eBUSINESS SCHEME FOR ENGINEERING CONSULTING SERVICES

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SUMMARY: *Despite the availability of ICT tools and infrastructures, civil engineers and design consultants still don't take full advantage in their daily activities of the eBusiness scheme which may open the door of the global market to providers of specialized consulting services. This perspective may allow even small consulting offices to get in contact with potential clients located in any part of the world widening enormously their commercial possibilities. Legal and contractual problems at present still hinder such perspective. The outcome of the combined effort of eLEGAL and ISTforCE projects (both funded by the European Commission under the IST programme), contributed to solve the problems due to lack of infrastructures for remote consulting and legally sound remote business relationships. The concepts and developments resulting from these two projects, which are going to be applied by Geodeco for its specialized consulting services to be offered on-line, are discussed in this paper.*

KEYWORDS: *eBusiness, eWork, ICT, Legal issues, business objects, AEC.*

1 INTRODUCTION

1.1 The current situation

Providers of consulting services in general and engineering consultants in particular, are not yet taking full advantage of the available ICT technology for many reasons but mainly because many problems are still open related to these activities in the ICT framework. In the AEC (Architectural, Engineering and Construction) field, civil engineers and consultants use daily ICT tools mainly for information and technical data exchange missing in many cases the opportunities that such technology can offer to foster new ways of working, and new business opportunities. In other words the opportunity of establishing new business models. This may be due to the fact that professionals usually provide high level services that require a clear and defined relationship between the client and the consultant also from the legal and contractual points of view. For instance, recognizing the remote consultant's responsibility relative to the results of the consulting assignment would be crucial in order, for these new working paradigms, to be accepted in real life design & construction projects. Moreover, an acceptable level of quality should always be guaranteed and demonstrated to the clients.

Therefore an efficient infrastructure for remote consulting services must be created and contractual as well as legal issues must be addressed and solved, in order to establish a new business paradigm allowing consulting engineers, willing to provide their services through the Internet, to overcome the problems listed above. The goal we want to achieve is to devise a way to enhance the capabilities of civil engineers, offering them new ways of working taking advantage of the most advanced available ICT technology.

European engineering companies or even single consultants, able to provide high quality engineering services, could highly benefit from the perspective of selling remotely their services reaching potential clients even in distant countries. Despite the integration efforts in industry standards, differences among European countries for instance are still significant concerning approaches to civil engineering design. Moreover, specific technical capabilities are not always available to solve problems that are peculiar of countries where the construction will be executed but not of the country where it will be conceived and designed. The open market for engineering services within the European Union allows engineering companies to bid for projects in other European

countries where geological or climatic conditions are completely different and consequently also the design solutions (i.e. seismic problems, ice engineering, etc.).

A North European design offices having to deal with seismic related issues for design contracts abroad for instance, usually don't have the necessary knowledge and may need the support of foreign companies or institutions having greater experience in the field.

Designing buildings or industrial facilities in seismic prone areas in fact is a complex and time consuming process. Seismic Hazard must be evaluated and geotechnical site conditions must be evaluated in order, for the local amplification effects, to be taken into account. Highly specialized experts in this field are not easily available, and data about seismic catalogs and geological conditions must be updated on a continuous basis. These are strong motivations to make desirable such a consulting service available on-line to the majority of designers.

It is therefore evident the need for a new technology able to help the engineering companies willing to perform their services at a global level, to overcome the difficulties of lack of specific knowledge for problems peculiar of different regions of the planet.

1.2 The perspectives

In order to contribute to the solution of the problems mentioned above, an environment enabling the provision of remote engineering consulting services was conceived and developed within the framework of the ISTforCE project, whereas the contractual and legal issues were addressed using the results and the developments from another EU funded Project (i.e. eLEGAL). The concepts, which were implemented for the engineering fields only, could eventually be broadened to "higher level" services of different kind which could be provided through the Internet. Two different approaches were investigated. A remote consulting service for specialized seismic risk assessment and a more complex service for remote consulting on special foundation design with need for data exchange and interaction between the consultant and the client. The premises and the requirements for the former case were described by Mangini et al. (2000), whereas the system as developed during the project will be described in this paper along with a description of the latter case.

Similar efforts, but with different goals have been made for instance in order to provide services to SME's as in Keravel et al. (2002) within the VIVA initiative, or in Fuerst et al. (2002) but mostly related to general procurement, accounting or e-Business services provided in ASP mode. More similar the effort made by Cervenka, et al. (2002) for the provision of services through a virtual laboratory for concrete testing. Most of the Web services developed so far are more related to collaborative and concurrent engineering rather than to high level service provision. Other aspects such as the quality control were addressed in Najmi et al. (2002).

2 THE AUTOMATIC ENGINEERING SERVICE PROVIDER (AESP)

The remote consulting services have been established through an AESP (Automatic Engineering Service Provider) where assistance is provided to the engineer by an intelligent system available on-line. The system is aiming at putting in contact engineering consulting companies with potential clients seeking design services, as a sort of virtual commercial manager, able to interact autonomously with the users filtering their information and asking questions concerning special needs, data availability etc. The AESP requests all the information necessary to perform the engineering service, provides preliminary results to the user and offers more accurate investigations on demand, to be carried out off-line through a human-based activity, at the Central Design Office.

The architecture of the AESP is shown in Figure 1, where three different levels of interaction can be distinguished:

1. An information level where the user provides to the system the information about the service he needs as well as the data available to him.
2. An "on-line" service level where the user starts a free of charge interaction with the system obtaining some preliminary results that he can use as precious feed-back in order to decide whether he actually needs the "off line" specialized service.

3. An “off-line” service level where, the consulting service is carried out at the Central Design Office following a negotiation conducted between the client and the consulting company by means of a negotiation tool which is part of the AESP.

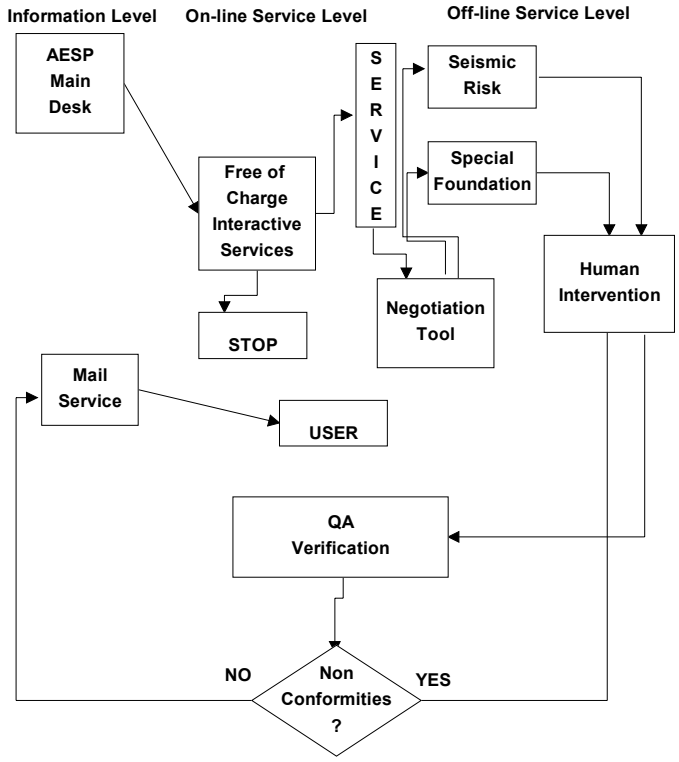

FIG. 1: AESP Flowchart

The AESP can be used either as a Java Application executed through Java Web Start or as an Applet to be executed through a Web Browser. It is equipped with “local intelligence” so that it can interact autonomously with the clients performing a simplified analysis (for the case of seismic risk assessment). If the client decides to order the offered off-line consulting service then a negotiation will take place by means of a negotiation tool.

In that case all the gathered information would be transmitted to the Central Design Office (Figure 2) where the consulting service will be performed by real experts in the field. As a result of the consulting service a report will be delivered to the client electronically signed by the author (the engineering consultant), who takes full legal responsibility on the correctness of the results. The report will contain also a trace of the quality verification procedures applied to ensure to the client a standard quality level.

The free of charge feed back over the actual needs for the service will also be very useful in attracting visitors that may take advantage from this opportunity and will spread the information about the AESP in the engineering community. Two consulting engineering services are available through the environment:

- Seismic Risk Assessment;
- Special Foundation Design;

These two services will require a different kind of interaction between the user and the AESP. In the former case only basic information concerning geographical location, building data and geotechnical data will be needed by the system whereas in the latter case heavier data exchange could be necessary.

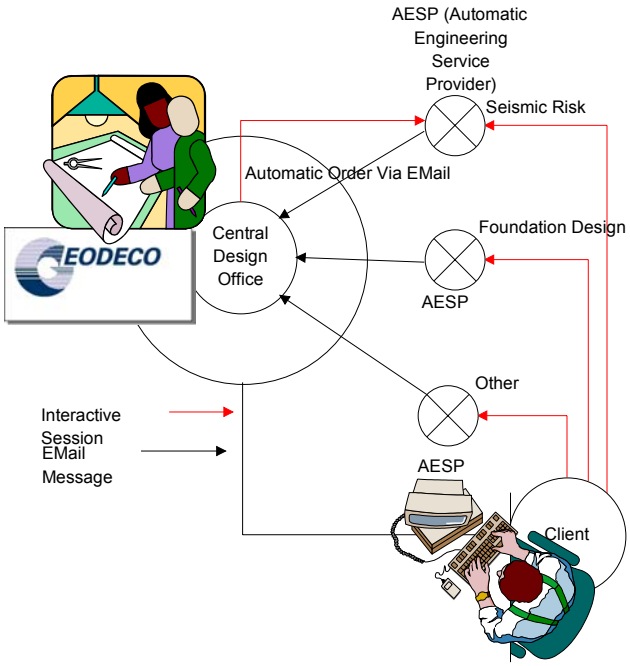

FIG. 2: Client interacts with the AESP

2.1 The Seismic Risk Assessment Service

By means of the AESP for seismic risk, engineers seeking advice on the matter can find a prompt answer on-line. They only need to input the coordinates of the site where they want to build the structure (by clicking on an interactive GIS map as shown in Figure 3) and the available information about the soil characteristics and the structure typology.

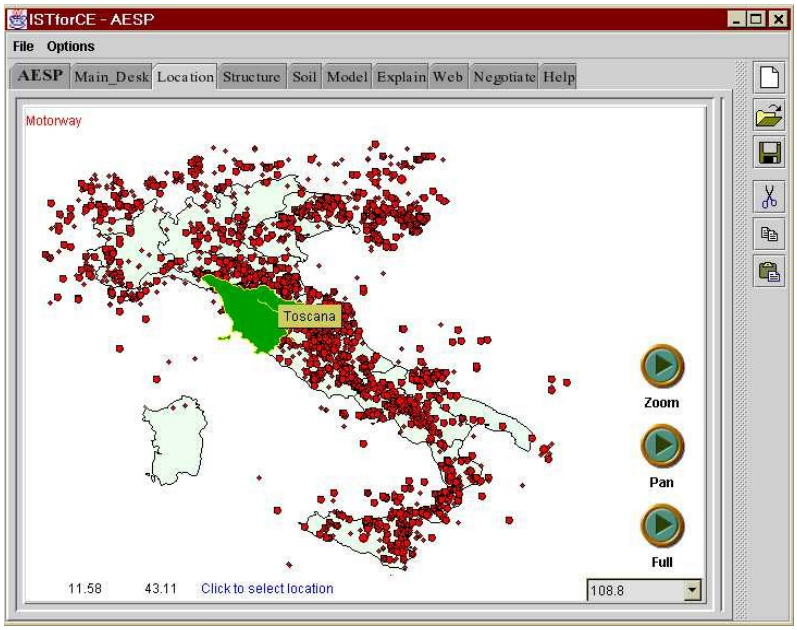

FIG. 3: GIS Screen for Selection of the Geographical Location

The system provides free of charge the results of a simplified risk analysis useful to establish the real need for a more sophisticated analysis that will be performed off-line through human intervention by experts in the fields and using innovative methodologies (Bazzurro et. al 1999). Figure 4 shows a simple input/output schema for the AESP. A yes/no answer will suggest to the user the need for an off-line detailed analysis.

The results of the preliminary analysis provided to the client may suggest for instance for a two storey building located in a slightly seismic area to just apply the national regulations, whereas for a ten storey hospital in a seismic prone area to perform a more detailed hazard analysis taking into account local amplification effects.

The AESP for seismic risk assessment establishes the need for a more accurate investigation by evaluating the expected damage on the proposed structure starting from an assessment of the seismic hazard on rock at the location selected by the user, and then considering the local soil amplification due to the site soil conditions.

The AESP offers to the designer a powerful tool for preliminary seismic risk evaluation. It is possible to evaluate quickly and automatically effects of ground motion on plant layout and construction schemes.

The service can be used efficiently for the following tasks:

- evaluate at design stage the probability of exceeding a certain level of structural damage due to earthquake loads;
- verify the level of safety of an existing building vs. earthquake loads to design retrofitting measures;
- establish the necessary input data for dynamic (linear or non-linear) analyses of relevant structures or lifelines;
- plan future urban development policies.

2.1.1 The On-Line Computations

The methodology for mapping the hazard on rock in large areas requires a heavy computational effort, and even for the free of charge simplified analysis it cannot be performed directly on-line through the AESP. Therefore a database has been created containing the territorial distributed results of pre-performed analyses (hazard maps on rock). A set of analyses were executed at the Central Design Office covering a regular grid on the territory and were stored in a remote database accessible from the AESP through a servlet located on a Web Server. Such results are then coupled with amplification factors derived from suitable attenuation laws. Fragility curves are finally used to estimate, for the computed acceleration level, the likelihood of exceeding a given level of damage for the proposed structure typology.

For the creation of the hazard maps, the computational cycle shown in Figure 5 is performed. The whole territory must be discretised by a grid of nodes where the analyses will be carried out. For each node of the grid the seismic hazard is evaluated by a probabilistic procedure. By looping the computation steps through the entire territorial grid the desired hazard maps can be created. They are produced, using the soil motion parameters most appropriate for the structural damage evaluation, (such as peak ground acceleration or spectral accelerations for different oscillation frequencies).

As an example, a very rough grid (about 30 by 30 kilometers) covering the Italian territory was established in order to create a hazard database for the “on-line” service provided by the AESP. In this case a simplified approach was adopted (in terms of seismotectonic provinces and uncertainty parameters). Still, a grid of about 1750 analysis points, and a total computational time of about 72 hours of a fast machine was necessary.

The following steps are performed in the simplified analysis on-line:

- assessment of seismic hazard on rock, by accessing a remote database of pre-performed off-line analyses on the region of interest and interpolating the value at the location selected by the user;
- evaluation of local site amplification effects by means of specific attenuation laws;
- evaluation of the expected damage on the given structure typology by means of pre-defined fragility curves.
- The AESP uses the following data:
- building data - type of structure, shape, number of floors, frame type etc.;
- soil data - soil stratigraphy and type, depth of bedrock, susceptibility to liquefaction etc.;
- geographical data – latitude and longitude.

The above mentioned data are acquired by means of a very easy-to-use interface, offering multiple alternatives for the building and soil data.

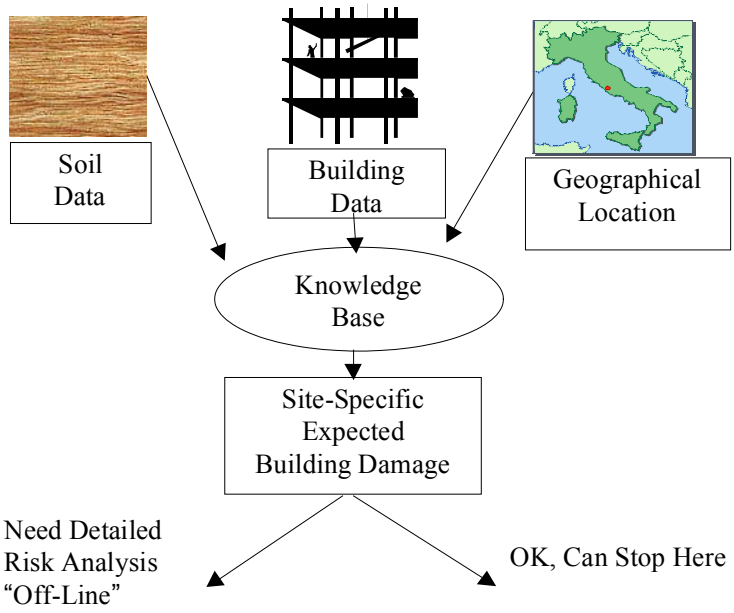

FIG. 4: AESP Performs Simplified Analysis "On – Line"

2.1.2 The Off-Line Computations

The off-line analyses offered through the AESP can be focused on a specific geographical location (i.e. location of the structure) or on a geographical area for the creation of hazard maps which take into account the local soil amplification effects.

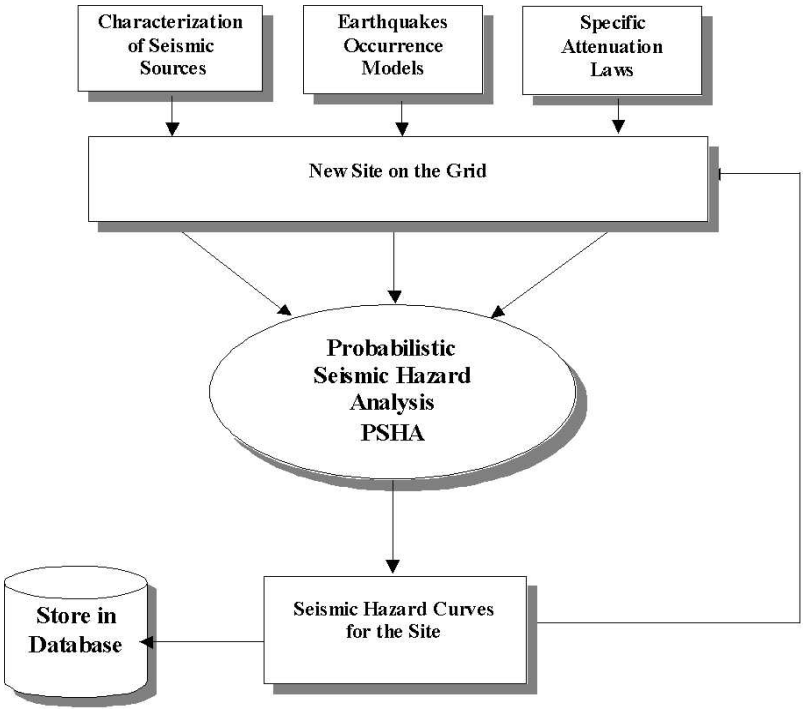

FIG. 5: Computational Cycle

An innovative methodology is used which includes an effective probabilistic approach for evaluating the ground motion hazard at the surface of a specific non-linear soil deposit located at a specific site. This methodology couples conventional Probabilistic Seismic Hazard Analysis (PSHA) with non-linear dynamic analyses of the soil column subject to real rock ground motions. Uncertainty in the soil characteristics (and statistical correlation

among properties in different layers) can also be incorporated by appropriately randomising the soil properties in each analysis.

The characterisation of the ground motion at the surface of a typical soil deposit is pursued via truly nonlinear dynamic analyses of the soil column subject to real rock ground motion recordings. A version of the computer program SUMDES (Li et al. 1992) modified by Geodeco is used. SUMDES (Site Under Multi-Directional Earth Shaking) is a finite element code, which performs dynamic response analyses of horizontally layered sites. The procedure is formulated on the basis of effective stress principle, vector motion, transient pore fluid movement and generalised material stiffness. The multi-directional formulation and the use of plasticity models for soil behaviour allow handling of shear wave and compression wave simultaneously. For simplicity, however, only one horizontal acceleration time history is usually applied in the analyses.

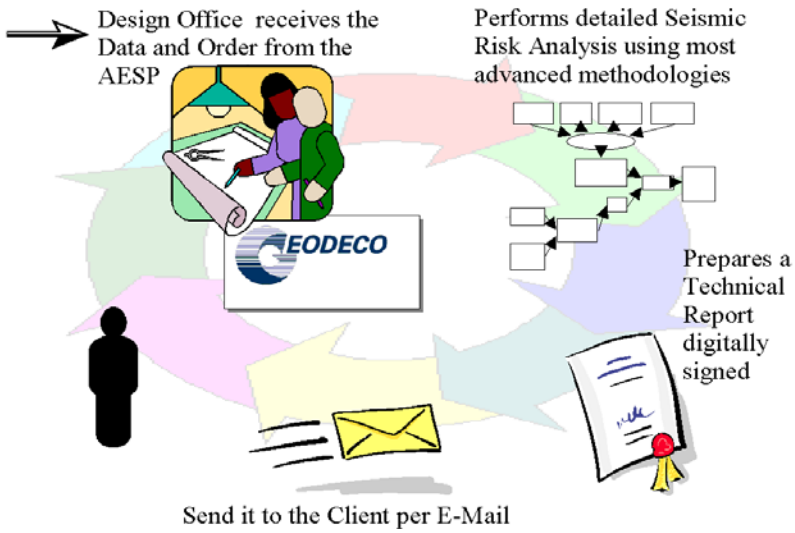

FIG. 6: Information Flow in Case of Detailed "Off – Line" Analysis

The information flow during the off-line process is shown in Figure 6. The Central Design Office receives the request to perform the detailed off-line analysis from the AESP.

This is a result of a negotiation process where the data gathered by the AESP during the on-line session with the client have been sent to the Central Design Office together with the client's data (name, e-mail address etc.). An offer in the sent to the client with the list of the foreseen activities and relative prices. Upon acceptance of the conditions from the client's side the Central Design Office can start working on the problem. A digitally signer report will then be sent to the client as result of the consulting service.

2.2 The Special Foundation Design Service

Another service offered through the AESP is the Special Foundation Design Service. The motivation behind this service lies on the fact that the selection of the most effective special foundation system or ground improvement technology often depends on local availability of specific technologies and can also be influenced by local regulations.

Therefore involving local designers or consultants with specific experience in a certain area of the world is common practice. Similarly, managing and contracting geotechnical and geophysical investigations on a local basis is almost always done, wherever possible, in order to contain costs. The special foundation design service can offer the possibility to access to specific knowledge and experience through a remote consultant.

An expert system is used to cope with special foundation design. The system prepares preliminary foundation designs, construction cost and time estimates for buildings and entire industrial complexes. The program provides an efficient means to evaluate layout alternatives in the preliminary design phase, and compares their costs. It designs foundations using an expert evaluation of site soil conditions, anticipated structural loads and building code requirements. Human experts then intervene to check and validate the results.

For such semi-automated design process a quality assurance program must be established in order to guarantee the user on the quality of the results. Furthermore the user will be able to monitor remotely, and in real time, the work progress, viewing the results as soon as they come out from formal calculations at different levels (i.e., preliminary, draft an final) and all stages of the QA procedures.

As a consequence, the user will be able to interact remotely with the engineers at all times, setting new priorities when required and providing feed-back on a continuous basis.

For this purpose the AESP for special foundations will act as a front-end with the remote designer, showing to the client a Web page resident on the site of the remote consultant and containing information about the current status of the project, the available preliminary results and the design choices made so far. The client can interact with the remote consultant by giving his feedback and setting possible priorities for the following phases.

3 THE QUALITY ASSURANCE ASPECT

Quality represents a key issue for consulting services in the engineering field. Normally the client is only provided with a stamp on the technical report ensuring that the standard quality procedures have been applied during the course of the consulting activities. Moreover the consulting company needs to be certified by a Quality Certification Authority.

For the remote consulting scheme that we are introducing some more problems arise. On the one hand a certification is necessary concerning the "human-based" consulting activity, but on the other hand the client needs also to be ensured about the quality of the on-line activities . A scheme for Quality Assurance control for semi-automated analysis has been established and will be followed for the remote consulting activities. It consists basically on a log of both the human-based and the automated activities. For hand calculations a check procedure consisting on a formal verification made by a person different from the originator will take place followed by a back-check where the originator must verify a agree on the corrections. Both operations will leave a trace on the QA Log by means of digitally signed files. For automated calculations (computer runs) also a trace will be left on the QA Log to ensure that the software used is QA Verified and that the input files or any other data file has been checked by an expert who again will leave its digital signature on the input file itself.

The remote consultant will be able to issue the final technical report only if the QA Log does not contain any non-conformities to the QA Procedures and it will be delivered to the client as part of the design documents attached to the technical report, digitally signed by the consultant's quality manager, proofing that the quality procedures have been applied during the consulting activities.

4 THE LEGAL ASPECTS

One of the key issues that could be raised against the remote consulting scheme concerns the legal implications both for liability and contractual issues. Traditionally a standard contract adapted to the needs of the specific project would be sent to the client for signature. The client would sign it and send it back to the consulting company.

This process could be highly facilitated by exploiting the results of the research project eLEGAL (Hassan et. al. 2001) using a newly developed software tool for legally valid contract negotiation. In eLEGAL the legal infrastructure among the players that through ICT want to establish a legally valid contractual framework for a Design and/or Construction project has been investigated and a Contract Negotiation Tool has been developed (Figure 7) for establishing a line of communication between the parties (the consultant and the client in a ICT environment) in order to agree on a common line of rights and duties. The contractual issues have also been studied in Carter et al. (2002).

By means of this tool, which can be used in connection with the AESP, it is possible for the two parties to really negotiate and eventually sign every clause of a consulting contract, in order to ensure that the remote consulting activity does not differ by any means, from the contractual standpoint, from a traditional "contact-based" consulting.

In our case the client could require to the Central Design Office (the remote consultant), through the AESP channel, services related for instance to seismic hazard. He could be located in a different part of the world with respect to the Central Design Office and therefore a solely remote approach may take place between the two parties, as far as contractual issues are concerned. The new concept on "e-Contracting" comes into play.

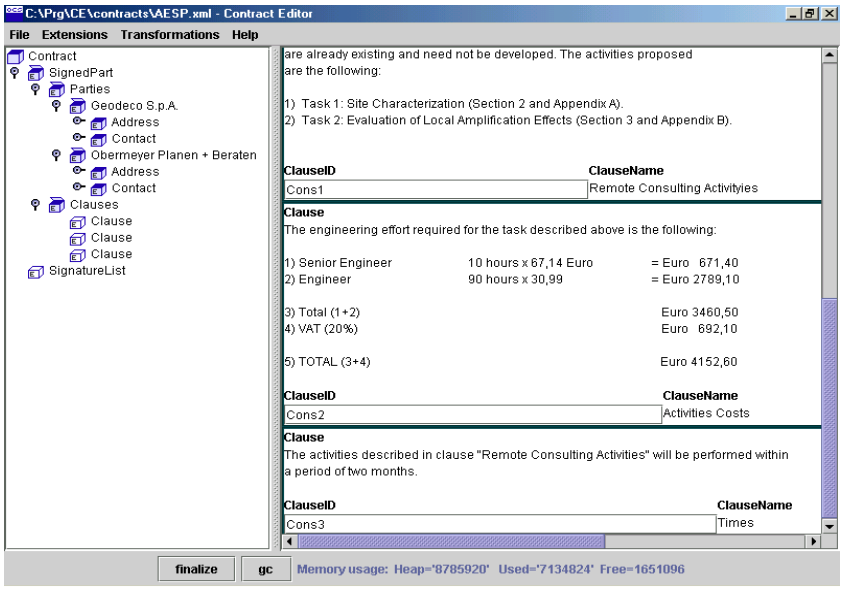

FIG. 7: The Contract Negotiation Tool Screen

E-Contracting is the IT-supported creation, negotiation, closing and performance of contracts. E-Contracts can drastically help accelerate the contracting process since they overcome media breaks and lengthy process wait states. E-Contracting is the process of setting-up, negotiating, signing, and maintaining contracts purely in electronic form. e-Contracting may require electronic signatures or not, it may take place implicitly by receiving a receipt after a retail transaction, it may involve two or many parties and it may consist of a single contract or a set of them – in any case, e-Contracting leads to a legal contractual situation.

E-Contracting affects very different aspects of business life: it is not only an economic act but also a collaboration of two or more parties. It starts with the selection of business partners over the negotiation of positions and modalities and does not even end with the final signing of a document. In many business relations, a contract is not engraved in stone – it is rather the basis for further refinements, amendments or extensions as the business relation develops its own dynamics. Digital signature on the reporting documents moreover ensure also the necessary responsibility tracking and consequent liability from the consultant side.

The whole contractual issues may be finalized by means of this Contract Negotiation Tool, in an extremely short time, which is crucial for services which may be required on a very short notice.

5 INSIGHTS AND LESSON LEARNED

What have we learned from this experience? First of all that remote consulting, a novel concept and method of working for high level professionals is possible. Infrastructures are needed of course for establishing a line of communication between the client and the consulting office and for contractual as well as legal issues. Still much work needs to be done in order to enhance such methods and tools for remote business relationship. For instance a video conferencing facility would greatly facilitate such contacts especially when it comes to discuss results or find an agreement about time and costs of the consulting service.

The concept of eContracting goes beyond our purposes and can be applied to any business relationship to be carried out on-line. Also we have learned that the results of EU projects can be better exploited if a clear strategy lies behind the participation in them. The synergy of such combined effort can greatly enhance the exploitable outcomes .

6 CONCLUSIONS

In this paper some of the concepts and the developments performed within the framework of the ISTforCE Project have been presented. In particular the possibility to perform remote consulting engineering services has been investigated. A prototype for providing on-line two different kind of consulting services has been developed also taking into account the results coming from the eLEGAL Project.

An Automatic Engineering Service Provider (AESP) was conceived and implemented in order to enhance the capabilities of civil engineers by providing specialist consulting services to cover lack of specific knowledge in particular fields. Two services were implemented covering the fields of seismic risk assessment and special foundation design. Approaches were also investigated in order to consider the Quality Assurance aspects as well as the legal problems arising in the remote consulting scheme proposed herein.

The results obtained were encouraging showing that such new approach of remote business relationship is possible also for professions where legal and contractual issues could be crucial. In the engineering field in particular such approach can result as a valuable means for widening the potential market for providers of high level content services like specialist in specific fields of engineering. The experience will keep growing as soon as the Seismic Risk Assessment service will be offered on-line.

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