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SCALABILITY, MOBILITY AND INTERACTIVITY IN COMPUTATIONAL MECHANICS

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ABSTRACT

In this paper, the authors examine the implications of three computing concepts in the field of computational mechanics: Scalability, mobility and interactivity. The paper is timely in that these concepts are revolutionising many business sectors from online banking to travel and tourism. It is our view that they also have the potential to challenge traditional approaches to engineering simulation. To demonstrate this, the authors have developed a massively scalable, component based architecture for finite element analysis. The philosophy behind the architecture is to facilitate interaction with a running analysis, evaluating "what if?" scenarios on the fly. The software permits the user to change material properties or loading conditions and view the recomputed analysis immediately. For analyses that take too long to solve interactively on the desktop, the component based approach permits the deployment of the computationally intensive parts of the analysis on a more powerful, remote computer. The authors have used systems with up to 128 processors to interact with 3D finite element analyses of materials with complex architectures.

Scalability: With respect to the first concept, we suggest that a truly scalable computer program for computational mechanics is one that permits the user to seamlessly employ the appropriate level of computer resource for the analysis to be undertaken. At one extreme, analyses with simple physics and geometry may be executed on a handheld device such as a mobile phone. From there, we can envisage a natural progression in which a scaling of the complexity of the physical problem could be matched by the scaling of the computational resources used to solve it, eventually leading to the use of massively parallel supercomputers.

Parallel computing has been a well established activity since the early 1980s, yet it is only in recent years that commercial software vendors have provided a parallel capability in their applications. There have been many barriers to uptake, such as the poor portability of programs (until the definition of a message passing standard [1]) and

the high cost of the hardware. Nowadays hardware is very cheap and widely available, so scalable computing should now emerge as a common place activity.

Mobility: The second concept of interest is mobility. Over the past few years, there has been an unprecedented expansion of network connectivity. Although most of us access the internet several times a day, few of us give a second thought to the ability to do this from wherever we like; at work, from home, a coffee shop or the airport. What relevance does this have for computational mechanics? Networking means that computational power can be accessed remotely or purchased on demand through the Grid [2]. Mobility implies this can be done at our convenience. For example, each time we access a popular online search engine, we are benefiting from the power of remote server farms. Why not adopt the same attitude to analysis? The user interface and analysis engine need not reside on the same machine and the user need not necessarily be aware of the resources being used. SUN Microsystems saw this age of mobility coming when they adopted their catchphrase "The network is the computer" in the 1980s.

Interactivity: What are the consequences when the concepts of scalability and mobility are brought together? Our vision of the future is one in which the practitioner generates their engineering model, interacts with it and views the simulation results straight away. Software applications that are designed to be scalable from the outset will ensure that interactivity can persist as the model complexity increases, simply by leveraging more powerful compute resources as and when required. These resources may be accessed automatically by the software across the network at the user's institution or remotely through on demand subscription to a remote service. A real example of scalable, mobile and interactive computing is the Star-P application from Interactive Supercomputing Inc. This enables desktop Matlab users to speed up their analyses when necessary by seamless access to a backend compute engine running on a parallel supercomputer [3].

In summary, the authors propose three drivers that will lead to the development of scalable, mobile and interactive tools for computational mechanics: (1) Technology drivers: faster and cheaper hardware; (2) People drivers: an age of self-actualisation where today's generation live in a world of information on-demand and (3) Business drivers: faster simulation that enables companies to front load the design cycle, leading to shorter development times and higher profitability.

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