Scalable Domain Decomposition Methods for Large Scale Simulations

Xiao-Chuan Cai
University of Colorado at Boulder, USA

Abstract
Computer simulations of many interesting physical phenomena require the numerical solution of systems of partial differential equations. This includes, for example, the modeling of the climate, the modeling of fluid flows around air planes or in the human body. One of the key elements of simulation technologies is the design and implementation of algorithms and software that are scalable for massively parallel computers. In this talk, we discuss some domain decomposition methods, which is a class of divide-and-conquer methods for solving mathematical problems defined on a physical domain for large-scale simulations on massively parallel, distributed memory computers. The focus is on several recently developed domain decomposition algorithms that exhibit linear, and sometimes super-linear, scalability for solving complex coupled multi-physics problems on machines with large number of processors.

Short Biography
Xiao-Chuan Cai is Professor and Department Chair of Computer Science at the University of Colorado at Boulder. He received his PhD from Courant Institute of Mathematical Sciences, New York University, in 1989. His research interests include parallel algorithms and high performance software for numerical solution of partial differential equations, domain decomposition methods, multigrid methods, numerical linear algebra, PDE constrained optimization, inverse problems, stochastic partial differential equations, computational fluid dynamics, computational plasma physics, and computational biomechanics.
Four Important Concepts to Consider when Using Computing Clusters and Grids

Jack Dongarra
University of Tennessee
Oak Ridge National Laboratory
University of Manchester
USA

Abstract
In this talk we examine how high performance computing has changed over the last 10-year and look toward the future in terms of trends. These changes have had and will continue to have a major impact on our software. Some of the software and algorithm challenges have already been encountered, such as management of communication and memory hierarchies through a combination of compile--time and run--time techniques, but the increased scale of computation, depth of memory hierarchies, range of latencies, and increased run–time environment variability will make these problems much harder.

We will look at four areas of research that will have an importance impact in the development of software.

We will focus on following themes:
- Redesign of software to fit multicore architectures
- Automatically tuned application software
- Exploiting mixed precision for performance
- The importance of fault tolerance

Short Biography
Jack Dongarra received a Bachelor of Science in Mathematics from Chicago State University in 1972 and a Master of Science in Computer Science from the Illinois Institute of Technology in 1973. He received his Ph.D. in Applied Mathematics from the University of New Mexico in 1980. He worked at the Argonne National Laboratory until 1989, becoming a senior scientist. He now holds an appointment as University Distinguished Professor of Computer Science in the Computer Science Department at the University of Tennessee and holds the title of Distinguished Research Staff in the Computer Science and Mathematics Division at Oak Ridge National Laboratory (ORNL), Turing Fellow at Manchester University, and an Adjunct Professor in the Computer Science Department at Rice University. He is the director of the Innovative Computing Laboratory at the University of Tennessee. He is also the director of the Center for Information Technology Research at the University of Tennessee which coordinates and facilitates IT research efforts at the University.

He specializes in numerical algorithms in linear algebra, parallel computing, the use of advanced-computer architectures, programming methodology, and tools for parallel computers. His research includes the development, testing and documentation of high quality mathematical software. He has contributed to the design and implementation of the following open source software packages and systems: EISPACK, LINPACK, the BLAS, LAPACK, ScaLAPACK, Netlib, PVM, MPI, NetSolve, Top500, ATLAS, and PAPI. He has published approximately 200 articles, papers, reports and technical memoranda and he is coauthor of several books. He was awarded the IEEE Sid Fernbach Award in 2004 for his contributions in the application of high performance computers using innovative approaches and in 2008 he was the recipient of the first IEEE Medal of Excellence in Scalable Computing. He is a Fellow of the AAAS, ACM, and the IEEE and a member of the National Academy of Engineering.
Petaflops Computing: Challenges and Opportunities

Jianping Fan
Shenzhen Institute of Advanced Technology (SIAT), Chinese Academy of Sciences, China

Abstract
A few years ago, petaflops computing appears to be an unreachable dream. While this year in June, IBM introduced its Roadrunner, petaflops computing have become a reality. Today, China's petaflops computing construction has been put on the agenda. Shenzhen will be deployed petaflops computing environment in 2010.

Rapid urbanization and industrialization are two basic characterizations in China's development, which are also the opportunities for petaflops computing. The application of petaflops computing will accelerate the development of industry informatization, city digitization, urban management, information processing and sharing, environmental protection and resource utilization, and will make a great contribution to China's whole economic and social development.

However, petaflops computing also faces some fundamental challenges, such as the highly scalable parallel algorithm design, the efficient parallel programming model, many-core computing, and so on. To be brief, algorithms and applications will be the two key points which will decide that whether petaflops computing will be fully utilized.

Facing the challenges on digital city and industrial informatization, Institute of advanced computing and digital engineering(IACDE), Shenzhen institute of Advanced Technology will focus on high-performance computing, and strive for China 's petaflops computing development.

Short Biography
Dr. Fan Jianping received his BS degrees from NanKai University in 1984, and received his PhD degree in Institute of Software (IOS), Chinese Academy of Sciences (CAS) in 1990. He worked at institute of computing technology from 1990 to 2006, where he served as deputy chief engineer of national research center for intelligent computing systems, director of National Engineering Center on High Performance Computing, vice Director of institute of computing technology. Since 2006, he served as Director of Shenzhen Institute of Advanced Technology, CAS.

Dr. Fan's research interests include high performance computing, Grid computing, and computer architecture. He took part in and developed Dawning I, Dawning 1000, Dawning 3000, Dawning 4000 and other series of Dawning supercomputers. He has published more than 70 papers and 1 book. He also acquired 11 pending or issued patents. Dr. Fan has received many awards, such as outstanding award of CAS science and technology progress, first price of national science and technology progress, first price of Beijing science and technology progress, and the outstanding young scientist of CAS.

Dr. Fan has actively participated in various professional activities. He served as editor of journal of computer research and development, joint professor in Nankai University, council member of china digital library consultant committee, Advisor of 11th five years science and technology development plan of ministry of information industry, and general chair of HPC China2007 and GCC2008.
Integrating Parallel and Distributed Computing Across Scientific and Web 2.0 Applications

Geoffrey Charles Fox
Indiana University, USA

Abstract
Distributed computing is changing with grids, clouds and Web 2.0 data intensive computing. At the other end of the spectrum we find individual multicore chips that offer a "Grid on a Chip". We have a variety of runtimes including inter-service messaging, Hadoop, publish-subscribe, MPI and threading. These have different latencies, quality of service, flexibility and ease of use. We have programming models including service oriented architectures, workflow, mash-ups, MapReduce and various data-parallel paradigms. We compare these approaches on distributed and parallel systems for data analysis applications in bioinformatics and particle physics. We suggest that integration of these ideas and software environments from different sources will enable a new generation of high performance, user friendly fault tolerant programming environments.

Short Biography
Fox received a Ph.D. in Theoretical Physics from Cambridge University and is now professor of Computer Science, Informatics, and Physics at Indiana University where he is director of the Community Grids Laboratory. He is chief technology officer for Anabas Inc. He previously held positions at Caltech, Syracuse University and Florida State University. He has supervised the PhD of 58 students and published over 600 papers in physics and computer science and currently works in applying computer science to Defense, Earthquake and Ice-sheet Science and Chemical Informatics. He is involved in several projects to enhance the capabilities of Minority Serving Institutions.
Network Computing: From Service Grid to Virtual Computing Environment

Jinpeng Huai
Beihang University, China

Abstract

In the past years many network computing paradigms, such as Grid Computing, P2P Computing, Pervasive Computing, have emerged, promising to enable resource sharing and collaborating across multiple domains. As one of the most important solutions, Grid computing provides the ability to gain access to data, processing power, storage capacity and a vast array of other resources over the Internet. As a practice of Service Oriented Architecture in grid computing, Service Grid has been adopted both in business and academy, and widely used in e-Science communities such as High Energy Physics, Bioinformatics, Atmosphere Physics, etc. New internet based application patterns such as SaaS (Software as a Service), HaaS (Hardware as a Service) become the key driven power for the next generation of network computing. More flexible, transparent and trustworthy resource management mechanisms are required. Beihang University has been engaged in Grid computing and Virtual Computing Environment research for years. We have proposed a service grid suite named CROWN as well as a distributed Grid testbed covering 41 sites in China, UK, Australia and American. Based on this, we have been working on CIVIC, a hypervisor based virtual computing infrastructure, to improve resource utilization by providing an integrated operating platform for users and applications.

Short Biography

Professor and Vice President of Beihang University, China. He serves on the China Computer Federation as Vice President and the IT Domain Steering Committee of the National High-Tech Program (863) as Chief Scientist, and chaired the 26th IEEE SRDS and the 17th WWW.

His research interests include Internet-oriented software, distributed computing and trustworthiness. He has published over 100 papers, received 19 patents, and won 2 the National Second Awards of the Scientific and Technological Innovation.
Virtualization Technology for Computing System: Opportunities and Challenges

Hai Jin
Huazhong University of Science and Technology, China

Abstract

Virtualization technology has attracted much attention in recent years. In this talk, I will describe the vision and mission of the national fundamental research program for virtualization technology in China. Furthermore, related topics about single host virtualization, multiple VM management schemes and desktop virtualization will be introduced. I will first describe a remote memory virtualization scheme and a VCPU management scheme for efficient use of physical resource. Then I describe a novel live VM migration approach based on deterministic replay with execution trace. Multiple VM management schemes are also introduced for multi-VM virtualization. In desktop virtualization field, I will present the LVD, a system that combines the virtualization technology and inexpensive personal computers to realize a lightweight virtual desktop system. All of those schemes and systems are good practices of virtualization solution and they have become a strong foundation of our future work.

Short Biography

Hai Jin is a professor of computer science and engineering at the Huazhong University of Science and Technology (HUST) in China. He is now Dean of the School of Computer Science and Technology at HUST. Jin received his PhD in computer engineering from HUST in 1994. In 1996, he was awarded a German Academic Exchange Service fellowship to visit the Technical University of Chemnitz in Germany. Jin worked at The University of Hong Kong between 1998 and 2000, and as a visiting scholar at the University of Southern California between 1999 and 2000. He was awarded Excellent Youth Award from the National Science Foundation of China in 2001. Jin is the chief scientist of ChinaGrid, the largest grid computing project in China.

Jin is a senior member of the IEEE and a member of the ACM. Jin is the member of Grid Forum Steering Group (GFSG). He has co-authored 15 books and published over 300 research papers. His research interests include computer architecture, virtualization technology, cluster computing and grid computing, peer-to-peer computing, network storage, and network security.

Jin is the steering committee chair of International Conference on Grid and Pervasive Computing (GPC), Asia-Pacific Services Computing Conference (APSCC). Jin is a member of the steering committee of the IEEE/ACM International Symposium on Cluster Computing and the Grid (CCGrid), the IFIP International Conference on Network and Parallel Computing (NPC), and the International Conference on Grid and Cooperative Computing (GCC), International Conference on Autonomic and Trusted Computing (ATC), International Conference on Ubiquitous Intelligence and Computing (UIC).
Virtual Organizations By the Rules

Carl Kesselman

University of Southern California/Information Sciences Institute, USA

Abstract

Increasingly, collaborative activities in science are using the concept of virtual organization as an organizing principle. One benefit of viewing these collaborations from an organizational perspective is that there is a long history of studying how organizations can be structured to function effectively. Many of these organizational principles have been reflected in the design of enterprise architectures and the use of service oriented architecture concepts as an implementation vehicle for capturing these organizational constructs.

One approach to meeting organizational requirements in systems architecture has been to express organizational structure in terms of business roles, business processes and business rules. To date however, this type of analysis and associated infrastructure tools has not been applied in any consistent way to the concept of virtual organizations and their associated scientific applications. In my talk, I will explore these established approaches to business IT systems and their applicability to the virtual organizations that are being created to support scientific endeavors. As an example, I will describe how data management policies for virtual organization can be expressed as business rules, and implemented via existing business rules engines.

Short Biography

Carl Kesselman is a Professor in the departments of Industrial and System Engineering and Computer Science in the School of Engineering at the University of Southern California. Dr. Kesselman is also a Fellow in the Information Sciences Institute where he is the co-director of the Medical Information Systems Division. He received a Ph.D. in Computer Science from the University of California, Los Angeles, a Master of Science degree in Electrical Engineering from the University of Southern California, and Bachelors degrees in Electrical Engineering and Computer Science from the University at Buffalo. Dr. Kesselman also serves as Chief Scientist of Univa Corporation, a company he founded with Globus co-founders Ian Foster and Steve Tuecke.

Dr. Kesselman’s current research interests are focused on the applications of distributed computing technology to Medical Informatics. In addition, he is interested in all aspects of Grid computing, including basic infrastructure, security, resource management, high-level services and Grid applications. He is the author of many significant papers in the field. Together with Dr. Ian Foster, he initiated the Globus Project™, one of the leading Grid research projects. The Globus project has developed the Globus Toolkit®, the de facto standard for Grid computing.

Dr. Kesselman received the 1997 Global Information Infrastructure Next Generation Internet award, the 2002 R&D 100 award, the 2002 R&D Editors choice award, the Federal Laboratory Consortium (FLC) Award for Excellence in Technology Transfer and the 2002 Ada Lovelace Medal from the British Computing Society for significant contributions to information technology. Along with his colleagues Ian Foster and Steve Tuecke, he was named one of the top 10 innovators of 2002 by InfoWorld Magazine. In 2003, he and Dr. Foster were named by MIT Technology Review as the creators of one of the "10 technologies that will change the world." He was recognized in 2007 along with Dr. Stephan Eberich by an Internet2 Idea award and Computerworld's Horizon award. In 2006 Dr. Kesselman received an Honorary Doctorate from the University of Amsterdam.
From Conventional to Unconventional GRID Programming

Thierry Priol
INRIA, France

Abstract
Over the last ten years, Grid computing has seen tremendous developments of research in various areas such as grid middleware architectures, resource brokering and scheduling, knowledge and data management, trust and security to cite a few. Despite all these efforts to design effective and usable Grid infrastructures, there is still a concern about how we can program such infrastructures with a higher level of abstraction than actual programming models do. To some extent, programming grids nowadays is very similar with what computer programmers faced before programming languages came in the light. Taking into consideration the increasing complexity of existing Grid infrastructures, it is of prime importance to extend existing programming models and also to study novel approaches that can both hide the complexity of the underlying computing infrastructure and provide a certain level of abstraction to enhance Grid programmers productivity. This talk will give an overview of some of the efforts, that have been carried out within the European CoreGRID Network of Excellence, towards the definition of a component programming model and the use of the Chemical metaphor to express the coordination of computations.

Short Biography
Dr Thierry Priol is senior scientist (Directeur de Recherche) at INRIA and is the head of the PARIS research group. This research group aims at contributing to the programming of PC clusters and Grids for large scale numerical simulation applications. Dr Thierry Priol holds a PhD degree in computer science from the University of Rennes I and a "Habilitation à diriger des recherches" from the same university. Since 1989, he has held a researcher position at INRIA and in 1995, he was promoted to a senior position in the same institute. His research fields are Parallel Rendering, High Performance Computing and Grid Computing. Concerning Grid Computing, his contribution concerns advanced programming models based on software component models and Chemical programming. He was the chair/co-chairs of several international workshops (Eurographics Workshop on Parallel Rendering and Visualisation) and conferences (topic 6 of EuroPar'03 and 04, CCGRID 2008). He is/was the member of some editorial boards for scientific journals (Parallel Computing, JPDC special issue on Grid computing) and of several program committees of international conferences and workshops related to parallel rendering, HPC and Grid computing. Dr. T. Priol plays an active role in the research communities related to High Performance Computing and Grid Computing. He acted as the Chair of the European Intel Supercomputer Users Group from 1992 till 1995. Dr. T. Priol acts as an expert for the European Commission helping to evaluate project proposals in the area of HPC and Grid computing and to review on-going projects funded by the commission. He acted as the co-chair of a group of independent experts convened by the European Commission with the objective to identify potential European Research priorities for Next Generation Grid(s) 2005 – 2010. He is currently the Scientific Coordinator of the only one Network of Excellence in the area of Grid and P2P technologies (CoreGRID). At INRIA, he was member of the INRIA Evaluation Committee, from 1992 till 1999, in charge of evaluating research activities at INRIA. From January 2000 till June 2003, he was the Deputy Chairman of the INRIA Evaluation Committee.
Scalable Computing in the Multicore Era

Xian-He Sun
Illinois Institute of Technology, USA

Abstract
Multicore architecture has become the trend of high performance processors. While it is generally accepted that we have entered the multicore era, concerns exist on when or will moving into the manycore stage. Technology is available, but major vendors are hesitant in making processors that have a large number of cores, citing Amdahl's law and the memory-wall problem. This is a very interesting phenomenon, where history seems to repeat itself on the scalability debate of parallel processing that occurred 20 years ago. In this introductory keynote talk we first review the history and concepts of scalable computing, and review the current technologies and the memory-wall problem. We then introduce two performance models of multicore architecture from the scalable computing point of view. These two models show that multicores have a good scalability and add a new dimension of scalable computing. Finally, we conclude with proposed solutions to the memory-wall problem to make the potential scalability of multicore reachable in practice.

Short Biography
Dr. Xian-He Sun is a professor of computer science and the director of the Scalable Computing Software laboratory at Illinois Institute of Technology (IIT), and is a guest faculty in the Mathematics and Computer Science Division and Computing Division at the Argonne and Fermi National Laboratory, respectively. Before joining IIT, he worked at DoE Ames National Laboratory, at ICASE, NASA Langley Research Center, at Louisiana State University, Baton Rouge, and was an ASEE fellow at Navy Research Laboratories. Dr. Sun's research interests include parallel and distributed processing, software systems, performance evaluation, and high-end computing. More information about Dr. Sun can be found at http://www.cs.iit.edu/~sun/.
Scaling Horizontally—The Distributed JVM Approach

Cho-Li Wang
The University of Hong Kong, Hong Kong, China

Abstract

Powering billions of devices and numbering millions of software developers worldwide, Java has been a dominant programming language everywhere. As computer prices drop and performance continues to increase, tens to even hundreds of low-cost commodity computers can be easily configured to form a cluster to obtain aggregate computing power larger than a million-dollar multi-CPU/core server. Scalable clustering solutions for Java applications in a cluster environment are thus very attractive and paramount.

In this talk, we will introduce a generic and easy-to-use application clustering approach coming out from the latest research in distributed Java virtual machines (DJVM). A DJVM system consists of a set of JVM instances spanning multiple cluster nodes, which work cooperatively to support parallel execution of a multithreaded Java program. The DJVM middleware abstracts away the low-level clustering decisions and hides the physical boundaries across the cluster nodes from the application layer. All available resources in the distributed environment, such as memory, I/O and network bandwidth can be shared among distributed threads for solving more challenging problems. As the design of DJVM adheres to the standard JVM specification, ideally all applications that follow the original Java multithreaded programming model on a single machine can now be executed in the cluster environment. This approach makes it possible for ordinary programmers to scale out their applications on a cluster environment and realize high-performance computing without the need to stick to the ponderous J2EE technology stack that usually requires explicit application code retrofit for efficient execution or to learn those complicated parallel languages. Thus developers can focus their efforts only on their business logics and software innovation. The talk reports our recent progress on the development of a DJVM, called JESSICA, and suggests future directions in this research.

Short Biography

Dr. Cho-Li Wang received his B.S. degree in Computer Science and Information Engineering from National Taiwan University in 1985, and his M.S. and Ph.D. degrees in Computer Engineering from University of Southern California in 1990 and 1995 respectively. He is currently an associate professor of the Department of Computer Science at The University of Hong Kong. Dr. Wang's research interests mainly focus on distributed Java virtual machine, Grid middleware, programming model for multi-core systems, and context-aware software for pervasive/mobile computing. The HKU team started working on the DJVM research in late 1990s. They have built the JESSICA DJVM which is now deployed in the "Hong Kong University Grid Point" as part of the China National Grid (CNGrid) project. Dr. Wang is serving in a number of editorial boards, including IEEE Transaction on Computers (TC), Multiagent and Grid Systems (MAGS), and the International Journal of Pervasive Computing and Communications (JPCC). He is the regional coordinator (Hong Kong) of IEEE Technical Committee on Scalable Computing (TCSC).
Emergent Properties in Net Computing

Zhiwei Xu
Institute of Computing Technology (ICT), Chinese Academy of Sciences, China

Abstract

As any computer architecture textbook will tell us, traditional computing systems have a few fundamental properties, such as work set and locality. Furthermore, we went on to invented techniques such as TLB, virtual memory, and caching to utilize such properties, which significantly improved performance. The Vega Grid research team at Institute of Computing Technology, Chinese Academy of Sciences, has been studying for several years and trying to identify similar properties for distributed and decentralized computing systems (i.e., net computing systems).

An important difference is that performance of a net computing system involves many parties, which may be autonomous, especially in decentralized systems. A consequence is that emergent properties are of much importance. We are interested in three questions: (1) Do such emergent properties exist in net computing systems, and if so, how to characterize them? (2) Can such properties be utilized to improve the performance and lower the cost of a net computing system? (3) If a net computing system does not exhibit nice emergent properties at the beginning, can we redesign the mechanisms of the system to attain such properties, similar to mechanism design in economics?

We show that the answers to the above three questions are all affirmative. Three emergent properties are identified and characterized for two net computing systems, called request locality, job success rate, and fair resource utilization. We also present techniques to utilize or attain such properties, which can be used to design better net computing systems.

Short Biography

Zhiwei XU received his PhD degree from University of Southern California in 1987. He is a professor and CTO of the Institute of Computing Technology (ICT) of Chinese Academy of Sciences. His research areas include grid computing, operating systems, and high-performance computer architecture. His volunteer services include associate editor of IEEE Transactions on Computers, and PC members for HPCA 2007 and Supercomputing 2008.
Research issues and Challenges to Advance System Software for Multicore Processors and Data-intensive Applications

Xiaodong Zhang
The Ohio State University, USA

Abstract

Compared with rapid technology advancements in multicore processors and rapid changes from computing-intensive to highly data-intensive applications, operating systems have been evolved very slowly for several decades. Application users are facing to two major challenges in today's computing environment. On the top level of the system hierarchy, private and shared caches are equipped for many cores to access concurrently, inevitably causing access conflicts to degrade execution performance. On the bottom level, the performance bottleneck of "memory wall" has been shifted to "disk wall" that is a serious bottleneck for many data-intensive applications. Since processor caches and disk storage are not in the major scope of operating system management, and their increasingly complex operations are not transparent to application users, the above mentioned performance issues have not been effectively addressed at any level of computer systems.

We have made a continuous effort to enhance operating systems with two objectives: (1) to well utilize rich but complex resources of multicore processors and (2) to access disk data as fast as possible. At the multicore processor level, we are developing new resource allocation management to improve the effective caching capacity per core and/or per thread, and to minimize congestion in off-chip memory accesses by coordinating memory bandwidth sharing. At the storage level, we enable operating systems to effectively exploit "sequential locality" --- for the same amount of data, sequential accesses are several orders of magnitude faster than random accesses in disks. In this talk, related research issues and challenges will be overviewed, and preliminary results will be presented.

Short Biography

Xiaodong Zhang is the Robert M. Critchfield Professor in Engineering, and Chairman of the Department of Computer Science and Engineering at the Ohio State University.

His research interests cover a wide spectrum in the areas of high performance and distributed systems. Several technical innovations and research results from his team have been adopted or being developed in commercial products and open source systems with direct impact to some key computing operations, including the permutation memory interleaving technique first in the Sun Microsystems' UltraSPARC IIIi processor and then in the Sun's dual-core Gemini Processor, the token thrashing protection mechanism and the Clock-Pro page replacement algorithm for memory management in the Linux Kernel and NetBSD.

Xiaodong Zhang was the Director of Advanced Computational Research Program at the National Science Foundation, 2001-2004. He is the associate Editor-in-Chief of IEEE Transactions on Parallel and Distributed Systems, and is also serving on the Editorial Boards of IEEE Transactions on Computers, IEEE Micro, and Journal of Parallel and Distributed Computing.

He received his Ph.D. in Computer Science from University of Colorado at Boulder.