WEB-BASED SERVICES FOR FINITE ELEMENT ANALYSIS

by

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CERTIFICATE

It is hereby certified that the thesis entitled, "**Web-Based Services for Finite Element Analysis**" being submitted by **Mr. N. Rajarathnam** to the Indian Institute of Technology, Delhi for the award of Doctor of Philosophy in Applied Mechanics Department is a record of bonafide research work carried out by him. He has worked under our guidance and has fulfilled the requirements for the submission of thesis, which, in our opinion, has reached the requisite standard.

The results contained in this thesis have not been submitted in part or full to any other University or Institute for the award of any degree / diploma.

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ABSTRACT

Web based finite element modeling and analysis services accessible from anywhere will make it cost effective and affordable to individual engineers and small scale industries. Web enabling existing applications using wrappers and middleware technologies can not bring down the premium prices of FEA packages. A new framework for providing Web based Services for Finite Element Analysis (WebFEA) has been presented with a data standard based on eXtensible Markup Language (XML), the de facto standard for Enterprise Data Interchange. An XML Schema based modular, scalable and flexible finite element modeling and analysis Markup Language (femaML) has been developed with the focus on providing Web based services for finite element analysis (FEA). The schema is suitable for representing finite element data pertaining to all stages of the three stage analysis process in a single or multiple documents. All finite element data are stored and interchanged in XML documents conforming to `femaML Schema`.

Applications for processing finite element data in XML documents have been built using two different APIs widely used in business applications for building parsers, namely, Simple API for XML (SAX) and Document Object Model (DOM). Though it is generally understood that SAX based parsers are faster than DOM based parsers, there is no quantitative study comparing the performance of the two parser applications, especially for processing engineering data in an object-oriented environment. As part of this study special purpose parsers based on SAX and DOM have been built and a comparison of performance of the two parser applications in processing finite element data has been made.

A novel approach that uses the new and emerging XML Query Language, XQuery, for processing finite element data has also been presented. The

XQuery based method of processing finite element data has been compared with the parser based methods. Three applications, based on SAX, DOM, and XQuery, have been built for the solution process that take mesh data from existing mesh generators and provide results in XML format. The three methods were compared quantitatively by solving problems of different sizes for a rectangular domain. Based on this comparative study it is found that SAX based parser is the most suitable for object-oriented FEA applications. Hence, with the SAX based parser for parsing the data and `femaML schema` for finite element data representation, an application framework for FEA has been developed. This framework has been extended to Web based FEA framework by suitable modifications and additional components to conform to the Model-View-Controller (MVC) design pattern. A prototype implementation has been presented. The Web based application has been compared with the standalone application in terms of processing time. Also, the performance of the system under multi-user environment is presented.

A new approach for visualizing finite element model data and results using Scalable Vector Graphics (SVG) on Web browsers has been presented along with the results of the prototype implementation. The SVG, being an XML application, is text based and is suitable for Web based FEA services due to its low bandwidth requirements and easy integration with other XML applications.

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