UNIVERSITY OF LOUISIANA AT LAFAYETTE

STEP Committee

Technology Fee Application

Shared HPC Resources for Enhanced Research and Education

Title

Farzad Ferdowsi

Name of Submitter
(Faculty or Staff Only)

Electrical & Computer Engineering Department

Organization

Title: **Shared HPC Resources for Enhanced Research and Education** Date: July 11, 2024

Name (Contact Person): PoC: Farzad Ferdowsi (***Electrical & Computer*** Engineering)
Team members: Shelby Williams (***Engineering***), Sen Liu (***Mechanical*** Engineering) , Emmanuel Revellame (***Chemical*** Engineering) , Ahmed Temani (***Petroleum*** Engineering), Li Hui (***Civil*** Engineering), Jim Lee (***Engineering Technology***)

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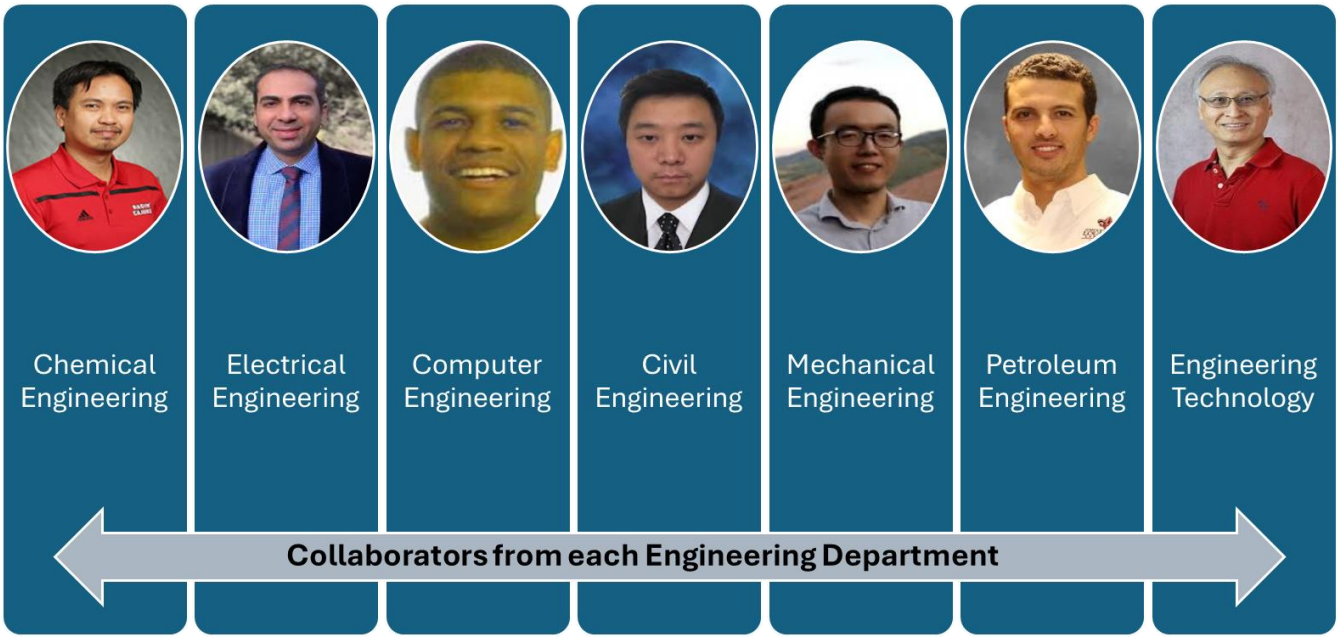
Department/College/Org: College of Engineering

ABSTRACT (250 words or less):

We are proposing the establishment of a high-performance computing (HPC) machine to be housed in Madison Hall (exact room TBD). This facility will serve as a shared resource among multiple instructors and researchers across various engineering departments. Currently, we rely on either typical machines with fairly good specifications that are very slow, especially for complex models, or the Louisiana Optical Network Initiative (LONI). Despite its capabilities, LONI presents significant challenges in terms of user-friendliness, management, and co-simulation integration due to the lack of physical access. The proposed HPC machine will address these issues by providing a more accessible and manageable computing environment. Resource allocation for the HPC facility will be overseen by Mr. Shelby Williams, who brings extensive expertise in IT and computer engineering/science. His management will ensure efficient and equitable access to the HPC resources. The new HPC facility will **directly benefit 7 research groups and four classes across all engineering departments**. Additionally, it will be available for use by other instructors and research groups upon request, fostering a collaborative and resource-rich environment for advanced computational research and education. This initiative aims to enhance the computational capabilities of our engineering departments, streamline research processes, and support the academic growth of our students and faculty. By investing in this HPC facility, we will significantly improve our ability to conduct cutting-edge research and provide high-quality education in engineering disciplines.



Purpose of grant and impact to student body as a whole

The Digitalization Era and the Need for High Performance Computing (HPC)

In today's rapidly evolving digital era, we are witnessing a significant transition towards technologies such as Artificial Intelligence (AI), the Internet of Things (IoT), and Industry 4.0. These advancements are transforming industries and academia alike, necessitating more complex models and computations. High-Performance Computing (HPC) has become indispensable, not only for cutting-edge research but also for modern education. HPC systems enable the processing of large datasets, complex simulations, and advanced computational tasks that are beyond the capabilities of standard computing resources

Direct Benefits to Research Groups and Classes

The proposed HPC facility will directly enhance the capabilities of six research groups across all engineering departments. These groups are engaged in diverse fields such as petroleum engineering, mechanical engineering, and chemical engineering, electrical engineering, computer engineering, and civil engineering each requiring substantial computational power for their research.

Petroleum Engineering: As noted by **Ahmed Temani**, research in the oil industry increasingly relies on Convolutional Neural Networks (CNNs) to analyze rock images and well logs, demanding significant computational resources. Reservoir simulation models and Computational Fluid Dynamics (CFD) simulations also require substantial computational power, which the proposed HPC facility will provide. This facility will support courses like PETE 403 (Applications of ML in PETE) and PETE 598 (Machine Learning Subsurface), as well as the Smart Oilfield concentration, enabling more students to pursue senior design projects involving machine learning

Mechanical Engineering: According to **Sen Liu**, the development of an intelligent metal additive

manufacturing system with in-situ characterization and closed-loop control capability requires supercomputing resources. The HPC facility will enable real-time data analysis and machine learning-based defect quantification, enhancing the quality control of the manufacturing process

Chemical Engineering: **Emmanuel Revellame** highlights the need for HPC in creating bioreactor digital twins using CFD software. Reducing simulation runtime from days to hours will significantly benefit both the project and the students. Additionally, molecular modeling and computational chemistry will be revitalized with the new HPC resources, supporting the theses and dissertations of MS and PhD students.

Civil Engineering: **Li Hui** emphasizes the crucial role of HPC in advancing structural engineering, particularly in bridge inspection and monitoring using machine learning and image processing techniques. The integration of HPC enables faster and more efficient analysis of high-resolution images and data captured by drones and sensors, which are crucial for accurately detecting structural issues and assessing bridge health. Additionally, the facility will support graduate students' research, providing students with the computational power necessary to develop innovative, data-intensive methodologies that advance the field of structural engineering.

Electrical Engineering: As highlighted by **Farzad Ferdowsi**, he proposed High-Performance Computing (HPC) facility will significantly benefit the Electrical and Computer Engineering department, particularly in enhancing both coursework and research. Courses such as EECE 447 (Electric Machines and Power) and EECE 450 (Electric Power Systems) already embed undergraduate research into their curriculum. Access to a robust HPC system will enable students to accelerate their model development, analysis, and simulations, thereby improving the quality and depth of their research projects. Beyond individual courses, research groups within the EECE department will also leverage the HPC for cyber-physical system analysis. Cyber-physical systems, which integrate computation, networking, and physical processes, are increasingly complex and require substantial computational power for modeling, simulation, and verification. The HPC facility will enable researchers to conduct high-fidelity simulations, develop real-time control algorithms, and analyze large-scale data, thereby advancing the state-of-the-art in cyber-physical systems research.

Engineering Technology: As noted by **Jim Lee**, A supercomputer as a shared facility will significantly enhance my teaching and research in systems engineering, benefiting both our graduate and undergraduate students. This resource will empower us to conduct complex system simulations, process large datasets essential for lean six sigma process improvements and perform advanced computations for class projects and research initiatives.

Computer Engineering: ***Shelby Williams*** serves as the Laboratory Manager in the EECE Department. He has written several funded STEP proposals over the past 20 years for upgrading nearly all laboratories in the department. He has worked in his current capacity for over 25 years.

Impact on Courses and Broader Student Body

The HPC facility will directly impact several courses, directly:

- PETE 403 – Applications of ML in PETE
- PETE 598 – Machine Learning Subsurface

- ENGR 480G – Applied Machine Learning
- EECE 433G – Data Engineering and Machine Learning

These courses will benefit from enhanced computational resources, allowing for more complex and realistic projects and simulations. Moreover, the facility will be available to other instructors and research groups upon request, fostering a collaborative environment for advanced computational research and education.

Managing a an inclusive HPC Facility

To ensure the efficient and equitable use of the proposed High-Performance Computing (HPC) facility, a structured approach to resource allocation and management will be implemented. Resource allocation will be overseen by Mr. Shelby Williams, leveraging his extensive expertise in IT and computer engineering. The facility will employ a queuing system to manage job submissions, ensuring that computational tasks are processed in an orderly and fair manner. Users will submit their jobs to designated queues based on the priority and resource requirements of their tasks. This system will prevent any single user or group from monopolizing the HPC resources, promoting fair access for all. Additionally, resource usage will be monitored regularly to optimize performance and prevent bottlenecks. Users will be encouraged to optimize their code and workflows to make the most efficient use of the HPC resources. The facility will also implement best practices for data management, including periodic reviews to remove unneeded data and ensure efficient storage utilization. By adopting these strategies, the HPC facility will support a wide range of research and educational activities, fostering a collaborative and resource-rich environment for the entire engineering community.

Addressing Resource Limitations and Enhancing Competitiveness

Currently, the lack of a local HPC in the engineering departments limits the scope of research and educational projects. The proposed HPC facility will alleviate these resource limitations, especially for high-resolution data analysis and machine learning applications. This will support the academic growth of students and faculty, enabling them to conduct cutting-edge research and stay competitive at the national level.

Supporting Undergraduate Research Programs

The HPC facility will also enhance Course-Based Undergraduate Research Experiences (CURE) and Mentored Undergraduate Research Experiences (MURE). These programs often face limitations due to the lack of access to advanced computational resources. By providing a local HPC, we will expand the range of research topics available to undergraduates, fostering a more robust research culture and preparing students for future careers in high-tech fields. The engineering faculty listed on these applications are actively involved in developing and mentoring undergraduate research projects.

Increasing Competitiveness

By providing state-of-the-art computational resources, the HPC facility will enhance our college's competitiveness at the national level. It will attract top-tier faculty and students, foster interdisciplinary collaborations, and enable us to stay at the forefront of technological advancements. This competitive edge is crucial for securing research funding and maintaining our reputation as a leading research institution.

Person(s) responsible for

i. *Implementation*: Shelby Williams and the team
ii. *Installation*: Mr. Shelby Williams and the team
iii. *Maintenance*: N/A
iv. *Operation*: N/A
v. *Training* (with qualifications): N/A

*The quote for all proposed equipment for this proposal is shown below.

Lambda Vector Pro $46,849.00
System: Lambda Vector Pro: Machine Learning Workstation with up to Quad GPUs GPU: 3x NVIDIA RTX 6000 Ada: 48GB GDDR6 memory, 18,176 CUDA cores, 568 Tensor cores, 300W CPU: AMD Ryzen Threadripper PRO 7995WX: 96 cores, 2.5~5.1GHz, 480MB cache, PCIe 5.0 System Memory: 512GB: DDR5-4800 OS Storage: 1x 4TB M.2 NVMe Data Storage: 1x 15.36TB U.2 NVMe Onboard Networking: 2x 10 Gbps RJ45 Ethernet ports and 1x dedicated RJ45 IPMI port Operating System: Ubuntu 22.04: Includes Lambda Stack for managing TensorFlow, PyTorch, CUDA, cuDNN, etc. Hardware Warranty: Hardware Warranty - 3 Year: Extended three year hardware warranty System Support: System Support - 3 Year: Three years of Lambda technical support for software issues including Lambda Stack, ML frameworks, drivers, OS and BIOS Power: 1600W ATX 3.0 PSU, C20 inlet, 115-240Vac 15A input, C19 to NEMA 5-15P cable included Physical: Full tower workstation, 22.8 x 9.5 x 22.0in (580 x 240 x 560mm, HxWxD)

Budget Proposal

1.	Equipment	$46,849
2.	Software	$0
3.	Supplies	$200
4.	Maintenance	$0
5.		
6.	Personnel	$0
7.	Other	$100 (SH&H)
TOTAL:		**$47,149**

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Shelby Williams
shelby@louisiana.edu
3374826852

Date: 7/10/2024
Valid through: 8/9/2024
Payment terms: Advance Payment

Quote #172-076-883

Lambda Vector Pro — $46,849.00

System: Lambda Vector Pro: Machine Learning Workstation with up to Quad GPUs
GPU: 3x NVIDIA RTX 6000 Ada: 48GB GDDR6 memory, 18,176 CUDA cores, 568 Tensor cores, 300W
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System Memory: 512GB: DDR5-4800
OS Storage: 1x 4TB M.2 NVMe
Data Storage: 1x 15.36TB U.2 NVMe
Onboard Networking: 2x 10 Gbps RJ45 Ethernet ports and 1x dedicated RJ45 IPMI port
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Items: $46,849.00
Total before shipping/taxes: $46,849.00

Taxes and duties may apply. Order subject to Terms of Service.