Computers and Information Sciences
Compute Process Allocator

Sandia's innovative solutions maximize throughput in parallel supercomputers

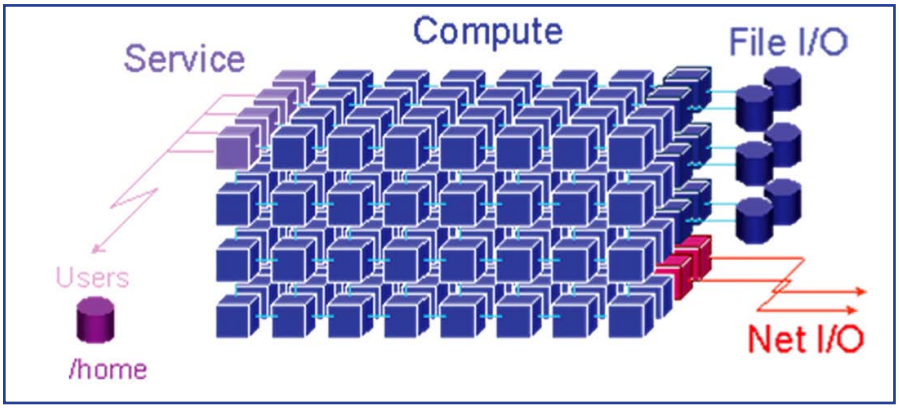

Figure 1: Parallel Supercomputer

CPA's optimized node allocation strategy wins a prestigious 2006 R&D award

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In collaboration with researchers from the State University of New York-Stony Brook and the University of Illinois, Urbana-Champaign, Sandia has developed an innovative solution to resource allocation for parallel processing on supercomputers (Figure 1). The Compute Process Allocator (CPA) uses a space-filling curve to reorder a network of processors so that locations remain close in the physical network of processors after reordering (Figure 2). It also uses Best Fit packing (Figure 3, next page), for contiguous allocation and span minimization for non-contiguous allocation. In experiments, the optimized node allocation strategy employed by CPA increased throughput by 23%, thus processing five jobs in the time it takes to process four. The CPA is distributed and scales to over 10,000 nodes while non-distributed allocators scale to 4,096 nodes.

For its superior strategy and scalability over other allocators, the CPA won a prestigious 2006 R&D 100 Award. The CPA's innovative solution was carried to the commercial sector in 2005 when CPA was licensed to Cray Inc. The breadth of impact has been extended through software licensing to numerous laboratory and research centers that bought XT3 systems from Cray. The CPA (at less than one percent of the cost of a parallel computer) is an example of how a relatively small investment in computer algorithms can dramatically leverage the return on a large investment in computer hardware.

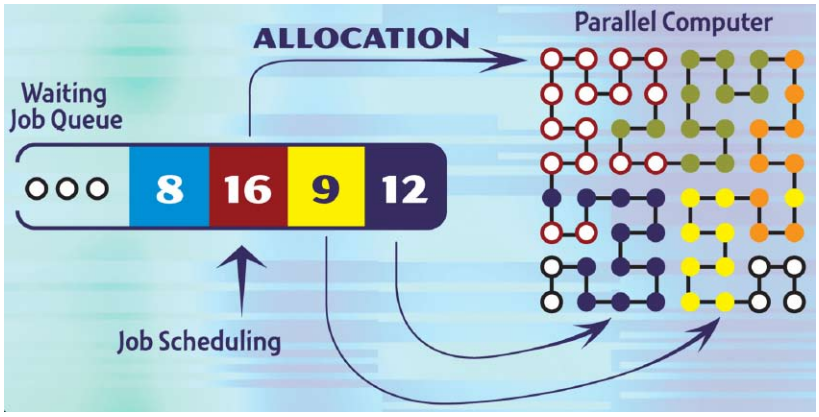

Figure 2. CPA with Hilbert Space-Filling Curve and Span Minimization.

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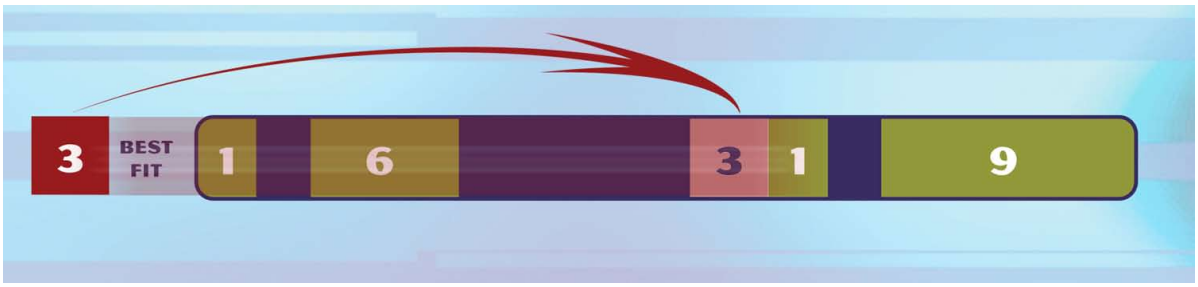

Figure 3. Best Fit Packing

Sites with supercomputers using CPA include:

- Sandia (Red Storm and C-Plant)
- Oak Ridge National Laboratory
- U.S. Army Engineer Research and Development Center
- U.S. Army High Performance Computing Research Center
- UK Atomic Weapons Establishment
- Pittsburgh Supercomputing Center
- Japan Advanced Institute of Science and Technology
- RIKEN Advanced Center for Computing and Communication in Japan.
- Swiss Scientific Computing Center

Publications related to the CPA:

V.J. Leung, E.M. Arkin, M.A. Bender, D.P. Bunde, J. Johnston, A. Lal, J.S.B. Mitchell, C. Phillips, and S.S. Seiden, "Processor Allocation on Cplant: Achieving General Processor Locality Using One-Dimensional Allocation Strategies," 2002 IEEE International Conference on Cluster Computing.

V.J. Leung, C.A. Phillips, M.A. Bender, and D.P. Bunde, "Algorithmic Support for Commodity-Based Parallel Computing Systems," Sandia Report SAND2003-3702, 2003.

D.P. Bunde, V.J. Leung, and J. Mache, "Communication Patterns and Allocation Strategies," 3rd International Workshop on Performance Modeling, Evaluation, and Optimization of Parallel and Distributed Systems, 2004.

M.A. Bender, D.P. Bunde, E.D. Demaine, S.P. Fekete, V.J. Leung, H. Meijer, and C.A. Phillips, "Communication-Aware Processor Allocation for Supercomputers," 9th Workshop on Algorithms and Data Structures, 2005.

Quotes on the R&D 100 Awards and the CPA, in particular:

"I congratulate the researchers who have won these awards, which highlight the power and promise of DOE's investments in science and technology. Through the efforts of dedicated and innovative scientists and engineers at our national laboratories, DOE is helping to enhance our nation's energy, economic and national security." (Samuel W. Bodman, Secretary of Energy).

"At a time when some question whether or not their tax money is delivering results... a time when a few even question the relevance of scientific research in their everyday lives... the R&D 100 Awards serve to recognize excellence, innovation and relevance." (David Garman, Former Acting Under Secretary, U.S. Department of Energy).

"The increased throughput of twenty-three percent that 'CPA' allows and the capability of being scalable to tens of thousands of processors is very impressive. Many prestigious computing centers are already realizing the great benefits of 'CPA'. This well-deserved recognition is an excellent reminder that our laboratories are outstanding science and technology resources for the Nation." (Linton F. Brooks, Former Administrator, National Nuclear Security Administration).

"Congratulations to you and your Sandia colleagues who teamed to win an R&D 100 Award for the project Compute Process Allocator (CPA). I am sure fellow Sandians are very proud of your achievement." (Thomas O. Hunter, President and Laboratories Director).

"These are coveted awards and you should be extremely proud." (Rick Stulen, Chief Technology Officer).

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National Nuclear Security Administration