional. Incentive programs for online rating systems have been put forward in the economic literature (e.g., [11].), but rating systems have been a feature of commerce since the Middle Ages [12].

Another issue that comes up is the sharing of information. Ideally, everyone would be better off if all information was shared about all activities. However, some information, such as subcontractor performance, is sometimes regarded as business secrets. Our interviews with project managers showed that they were often willing to share information about poor performance but were less likely to reveal who was a high performer. The reason for this is obvious. If other general contractors found out that a subcontractor is particularly good, they would be willing to pay more to hire this subcontractor and the general contractor would then be forced to pay more to keep this subcontractor. The general contractor would on the other hand never hire a non-performing subcontractor again and it is therefore a low cost for the general contractor to reveal the information. Reciprocity also comes into the picture as the general contractor expects the favor to be returned sometime in the future. Lastly, we identify the need for formation of an independent third party, which would be in charge of such a rating system. In Finland and Norway, such examples exist [13, 14]. Alternatively, this function could be filled by an emerging e-service provider, which is something that, for example, the start-up Struxicon tries to do[15].

6.4 Scale

A further issue with respect to infrastructure is one of scale. The degree of connectivity of the AEC industry will be an important factor in the efficiency of electronic commerce for bidding. As Metcalf's Law indicates, the efficiency of a system squares with the addition of each new user ref. Thus, for electronic bidding to be effective, a large number of industry users must participate. As companies begin to provide on-line services that may lead to bidding, they are creating alliances (e.g. Primavera and PurchasePro) and/or leveraging off of their existing customer base (e.g. Buzzsaw and Autodesk).

Scale also refers to the amount of content available in sharable, computer-interpretable format for conducting commerce. If insufficient information is available, then the bidding process will not migrate to the Internet. This highlights a significant problem that must be overcome. For the system to have value to the potential users, the content must be available. However, in order for companies to invest in the creation of the requisite content, there needs to be a ready market.

6.5 Differentiation to support automation

During our study, we also identified the need for differentiating between transactions and activities as a prerequisite for automation. It is hard to foresee the entire bid process being automated at once. A stepwise procedure that starts off where the highest costs and least difficulties are is more likely. For example, in Sweden, the public sector program for e-commerce began with the automation of invoicing for the purchasing of commodities that are bought frequently. This activity is of low complexity and the potential value from automation in term of cost savings is substantial. In this section, we show that there is a need to identify between activities that can easily be automated and the type of subcontracts that easily lend them to automation.

6.5.1 Differentiation between activities

Some activities are easy to automate. These are normally labor intensive and of low complexity. Another factor that impacts the feasibility for automation is the economic impact of the outcome of the activity. Will an error lead to minor rework or cause million dollar losses. The search for potential subcontractors is an example of an activity that could be automated with relative ease. Today’s process is tedious and labor intensive and the inclusion of an extra (non-performing) subcontractor is not critical at this stage, since it can be corrected later. The activity is not very complex, since it depends on relatively few input parameters that can be formalized easily. The award of a contract to a bidder is on the other hand an example of an activity that we predict will be hard to automate. It is a complex activity with a large number of input and output dimensions. It is hard to formalize, since it depends on what one manager called “fuzzy stuff”. The decision can also be of critical importance, since it can both decide whether the general contractor will be awarded the contract from the owner and also determine the general contractor’s profitability if the project takes place. Finally, the decision itself is not very labor intensive. The gathering of the information on which the decision is based takes a lot of work but the analysis itself does not.

6.5.2 Differentiation between subcontracts

As for activities, the ease of automation differs between different types of subcontracts. The major dimensions in this case are technical complexity and economic importance. For subcontracts of low technical complexity and low economic importance, automation will be less difficult because we are dealing with commodity type transactions. Business to business auctions for commodities such as steel do already exist, as shown by, for example, the Internet marketplaces Esteel[i] and Metalsite[ii]. To create auctions of non-critical services of low complexity, such as paintin, would be more difficult but not impossible. The decision is relatively easy because the dominating decision criterion is price. For complex and important subcontracts, such as structural steel, the obstacles to automation are much higher. If the structural steel subcontractor does not perform, then the economic outcome of the whole process may be threatened. It is far from certain that the lowest bidder is the best choice.

However, our interviews with project managers show that the picture is more complex because of interdependencies between the different subcontracts. If the subcontractor that is hired to paint the structural steel is a non-performer, it may delay the erection of the structural steel and thus threaten the entire project. The subcontract in itself may be of low complexity but, given its high degree of context interdependence, the complexity rises.

7 Conclusion

As we have illustrated in the diagram below, the automation of bidding activities on the Internet should start with items where both the type of service and the activity easily lend themselves to automation. Searching for painting contractors is a better first step than trying to decide who is going to be awarded the structural steel contract. Evidence of this can be found at the new AEC Internet service provider Buildpoint[iii] whose first application consists of electronic invitations to bid over the Internet.

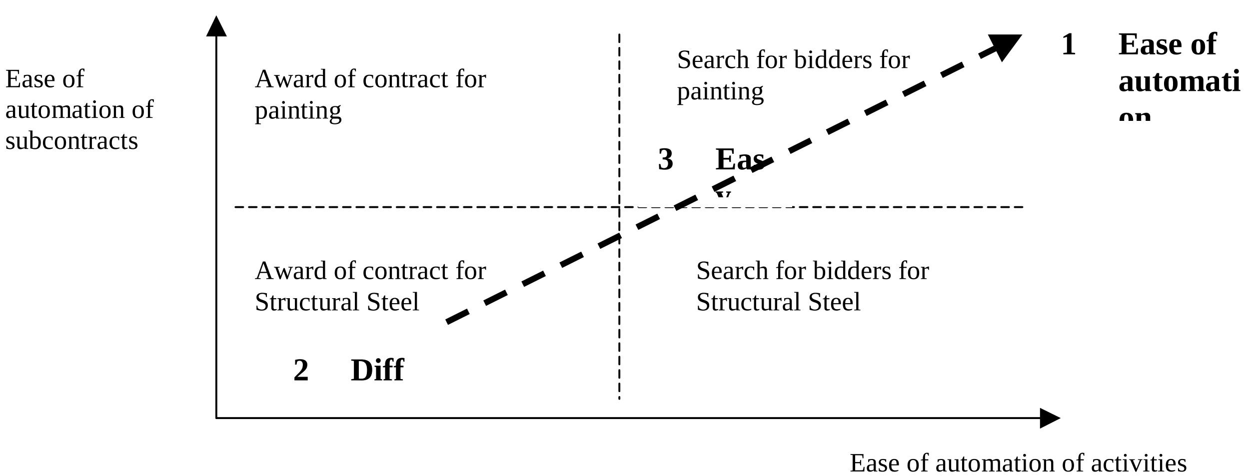


Figure 13 Selection of processes to automate

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Some selected URLs

[i] www.esteel.com
[ii] www.metalsite.com
[iii] www.buildpoint.com