Advances in High Performance Computing – the IBM Perspective

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The last year has seen the installation and deployment of two systems which deliver performances above 1 PetaFlop (10^{15} floating point operations per second), and efforts targeting the next performance plateau of 1 ExaFlop (10^{18} floating point operations per second) are now underway.

Petascale performance allows development and deployment of applications which have the capability to deliver accurate modeling of complex systems in many different fields. In particular, development of computer aided engineering solutions which can accurately assess both steady state and transient phenomena relevant to design optimization and to production optimization in a variety of applications are now very attainable.

Future HPC technology however has to now address a number of fundamental physical limitations which impact performance, power, networking bandwidth and I/O bandwidth on High Performance Computing systems. To deliver performance within these fundamental physical limitations the emerging Petascale and Exascale computer architectures have very large counts of processing elements and uncomfortably small memory and network bandwidths. The consequent impact on algorithms and application development presents an interesting challenge for the algorithm developer and application programmer.

An additional element to be considered in application development for Petascale and Exascale systems is that, because these systems now provide useful capability to carry out multiscale studies on a variety of systems to do serious assessments of parameter and model dependencies in the results and to execute sensitivity analyses on the systems being studied, the application work flows which researchers and developers are seeking to deploy are now also increasingly complex.

IBM has significant experience over the last few years in building systems and developing and deploying applications solutions for the very complex systems modeling which is now becoming possible. This experience shows that, with appropriate effort, the systems, algorithm and workflow challenges emerging on Petascale and Exascale architectures can be addressed. Examples of success abound in such areas as materials modeling, computational fluid dynamics, structural analysis – all key elements in understanding Reactor Physics.

This presentation will document the emerging challenges at the systems, algorithms and workflow levels for the complex systems modeling which is now possible on Petascale and Exascale architectures, and will discuss a number of examples of successful application deployments which illustrate the approaches needed to address these challenges and deliver usable modeling tools on these systems in the future.