# An Internet-Enabled Software Framework for Collaborative Development of Structural Analysis Program

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## Introduction

Finite element programs are typically run on a dedicated computer, with only those elements and analysis algorithms that are included in the programs. In this work, we propose a collaborative framework that can be employed to extend a finite element program to allow elements or algorithms to be dynamically linked to the finite element program during runtime. This paper describes an open framework that enables the online utilization and the collaborative development of structural analysis programs (Peng and Law 2000, Peng et al. 2000).

## Principal Concepts

The system architecture of the Internet-enabled framework is schematically depicted in Figure 1. In this framework, new element and material technologies, together with new solution and analysis strategies, can be brought into the *Analysis Core* module to enhance the functionality of the core FEM program. The *User-Interaction* module is deployed to provide web-based or MATLAB-based interfaces to facilitate the interaction between the collaborative framework and the users. The *Registration and Naming Service* is provided for on-line services to register to the core so that these services can be dynamically linked during analysis. The *Database Interface* is provided to support efficient data access and to enable post-processing tasks. One of the salient features of the collaborative framework is to support analysts to integrate new element technologies and material models with the core server. There is a standard interface for communicating the element with the analysis core. Two approaches are provided for remote access to the element services residing in different locations. The *Distributed Element Service* is intended to provide a communication link to remote element services. The *Dynamic Linked Element Service* is implemented to dynamically load the element code from a remote site and to link and bind the code with the core during runtime. Although there are three types of element services (static element library and two forms of on-line element services), the selection and binding of element services are automatic and transparent to the end users.
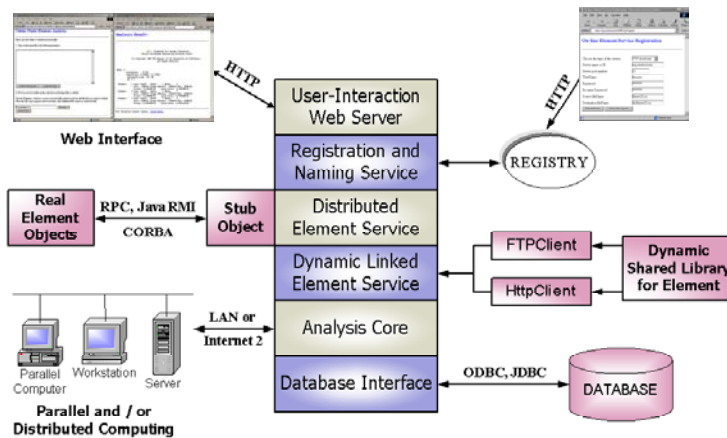


Figure 1. Collaborative System Architecture

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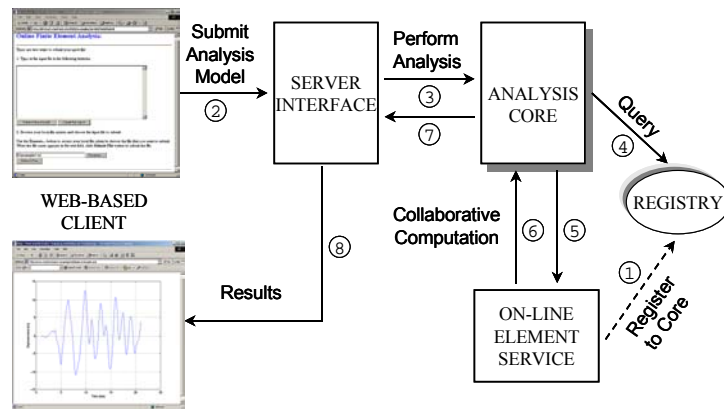[2] Professor, Stanford University, Stanford, CA.

Figure 2. Mechanics of the Collaborative Model

The mechanics of the system is illustrated in Figure 2. Users interact with the analysis core via a web-browser or an application program. Users can submit the analysis model as well as query and view the analysis results, using the Internet as a communication channel. The analysis core server performs an analysis in a distributed and collaborative manner, and if necessary, dynamically links on-line element services.

A data management system module has been designed to facilitate the retrieval of analysis results and to support project management. In this design, only selected analysis results are stored. More specifically, the state information, instead of all the analysis results, is saved in specified intervals. The saved state information will be sufficient to restore the domain to any particular time step. In addition, a data query language is designed to retrieve the data, which can in turn be processed using other application programs, such as MATLAB.

## Summary and Conclusions

- The main design principle of the collaborative framework is to keep the kernel flexible and extendible. By providing a component-based modular infrastructure, services can be added or updated without recompilation or reinitialization of the existing services.
- The platform provides a means of distributing services in a modular and systematic way. It provides a way to integrate legacy code as one of the modular services in the infrastructure.
- The framework alleviates the burden of managing a group of developers and their source code. The communication is based on the defined common protocol.
- The database facility can enhance the retrieval of analysis results for post-processing by other application programs.

## Acknowledgements

## References
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