The design of high-performance computing architectures requires performance analysis of large-scale parallel applications to derive various parameters concerning hardware design and software development. The process of performance analysis and benchmarking an application can be done in several ways with varying degrees of fidelity. One of the most cost-effective ways is to do a coarse-grained study of large-scale parallel applications through the use of program skeletons. In this work, we develop a semi-automatic approach for extracting program skeletons based on compiler program analysis. We demonstrate correctness of our skeleton extraction process as well as show the performance speedup of using skeletons by comparing trace files derived from executing a large-scale parallel program and its program skeleton on the SST/macro simulator.