Chapter XVI

High Performance Computing, Simulation and Forest Fires

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INTRODUCTION

Forest fire are one of the most critical environmental risks in all the Mediterranean countries. The fight against these emergencies requires useful tools to predict the propagation and behaviour of forest fire in order to make the best decisions. This means it is necessary to know the propagation and behaviour of the forest fire in advance to act in the best possible way.

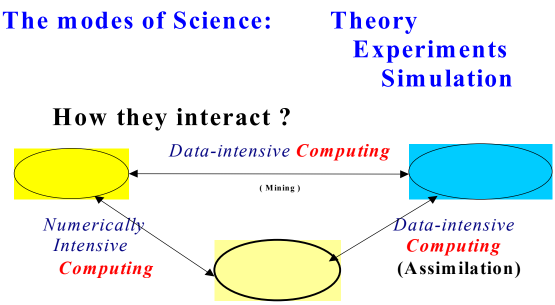
Common to realistic models of time dynamic systems is their complexity, very often prohibiting numerical or analytical evaluation. Consequently, for these cases, simulation remains the only tractable evaluation methodology, making up an attractive alternative to conventional experimental tests. In this sense, a computer can be viewed in context as an “electronic wind tunnel.”

Simulation requirements for these complex systems mean more and more computing power and storage capacity. As the volume of input (sensor) and simulation output data (visualisation) increases, large archival storage systems with rapid data retrieval play an increasingly important role.

To accomplish the above objective “to predict the propagation and behaviour of forest fire” it is necessary to apply numerical methods and algorithms that solve the proposed models. This work implies direct cooperation between forest fire researchers and computer scientists. We can infer an important principle from this situation, namely, the necessity of yoking together the computer science and application science research communities. This collaboration defines a fundamental guiding principle: the combination of application *pull* and technology *push* (Karin and Graham, 1998).

Examples of this principle can be considered in the context of “Grand Challenge” problems (NSF, 1992) such as long-range climate forecasting. The *pull* is provided by the **need** to predict events. The *push* required to accommodate and apply the huge output of the prediction is **a new** data management and visualisation system.

Figure 1. Modes of Science



Concerning the role of simulation, this can therefore be considered as the third mode of science, in addition to theory and experiments. The scheme of Figure 1 shows the relationships among the three modes. In this scheme a form of data-intensive computing, namely *data mining*, is the link between theory and experiment. Another form, *data assimilation*, links simulations and observations. And, of course, numerically intensive computing is also the bridge between theory and simulation.

As we can see from Figure 1, in addition to simulation computing requirements, computing is present in the three interactions, thus creating a demand for computing power not only because of processing speed, but for memory size and speed and data input and output rates as well.

General areas that require great computational speed include *modelling, simulation and prediction,* which often need repetitive calculations on large amounts of data to give valid results. Commonly quoted application examples include weather forecasting, economic forecasting and aerodynamic simulation for aircraft and space vehicles.

High-performance computing (HPC) systems are recognised today as an important vehicle for the solution of many problems, especially those known as the Grand Challenges. These include climate modelling, human genome mapping, semiconductor and superconductor modelling, pollution dispersion, and pharmaceutical design.

Although traditionally, high-performance computing (HPC) has been synonymous with the deployment of multimillion-dollar vector and/or parallel computers, recent advances in both microprocessor performance and network bandwidth are radically altering HPC environments. Today high-performance computing spans a broad range of systems, from our desktop computers through large parallel processing systems. For these systems, the necessity of programming multiple processors to solve a single problem adds its own set of additional difficulties for the programmer. The programmer must be aware of how multiple processors operate together, and how work can be efficiently divided among those processors.

The simulation of forest fire propagation is a complex problem that requires high performance computing capabilities to provide accurate results faster than real time. High performance computing, mainly parallel and distributed systems, provide the computing capabilities to solve this problem in a reasonable time.

The content of this introduction can be summarised along the following three main components:

a) The problem: the prediction of the Forest Fire propagation
b) The way to solve the problem: simulation

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