July 3, 2015

444 Saratoga Avenue
Santa Clara, CA 95050
Email: gupta59@illinois.edu

Whomsoever it may concern

Dear Sir/Madam,

I am currently working as a researcher and software architect at Intel Corporation headquarter in Santa Clara, CA. I received my PhD in Computer science from University of Illinois at Urbana Champaign. I am applying to this adjunct faculty position since it closely matches my interests, skills, and expertise in the area of computer systems research in cloud computing, High Performance Computing (HPC), and security.

My experience in this domain of systems research, specifically HPC and clouds, include comprehensive performance analysis, large-scale HPC application development, experience with research and development of HPC runtimes (MPI, Charm++), interaction with hypervisors (particularly KVM), extensions to cloud schedulers (Open Stack), and modifications to Cloud simulators (CloudSim). Moreover, in my current role at Intel, I research, architect, and develop solutions for data center and cloud security. Hence, I see close match between my interests, skills, and experiences and the adjunct faculty position requirements.

My Ph.D thesis research focussed on techniques for Effective High Performance Computing in the Cloud - evaluating HPC in cloud, making cloud schedulers (Open Stack) HPC-aware, and making HPC-runtime system cloud-aware. Post-PhD I have continued addressing some of challenges faced by HPC clouds, in particular my focus has been on security. Details of my research projects and related publications can be found in my CV. My CV is attached and lists my projects, awards, interests, and publications. I have also attached my research, teaching, and diversity statement. I hope you will consider me for this position given my expertise in the area of cloud computing, HPC, and computer security.

I believe that fostering from the teaching and research involvement, this adjunct faculty position will also give me the opportunity to establish a close collaboration between my employer and the university. This will benefit all stakeholders including myself, students, university, and my employer.

I look forward to hearing from you.

Sincerely,

Abhishek Gupta
Researcher and Software Architect, Intel Corp.
PhD, University of Illinois at Urbana Champaign

RESEARCH STATEMENT OF ABHISHEK GUPTA

RESEARCH CHALLENGE: CLOUD COMPUTING, HPC, AND SECURITY

My research interests are focused on exploration of techniques for enabling high performance and secure cloud computing. The idea of a cloud as an elastic, pay-as-you-go infrastructure is appealing to a large number of researcher organizations and companies that find installing hardware of their own to be prohibitively expensive, or at least more expensive than “renting" compute capabilities in the cloud as they need them.

Cloud facilities are easiest to use when you are running (one or many) single-node jobs. However, much of technical computing involves multi-node jobs that are much more tightly coupled, i.e., they involve frequent synchronizing communication between nodes. The typical high latencies and communication variability of cloud-based clusters make it hard to get good, or even reasonable, performance for many HPC applications. Further, the static and dynamic heterogeneities, as well as price variations, presented by cloud infrastructures also hinder performance and cost-effectiveness.

Loss of control, lack of trust, and multi-tenancy result in security challenges moving from on-premise infrastructure to cloud. Due to above challenges, the tremendous potential of cloud for scientific and industrial analytical computing have largely remained unutilized. Novel techniques need to be investigated to bridge the gap between cloud computing and High performance Computing (HPC).

RESEARCH SOLUTION

Clouds Computing and HPC: My research makes one of the first attempts to study the reasons for the lack of adoption of cloud computing by HPC community and alleviate them using software techniques. I hypothesized that current clouds are suitable for some HPC applications not all applications, and for those applications, clouds can be more cost-effective compared to typical dedicated HPC platforms using intelligent scheduling of applications to platforms in cloud. Through comprehensive performance evaluation and analysis, I showed that there are gaps between the characteristic traits of many HPC applications and existing cloud environments. The poor interconnect and I/O performance in cloud, network virtualization overhead, HPC-agnostic cloud schedulers, and the inherent heterogeneity and multi-tenancy in cloud are some bottlenecks for efficient HPC in cloud.

My unique but highly impactful philosophy for bridging the divide between HPC and clouds is to a) use a complementary approach of making clouds HPC-aware and HPC cloud-aware, b) consider also the unique opportunities offered by cloud for HPC, such as virtual machine (VM) consolidation and elasticity, besides addressing the challenges posed by clouds, and c) consider views of both, HPC users and cloud providers, who sometimes have conflicting objectives: users must see tangible benefits (in cost or performance) while cloud providers must be able to run a profitable business. With this philosophy, my novel techniques, viz. HPC-aware cloud scheduling and VM placement, cloud-aware load balancing for HPC applications, and parallel runtime for enabling dynamically shrinking or expanding parallel jobs, significantly improve HPC performance and cloud resource utilization for HPC in cloud.

Cloud Security: Currently, I am also conducting research to enable high performance and secure clouds for government and enterprise movement to public, private, and hybrid clouds. With these goals, I am providing novel solutions for trusted platform and applications running in clouds using low overhead virtualization technologies which gives near native performance. Regardless of the specific cloud model, a detailed assessment, characterization and understanding of these often very complex systems is required in order to improve the performance and security. I have had to not only adapt existing techniques, but also to develop novel techniques to address these research questions.

BENEFITS AND IMPACT

My research helps users gain confidence in the capabilities of cloud for HPC, and enable cloud providers to run a more profitable business. These techniques are expected to drive mass enterprise, government, and academia movement to cloud for variety of applications – ranging from business and web applications to scientific applications. Cloud computing, particularly private clouds are already used extensively internally by large scale enterprises of United States and other countries around the world. Public and hybrid clouds are expected to penetrate the small and medium scale scientific users, both in academia and industry, in the next decade, providing low-cost, high-performance solutions to personal computing, enterprise computing and high performance computing, thus enabling and serving the computing needs of the future age.

RESEARCH COMPONENT DETAILS:

Evaluation, mapping, and models of High Performance Computing in Cloud:. I performed comprehensive evaluation and analysis of the performance and cost of running a set of HPC benchmarks and application on a range of platforms varying from supercomputer to cloud. I also performed an economic analysis of HPC in cloud. Furthermore, my work identified the performance bottlenecks of running HPC applications in cloud. I co-related the application characteristics with performance achieved on various platforms, and identified what application and platform characteristics are most crucial for the selection of a platform for a particular application. Instead of considering cloud as a substitute of supercomputer, I investigated the co-existence of multiple platforms-supercomputer, cluster, and cloud. With this philosophy, I first considered a cloud provider perspective who owns multiple platforms and is looking to optimize the re-source utilization while providing good application performance. **My contributions are novel heuristics for application-aware mapping of jobs in this multi-platform scenario.** Next, I considered the HPC user's perspective and show how one can use the application knowledge to use a hybrid supercomputer-cloud approach that can be more cost-effective compared to running all applications on a dedicated supercomputer or all in cloud.

Making cloud schedulers and VM placement HPC-aware: I demonstrated novel techniques for application-aware consolidation and placement of VMs on physical machines. Through topology-awareness, heterogeneity-awareness, cross-VM interference accounting, and careful co-location of application VMs of complementary execution profiles, my techniques achieve significant improvement in performance and resource utilization. My paper at IEEE International conference in Cloud Engineering

(IC2E 2013) discusses these techniques and presents both experimental results using OpenStack and simulation results using advance tools such as CloudSim.

Making HPC execution and runtime cloud-aware:

a) **Heterogeneity and Multi-tenancy-aware HPC runtime and Dynamic Load Balancing:** I contributed novel dynamic load balancing techniques for efficient execution of tightly-coupled iterative HPC applications in heterogeneous, multi-tenancy, and dynamic cloud environment. My breakthrough idea is periodic refinement of task distribution using measured CPU loads, task loads, and idle times.

b) **Malleable Parallel Runtime**: I presented a novel technique for providing parallel runtime support for malleable HPC jobs, that is jobs which can dynamically expand/shrink to benefit from the inherent elasticity in cloud. Salient features of this scheme are task migration, checkpoint-restart, load balancing, and use of Linux shared memory. I also developed a technique for enabling split-phase execution of malleable job scheduling decisions in a shared cluster, incorporating scheduler-runtime communication. This research benefits both cloud providers and users. First, cloud providers can increase the cluster utilization using such jobs. They can pass some benefits to users by reduced pricing as an incentive for making their jobs malleable. Second, there are emerging use cases, such as Amazon spot markets, which can be exploited by malleable runtimes in future.

WHAT MAKES MY RESEARCH UNIQUE?

The application and development of state-of-the art techniques to solve real and diverse high performance cloud computing problems.

My research has been at the forefront of bringing new techniques to bear on current problems in high performance cloud computing, whereas many other researchers either restrict their attention to identification of problems for HPC in cloud. I have taken a more holistic approach unlike past research. First, rather than limiting to the problem *what* is the performance achieved on cloud vs. supercomputer, my work addressed the bigger and more important question *why* and *who* should choose (or not choose) cloud for HPC, for *what* applications, and *how* should cloud be used for HPC? Secondly, besides addressing the challenges of running HPC applications in cloud, I also explored the opportunities offered by cloud for HPC. Finally, with the goals of improving HPC performance, resource utilization, and cost when running in cloud, my research is beneficial to both users and cloud providers.

Through several inter-disciplinary research collaborations, I have used some of these techniques to address previously unanswerable questions in fields ranging from high performance computing to cloud computing

TEACHING STATEMENT OF ABHISHEK GUPTA

OVERVIEW AND AREAS OF EXPERTISE

The pleasure and power of educating the minds of young genius is overwhelming. With such great power provided by teaching, comes great responsibility. To be able to enjoy that power and be responsible to the same, I have a focused teaching philosophy and strategy. My goal (and associated strategy) is to influence the overall impact of teaching – both short term (by inculcating the conceptual and practical material in the present courses I teach) and long term (over generations of classes by improving course materials and teaching methodologies). My philosophy is to explain the fundamental computer science and engineering concepts (with right breadth) and use them as building blocks leading to advanced technical education (depth).

I have followed this philosophy in my areas of expertise - computer systems and security, in particular cloud computing, High Performance Computing (HPC) and computer security. The idea of a cloud as an elastic, pay-as-you-go infrastructure is appealing to a large number of researcher organizations and companies that find installing hardware of their own to be prohibitively expensive, or at least more expensive than “renting" compute capabilities in the cloud as they need them. I am conducting research to enable high performance and secure clouds for government and enterprise movement to public, private, and hybrid clouds. My publication records in the field demonstrate my expertise and strong qualifications to teach the courses in these fields.

PRIOR EXPERIENCE

My prior experiences include 1) teaching the essential course concepts to my friends before the final exams during my undergraduate years, 2) voluntary teaching school classes as part of National Social Service program in India, 3) mentoring young student researchers during my five years as a PhD student at University of Illinois at Urbana Champaign, 4) guiding and explaining project concepts and architectures to interns and fresh graduates in my current industry position as an architect, and 5) plethora of presentations, talks, posters, and keynote speeches I have given at various academic and industry conferences (details in my CV). Furthermore, I have had ample experience in evaluating the work of others. This include the multitude of research papers and industry intern projects I have reviewed and evaluated. To summarize, my experience as an educator is diverse and often involves explanation of fundamental computer science and engineering concepts leading to advanced technical education. This approach has been fruitful in the past to ensure my students follow me along the course.

TEACHING PHILOSOPHY

My observation through prior experience both as a student and a teacher is that often times the educator is very knowledgeable in his field, still his students are able to inculcate only tiny fraction of his expertise and knowledge of the field. My unique but highly impactful philosophy for bridging the divide between educator and student is to a) use a complementary approach of making educator to be student-aware and b) the courses to be more practical, modern and tied to real-life applications of the concepts. The primary components of my teaching philosophy are:

a) Breadth first Depth next approach: Explain the fundamental course concepts (with right breadth and high level overview) and use them as building blocks leading to advanced technical education (depth).
b) Exposing the beauty of computer science and engineering to student to demonstrate the applicability of the taught concepts in daily life - emphasizing the practical value of knowledge
c) Interactive teaching style rather than one-way communication to keep students interested and engaged in the class
d) Mid-course feedback and runtime improvisation to adapt teaching methodology for best results
e) Adapting course material to rapidly changing industry (e.g., learn from the industry in silicon valley) and modernizing the curriculum

The application of above approach has resulted in great accolades that I have received in my presentations including best poster awards at IEEE IPDPS PhD Forum and excellent feedback by my PhD committee on my final PhD defense. I am determined to apply this philosophy to the wider set of students and to serve the human kind.

SUMMARY

To summarize, I want to convey the following message to my students as they participate in the class - what they are learning are not just some archaic concepts but fundamental building blocks used to solve real problems. In other words,

The application and understanding of fundamental concepts as building blocks is necessary to apply state-of-the art techniques to solve real and diverse problems.

To convey that message, I plan to follow the breadth first depth next approach outlined above, especially to teach courses in my areas of expertise including cloud computing, high performance computing (HPC), parallel computing, computer systems, and security. During my teaching experience at University of Illinois at Urbana Champaign as project mentor and at Intel Corp as an architect, I developed my own teaching philosophy which has been very successful. I hope to apply and adapt that to teach courses at your university in the field of computer science and engineering.

DIVERSITY STATEMENT OF ABHISHEK GUPTA

It is a great pleasure that your university is specifically requesting the diversity statement as part of the faculty application process. This fact emphasizes the growing import of promoting diversity in our educational system. To me, diversity represents various facets, which I will succinctly cover in this essay. On one hand, diversity in education aims at promoting and serving the needs of students from diverse backgrounds including diverse nationalities, races, genders, cultures, and languages. On the other hand, diversity can also mean applying diverse methods to obtain best results for the process of disseminating knowledge.

International students: United States of America is a country where international students comprise a significant chunk of students. Addressing the needs of students who are struggling while adjusting to a different culture, different language, and different climate is one of my foremost priority. My own experience as an international student in the US allows me to understand and address the specific challenges faced by the international students trying to acclimatize themselves to the US.

Under-represented communities, technical females, and other diverse groups: I have had the pleasure of interacting with and understanding the challenges faced by under-represented groups in technical fields specifically computer science. Many times, well qualified individuals from these groups face discrimination due to the background they come from rather than being judged by their qualifications and intellect. By addressing this thought process at the fundamental root – that is our educational system, this faculty position provides me an excellent opportunity to make a major impact in this field. In the past, I have made this a point to strive for excellence towards diversity. I have had multiple interactions with people from diverse communities. Examples include undergraduate students from historically backward classes in India and technical females and under-represented communities in computer science with whom I interacted during my PhD education and also during my present employment. From these ample interactions, I have comprehended the problems faced by both the students and the educators in this setting. As an educator, I have always tried to specifically promote the abilities and single out the accomplishment of each individual in my audience irrespective of their background.

Non-computer science students: Another facet to diversity is to address the needs of non-computer science students. I have had first-hand experience as an alien in a non-core course. This happened to me when I took a non-computer science course - one from Civil engineering where most of the students were from the same department. I learned important lessons while attending that course on how to cater to the needs of student from diverse academic backgrounds. I have applied those lessons when presenting my work/research to a diverse audience and also when mentoring students during my PhD and my current employment. The best strategy that I found to work in such cases is to first listen and learn the needs of students and then make them learn what is needed.

To summarize, having studied as an international student in USA, I have always understood the needs of diverse students and also the import of diversity in education. It's my goal to specifically cater to the needs of students from various backgrounds – cultures, genders, races, and nationalities.