Benchmark Generation and Simulation at Extreme Scale

Achievement: Developed a new method for investigating the performance of parallel applications at scale on future high-performance computing architectures and the impact of different architectural choices.

Significance and Impact: This novel solution combines simulations using models of future HPC systems and communication traces of current HPC applications, such that benchmarks are automatically generated from communication traces and executed within a simulation. This technique provides a number of benefits, such as eliminating the data intensive trace replay, enabling simulations at different scales and obfuscating proprietary application implementation details.

Research Details:

- Developed the ScalaTrace II tool to extract scalable communication traces from parallel applications.
- Developed the ScalaBenchGen II tool to automatically generate skeleton benchmarks from ScalaTrace II communication traces.
- Improved the Extreme-Scale Simulator (xSim) tool to execute the generated benchmarks efficiently within a simulated HPC system.
- Performed experimental evaluation by comparing the performance of parallel applications with the benchmarks on the HPC system they were generated on and with simulated HPC systems.

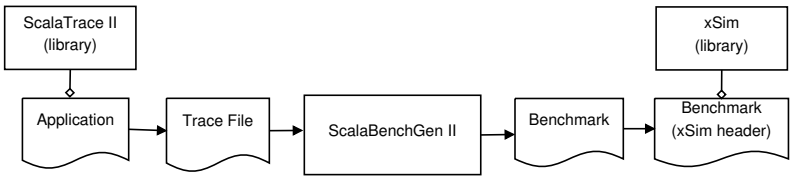

Figure 1: Benchmark Generation and Simulation

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PI and affiliation: Christian Engelmann – Computer Science and Mathematics Division (CSMD), Oak Ridge National Laboratory (ORNL)

Team: Mahesh Lagadapati (NCSU), Frank Mueller (NCSU), and Christian Engelmann (ORNL)

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Overview:

Investigating the performance of parallel applications at scale on future architectures and the performance impact of different architectural choices is an important component of HPC hardware/software co-design. Simulations using models of future HPC systems and communication traces from applications running on existing HPC systems can offer an insight into the performance of future architectures. Instead of simply replaying a trace within a simulator, this work promotes the generation of a benchmark from traces. This benchmark is subsequently exposed to simulation using models to reflect the performance characteristics of future-generation HPC systems. This technique provides a number of benefits, such as eliminating the data intensive trace replay and enabling simulations at different scales. This work features novel software

co-design aspects, combining the ScalaTrace tool to generate scalable trace files, the ScalaBenchGen tool to generate the benchmark, and the xSim tool to assess the benchmark characteristics within a simulator.