Japan Academy Prize to:

Genki YAGAWA
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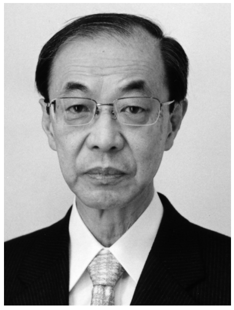
Emeritus Professor, The University of Tokyo

and

Tadashi WATANABE
Project Leader, Next-Generation Supercomputer R&D Center, RIKEN



for "Studies on Computational Science of Large Scale with High Accuracy"

Outline of the work:

The theoretical and experimental approaches were the only two methods available for solving various science/technology problems up until the middle of the last century. In later decades, a new approach called the computational method, typified by computational mechanics, emerged as the third method along with progress in high-speed computers. The success of this approach in science and technology depends strongly upon the development of state-of-the-art software and computer hardware. Against this background, Dr. Genki Yagawa has created new methodologies for solving computational mechanics problems of ultra-large scale with high accuracy, whereas Dr. Tadashi Watanabe has laid the foundations for building an architecture for world-class supercomputers.

Dr. Yagawa developed a new massively parallel computing method, which employs hierarchical domain decomposition and variational methods to satisfy the boundary conditions between sub-domains. This new method was able to solve a thousand times larger problems than previously possible with high accuracy and high performance. In other words, the world largest problems of computational mechanics could be solved when software based on this method was employed. The engineering applications of computational mechanics include numerical fracture mechanics problems for nuclear pressure vessel integrity under severe loading conditions. Dr. Yagawa created a new method for such computational mechanics called the Free Mesh Method. With the amazing progress being made in computers, the finite element method (FEM) has become widely used in many practical situations. There exists, however, a large gap between its use in industrial applications and in fundamental scientific research. One reason for this is the difficulty in pre-processing FEM, i.e. mesh generation. Generating mesh is a very difficult task if the degree-of-freedom in the analysis model is extremely large or if the geometry of the domain is very complex. With the new method, both pre-processing and main-processing in finite element analysis can be parallelized in terms of nodes, where pre-preprocessing involves generating local mesh and constructing a system of equations, and main-processing involves solving the system of equations. This method is well-suited for massively parallel environments. The above-mentioned methods developed by Dr. Yagawa have been embedded within such internationally well-known software as MARK, ADVENTURE and GeoFEM, which have been used by thousands of researchers and engineers worldwide. In addition to these scholarly achievements, he has contributed significantly to the development of the academic community in this field.

Dr. Watanabe developed a fundamental computer architecture for achieving ultra-high performance in the supercomputers that have provided an R&D infrastructure for computational science and engineering. His research realized a supercomputer that achieved over 1 Giga-flop of speed for the first time 1985 in the world. His Earth Simulator held the record for fastest speed every three to five years to June 2002. The major characteristics of his architecture include

(1) RISC (Reduced Instruction Set Computer) architecture, which is the basic architecture of current microprocessors,
(2) multiple and parallel vector pipelined arithmetic units introduced to process a large quantity of data at very high speed, and
(3) vector arithmetic registers and programmable vector caches with variable length employed to access vector data at high speed.

This architecture was developed for general purpose high-performance computers and aimed at broad application areas in computational science and engineering, differing from application-specific computers like those for many-body problems employed in astronomy and molecular dynamics. The supercomputers and the Earth Simulator, based on architecture researched and developed by Dr. Watanabe, have been globally installed, providing a research infrastructure universally used in the fields of climate and environment, aero-space, atomic energy, material design, life science, and automotive and other industries. In particular, the Earth Simulator achieved five times higher performance than the fastest supercomputer at that time, and has enabled remarkable achievements in its applications to climate prediction ramified by global climate change, weather prediction such as the course of typhoons, analysis of the earth's crust, simulation of earthquakes and tsunami, and material development such as carbon nano-tubes. Hence, Dr. Watanabe has made remarkable contributions to advancing computational science and engineering.

In summary, Dr. Yagawa and Dr. Watanabe have both made remarkable research advances in computational science and engineering, especially in the analysis of large-scale and complex problems with high accuracy. For their contributions toward these achievements, they have received the following awards: Dr. Yagawa has received 25 awards including the IACM Computational Mechanics Award, Cray Gigaflops Award, Zienkiewicz Medal and Japanese Prime Minister's Award. Dr. Watanabe has received the ACM/IEEE Eckert-Mauchly Award, IEEE CS Seymour Cray Award, and JSCES Distinguished Contribution Award.

Major Publications by Dr. G. Yagawa (Selected from 386 papers)

1. G. Yagawa and S. Yoshimura, Computational Solid Mechanics, Iwanami Publ. Co., 2005 (in Japanese).
2. G. Yagawa, H. Homma and D. A. Shockey (Eds.), Dynamic Fracture Mechanics for the 1990's, ASME PVP Series, Vol. 160, 1989.
3. G. Yagawa, T. Aizawa, Y. Ando, Linear and Nonlinear Elastic Analysis of Cracked Plate: Application of a Penalty Function and Superposition Method, International Journal for Numerical Methods in Engineering, Vol. 17, 719–733, 1981.
4. G. Yagawa, Y. Takahashi, H. Ueda, Three-Dimensional Fully Plastic Solutions for Plates and Cylinders with Through-Wall Cracks, Trans. of ASME, Journal of Applied Mechanics, Vol. 52, 319–325, 1985.

5. G. Yagawa, N. Soneda, S. Yoshimura, A Large Scale Finite Element Analysis Using Domain Decomposition Method on a Parallel Computer, Computers and Structures, Vol. 38, 615–625, 1991.
6. G. Yagawa, S. Yoshimura, Y. Mochizuki, T. Oishi, Identification of Crack Shape Hidden in Solid by Means of Neural Network and Computational Mechanics, Inverse Problems in Engineering Mechanics, Proc. of International Union of Theoretical and Applied Mechanics (IUTAM) Symposium, 213–222, 1993.
7. G. Yagawa, A. Yoshioka, S. Yoshimura, N. Soneda, A Parallel Finite Element Method with a Supercomputer Network, Computers and Structures, Vol. 47, 407–418, 1993.
8. G. Yagawa, T. Yamada, Free Mesh Method: A New Finite Element Method, Computational Mechanics, Vol. 18, 383–386, 1996.
9. G. Yagawa, Y. Nakabayashi, H. Okuda, Large-Scale Finite Element Fluid Analysis by Massively Parallel Processors, Parallel Computing, Vol. 23, 1365–1377, 1997.
10. G. Yagawa, Parallel Computing of Local Mesh Finite Element Method, Computational Mechanics – New Frontiers for New Millennium, Vol. 1, Elsevier, 17–26, 2001.
11. G. Yagawa, Node-by-Node Parallel Finite Elements: A Virtually Meshless Method, International Journal for Numerical Methods in Engineering, Vol. 60, 69–102, 2004.
12. G. Yagawa, T. Miyamura, Three-node Triangular Shell Element Using Mixed Formulation and Its Implementation by Free Mesh Method, Computers & Structures, Vol. 83, 2066–2076, 2005.

Major Publications by Dr. T. Watanabe

1. T. Watanabe, “Mechanism of Pipeline System,”Supercomputer-Present and Future-, Edited by Physics Society of Japan, Baifukan, pp. 19–28, 1984 (In Japanese).
2. T. Watanabe, H. Katayama and A. Iwaya, “Introduction of NEC Supercomputer SX System,” Supercomputers, Class VI systems, Hardware and Software, pp. 153–167, S. Fernbach (Ed.), Elsevier Science Publishers B. V., Amsterdam, 1986.
3. T. Watanabe, “Advanced Architecture and Technology of the NEC SX-3 Supercomputer,” NATO ASI Series, Vol. F62, Supercomputing, Edited by J. S. Kowalik, Springer Verlag ’90, pp. 119–128, 1990.
4. T. Watanabe and A. Iwaya, “The NEC SX-3 Supercomputer Series,” High Performance Computing, Research and Practice in Japan, pp. 21–33, R. Mendez(Editor), John Wiley & Sons, 1992.
5. T. Watanabe, “NEC SX-3 Supercomputer System,” Supercomputers and Their Performance in Computational Fluid Dynamics, Vol. 37, pp. 63–75, Vieweg, 1993.
6. T. Watanabe, T. Furukatsu, R. Kondo, T. Kawamura and Y. Izutani, “The Supercomputer SX System: An Overview,” Proc. of the 2nd International Conference on Supercomputing, pp. 51–56, 1987.
7. T. Watanabe, “Architecture and Performance of NEC Supercomputer SX System,” Parallel Computing 5, pp. 247–255, North-Holland, 1987.
8. T. Watanabe, “Supercomputer NEC SX System,” Journal of Information Processing Society of Japan, Vol. 29, No. 12, pp. 1530–1534, 1988 (in Japanese).
9. T. Watanabe, H. Matsumoto and P. D. Tannenbaum, “Hardware Technology and Architecture of the NEC SX-3/SX-X Supercomputer System,” Supercomputing ’89, Reno, Nevada, 1989.
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11. T. Watanabe, “NEC Supercomputer SX-3R Series,” Journal of System/Control/Information, Vol. 36, No. 8, pp. 44–46, 1992 (In Jpanaese).
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