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November 07, 2011

Blue Collar Computing Revisited: Lessons Learned

Ashok Krishnamurthy and Kathryn Kelley, Ohio Supercomputer Center

As early as 2004, we at the Ohio Supercomputer Center (OSC) believed that the HPC market was heavily focused on "Grand Challenge" problems and missing a huge opportunity in the "HPC for the rest of us" segment. To address this, we launched a program called Blue Collar Computing (BCC) to expand the applications of HPC in the mid-range where you find the vast majority of industrial applications. In a 2006 *Clusterworld* article, "Blue Collar Computing: HPC for the Rest of Us," we wrote about OSC's initial forays in this area of industry-focused HPC.

In this article, we take stock of where we are five years later. Some significant successes have been attained, while others have taken more time to realize, and much remains to be done.

In the last five years the language used to describe the market has changed somewhat – "HPC for the rest of us" has become "digital manufacturing for the missing middle," and "high performance computing" has morphed into "advanced modeling, simulation and analysis." Nonetheless, we continue to believe that public-private partnerships that provide a complete solution and overcome the multiple barriers are essential for success in this area – and will allow small- and medium-sized manufacturers (SMMs) to shift to digital manufacturing.

HPC in Manufacturing a Must

Why is there a need for HPC in the manufacturing industry? If you read the ***Digital Manufacturing Report (http://www.digitalmanufacturingreport.com/dmr/2011-06-06/hope_for_the_missing_middle.html)*** on a regular basis, you already know that a number of companies from a range of industries – from automobile and airplane manufacturing to industrial glues and energy-efficient buildings – have dramatically benefited from the infusion of computation and computational models. To date, however, these typically have been the large Fortune100 manufacturing companies, and the benefits reaped from advanced modeling and simulation – faster and improved product design, increased productivity and enhanced competitiveness – usually are not available to the SMMs. The full benefits of a complete digital manufacturing economy can only be realized if the original equipment manufacturers (OEMS) as well as their supply-chain SMMs use computational methods throughout their complete product life cycle. The overarching goal of BCC is, therefore, to infuse HPC into the full manufacturing chain, with a focus on where it is needed the most – the SMMs. In these five years, the market is not where we would have liked it to be – a surge in digital manufacturing leading to innovative new products, but we have made significant progress.

That was Then, This is Now

The scope of Blue Collar Computing has transitioned over the years as we have learned the needs of the market. SMMs are typically stretched thin, in terms of both expertise and financial capabilities. One-time assistance, perhaps funded by federal or state monies, only goes so far to convert them to digital manufacturing. For BCC to be sustainable, we realize that we need business models – similar to the way that LEAN manufacturing has become a common production practice – that keep the SMMs engaged, demonstrate a solid ROI and show that digital manufacturing can achieve better results at a predictable cost. While we have not solved all of these sustainability issues, some of the paths we are pursuing are outlined here:

Increase the stickiness: While one-on-one engagements with an SMM to solve a specific problem are important, we have realized that there are a number of steps that can be taken to scale the engagement. The SMMs, for example, may need to repeat the solution on similar designs or they may need to add features.

How do we increase stickiness, i.e., have the SMM continue to see modeling and simulation as a continued solution, rather than reverting back to their old way of doing things? If, as is typical, the SMM does not have internal expertise, it is unlikely that they can continue to run the developed models and codes "as is" on an HPC system. Our solution is to wrap the developed solution in a web browser-based user interface that hides the complexity of shell scripts and multiple job launches behind a "subject-matter or domain-expert" portal. This will typically allow an in-house SMM design expert to upload new CAD files and run variations on the basic problem – no computational science knowledge needed.

Feature additions will typically require additional engagements with HPC and modeling experts, but can usually be done at modest cost and will expand the scope of the problems that can be addressed, further adding to stickiness. We look at this as the first generation of digital manufacturing "apps" – very much in keeping with the recent trend in "apps" for the consumer and enterprise markets – that provide a simple interface to solve a single problem.

Use consolidators: A powerful way of scaling the reach of digital manufacturing "apps" is to use industry-specific groups and technology providers who already are trusted partners with the SMMs we are trying to reach.

Examples include the WeldPredictor app that we have created with the Edison Welding Institute (EWI) to reach the welding engineering community and the Polymer Portal that we have developed in collaboration with PolymerOhio to reach the large polymer community in Ohio.

For EWI, which is a membership organization with 2800 worldwide members, the WeldPredictor provides a way to bring easy-to-use welding simulation and analysis to their member companies. The WeldPredictor app provides the ability to simulate the structural and thermal properties of a variety of arc welding processes. Over the last three years, based on customer requests, EWI and OSC have added a number of features to WeldPredictor to make it useful to a larger number of SMMs. We recently deployed a version of WeldPredictor at KISTI in South Korea.

PolymerOhio also is a membership organization and receives funds from the State of Ohio to provide services to all polymer companies in Ohio. Staffed by retired and active members from the polymer industry, PolymerOhio is a trusted source of business and technology expertise for polymer SMMs. The Polymer Portal is not a single app but a true portal, providing access to polymer process modeling and simulation codes (currently for injection molding and twin screw mixing), education and training in using the codes, and polymer expertise.

Educate and train: A third, and perhaps the most important part of a sustainable digital manufacturing economy, is creating the talent and expertise pool. Many SMMs are concerned about becoming dependent on modeling and simulation as a way of doing business if they cannot acquire the needed talent. And a range of expertise in computational science is needed, from those who can use the manufacturing apps for real-world problems, to those who can develop new computational models and simulations.

OSC is addressing this by developing associate-degree specializations in conjunction with two-year community colleges, baccalaureate minors in computational science and engineering at four-year institutions and a certificate program for working professionals. Today, the deep expertise needed for developing a complete modeling and simulation app from scratch requires doctorate-level training; as an alternative, OSC is considering a professional master's degree program in computational engineering that can be completed in 18 months.

To date, BCC has focused on a wide range of industries that traditionally do not have the expertise or resources to implement modeling and simulation into their day-to-day work, totaling 52 industries for one-off projects and dozens more served by our industry-specific portals. We have integrated the infrastructure, software applications and domain-specific academic computational expertise that can advance the industrial applications of modeling and simulation, so that industries can use HPC in their everyday work. Of course, this mission has expanded to a regional approach, as well as the national agenda, through partnerships with the Alliance for High Performance Digital Manufacturing (AHPDM), the National Center for Manufacturing Sciences (NCMS) and the National Digital Engineering and Manufacturing Consortium (NDEMC).

Nationally, the U.S. has lost millions of jobs in manufacturing; the states with the most significant losses include California, Texas and Ohio. A topic rarely discussed before Blue Collar Computing and other related programs at supercomputing centers in the U.S. was how manufacturing might use HPC to improve workforce productivity and manufacturing technologies in order to produce radically improved products and processes. According to analysis organizations such as IDC, the overall market has been ripe for higher-end manufacturing and industrial engineering. Before growth can occur, however, a number of barriers outlined in 2006 yet remain and must be addressed before HPC is widely viewed as a major benefit to manufacturing.

Barriers to Entry

The more things change, the more they stay the same.

Five years ago, we outlined several barriers that must be removed for industry to effectively use HPC. They included:

- Technical Expertise/Education
- Pricing and Support

- Intellectual Property
- Security
- No Immediate ROI
- Nontraditional Barriers
- Cultural Barriers
- Little HPC/Industry Collaboration
- Lack of Imagination
- Not Forging New Tools and Utilities
- Collaboration
- Lack of Imagination
- Not Forging New Tools and Utilities
- Risk Aversion

Many of these barriers still remain today, and it is worthwhile to understand why:

Technical expertise and education. In 2006, we stated that one of the traditional barriers to industry HPC use has been the lack of technical expertise within the existing and emerging workforce. Put simply, engineers need to know how to write software, and computer scientists need to know engineering fundamentals. In addition, engineering and computer science curricula in most U.S. colleges and universities focus on mainstream industry requirements, and doctoral students in engineering and science are channeled into very specialized domains. What is needed is a sophisticated computational science curricular approach that integrates and uses concepts that have been developed in multiple science and engineering domains. HPC should be an integral part of forthcoming computational science programs and/or integrated in existing computing curricula at the undergraduate levels.

BCC solution: Through the virtual Ralph Regula School of Computational Science and in cooperation with Ohio's universities and community colleges, OSC has developed baccalaureate minor and associate specialization programs. More recently, the Ralph Regula School has partnered with Ohio colleges to create industry certificate programs to train Ohio's workforce in advanced modeling and simulation skills to solve complex problems in manufacturing, such as simulations in injection molding for the polymer industry. This educational model has lent itself well to the National Science Foundation's Extreme Science and Engineering Discovery Environment (XSEDE) project. Its education and outreach mission is to answer the critical need to advance computational science and engineering by recruiting, preparing and sustaining a large and diverse scientific academic and industrial workforce using XSEDE cyberinfrastructure.

ISV licensing. Another barrier to the extensive industrial use of HPC is cost-prohibitive pricing and support for industry computational systems and software. Third-party software vendors and their costs for licenses differ from those available for industry users and academic software licenses are not transferable to commercial use – even for testing. This situation is a barrier for mid-level companies that wish to engage academia in research that uses HPC for innovative industrial research.

BCC solution: This remains a difficult barrier, but the situation is looking much better than even a year ago. Driven by the recent impetus behind cloud computing and collaborative cross-industry groups such as NCMS' Digital Manufacturing SIG, ISVs are beginning to evaluate alternative licensing models, and OSC is involved in several studies related to this. Along with AltaSim, PolymerOhio and Nimbis Services, we have also engaged in short-term licensing agreements with ISVs. This approach is not for the faint of heart, as it requires determination and a significant investment in time – in our case, funded by grants from federal funding agencies to document the national value of SMMs using HPC to improve their competitiveness.

Intellectual property and the security needed for handling industrial data is yet another barrier. There are documented cases in which legal confidentiality issues have extended the process of providing HPC services to industrial partners by 18 months or more. Simply stated, most companies are not ready to address the legal and security issues that accrue when they consider moving their most challenging problems to HPC centers.

BCC solution: We have developed memorandums of understanding that address security issues, as well as codify our business continuity practices to meet industry standards. Many of these advantages have been due to higher education institutions such as The Ohio State University becoming more cognizant of meeting the legal and security requirements of companies for greater technology transfer between academia and industry.

Return on investment (ROI) is calculated differently in educational and governmental HPC research labs than it is in industry. Industry's timing is driven by their need for immediate returns and deliverables and yearly, if not quarterly, ROI. In addition, manufacturers are accustomed to solving problems on the desktop, so many simply are not exposed to HPC. Little HPC/industry collaboration currently takes place, and in those circumstances where introductions are made, some companies cannot work within an academic time-share approach for HPC resources.

BCC solution: OSC is part of the NCMS Digital Manufacturing SIG which is collaboratively working together to help roll out NCMS' national Predictive Innovation Center strategy, which will give SMMs access to Modeling and Simulation tools, knowledge, training and infrastructure on a pay-as-you-go model (See Fig. 1.) Additionally, in 2011, the U.S. Department of Commerce, Economic Development Administration awarded $4.5 million to support the supply chain of four large manufacturers in the Midwest. This pilot program (NDEMC) will provide computing and software resources as well as "field trainers" to introduce the small- and medium-sized suppliers of these large manufacturers to the use of technology resources in order to create innovative products and services.

Difficult to use tools. The biggest barrier is that the tools created and used by the HPC industry are hard to use by industry, due to many of the factors listed above. If HPC systems and software were easier to use, we argued in 2006 that industry could tackle more complex models in a much wider context – thus creating more business opportunities. Convincing companies to invest in the development of new HPC tools has been an uphill battle.

BCC solution: We have found a way to bridge the gap between HPC use in manufacturing and expertise by building digital manufacturing apps – web portals around tailored, problem-specific computational codes so that industries can take care of the content expertise without needing to hire or train computational experts. By working with member organizations such as PolymerOhio, we have been able to develop parameters and specifications that make sense to the manufacturer and make it readily available in a format whereby an engineer can input measurements and get nearly immediate results from our supercomputers. This is also a mission of the NCMS DM SIG where the hardware and software providers are coming together to give access to affordable and easy-to-use tools to SMMs through Predictive

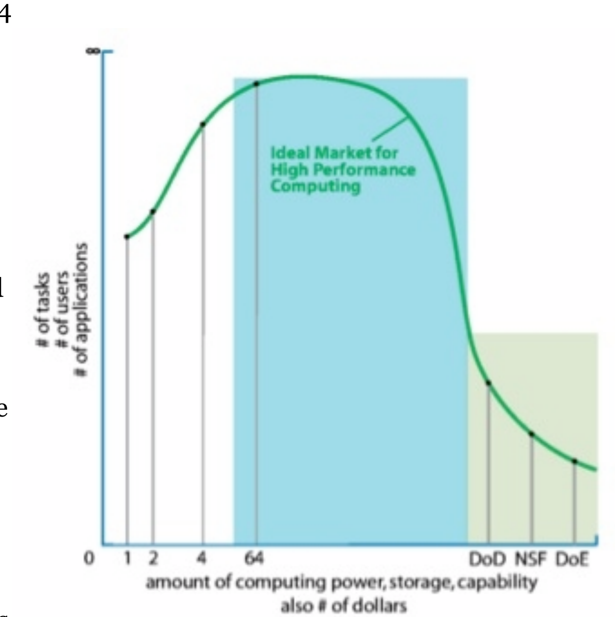
Innovation Centers (see figure below).

Lessons Learned

In 2006, we asked: Can HPC seriously be viewed as one of the critical economic drivers for our future? Is this view of HPC realistic or even realizable? And if HPC is one of a relatively small number of critical economic differentiators, what level of national investment in HPC is justified by its economic potential?

Through OSC's Blue Collar Computing program, we have found that high performance computing is a viable solution for industries that do not currently have the expertise or the time to be an HPC incubator or research new HPC applications. High performance programming languages, training and collaborations have opened up greater capability and competitiveness to manufacturing users, reducing the barriers outlined above.

Looking at one of our original diagrams from 2004 (shown here), we predicted that demands from industry as they move from one or two processors to HPC parallel computation may allow us to push the mid-range of the market to a higher level, especially in the automotive, petroleum, financial and pharmaceutical industries. We still need HPC for grand challenge problems to push research and supercomputing to new heights. Yet, the need for industry to partake in the benefits of increased HPC investment, processing power and compatible software is still being realized.



Let's Roll Up Our Sleeves and Get Back to Work

OSC continues to build public/private partnerships to work on sustaining interfaces and software tools. These collaborations have included individual HPC hardware and software companies collaborating with us to develop more advanced applications for industry that utilize the power of supercomputers. Also, government agencies, such as the National Science Foundation, DARPA and NIST, have invested in proof-of-concept studies to help convince manufacturers that there is ROI in exploring long-term HPC research as a productivity boost.

In the last five years, many more businesses have recognized the value of using modeling and simulation for virtual product development, but they still face barriers to its timely adoption due to the lack of a computational infrastructure and relevant expertise. While the barriers may have been more firmly entrenched than first perceived, the lessons learned have informed each step taken, making sure that the rewards realized by all levels of manufacturing have been built on a strong foundation. The solution remains the same – a focused attempt to solve specific industrial HPC problems and barriers is vitally needed in order to revitalize U.S innovation.

Editor's Note: Ashok Krishnamurthy is Interim Co-Executive Director of the Ohio Supercomputer Center, and Kathryn L. Kelley is Senior Director of Outreach for the Ohio Technology Consortium.

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