SOCIETY OF PHYSICS STUDENTS
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SPS Chapter Research Award Interim Report

Project Title	Data Analysis and Accuracy: Small Supercomputer Versus a Dell Dinosaur
Name of School	University of Kentucky
SPS Chapter Number	3511
Total Amount Awarded	$1,157.20
Project Leader	Dany Waller

Abstract

Computational methods provide powerful tools for solving problems in physics. We plan to build a mini-supercomputer from Raspberry Pis following the "Tiny Titan" build specifications available from Oak Ridge National Lab. Once built, the cluster can be used indefinitely for education, outreach, and community building.

Statement of Activity

Interim Assessment

The Tiny Titan supercomputer project is designed for students to learn hands-on skills for computational physics, data acquisition and analysis, and computer hardware. Approximately 25 students are involved in this project, mostly SPS members from the physics department but a few from computer engineering and mathematics, all students ranging from freshman to seniors. This project has generated interest and involvement from professors and several students have joined SPS after joining the project as they enjoyed the social network and academic resources in our organization. There were weekly meetings, students sometimes meeting two or three times a week during particularly difficult steps of the project. Thus far, students have assembled each individual Raspberry Pi, learned the mechanics of parallel processing to create a supercomputer and set up one program to run on their small cluster. The project has hit several obstacles that introduced students to new problem-solving methods and emphasized the importance of collaboration in scientific settings. The construction of the Raspberry Pi units in a parallel configuration presented unanticipated programming dilemmas which students grappled with for two weeks, retracing their steps and eventually discovering a missing file that was preventing the cluster from functioning correcting. During this two-week stagnation, one student realized that the missing file was not mentioned in the Oak Ridge National Laboratory Tiny Titan documentation and created their own resource for future students, also submitting it to the ORNL GitHub to complete the documentation on their end. Once this was addressed and noted for future reference, the Tiny Titan setup continued smoothly, and the cluster now functions as a small supercomputer. The team of students tested their first program on the cluster, a fluid dynamics simulation accessed from the ORNL GitHub. Students discovered that the old SPS desktop was not capable of running the simulation at all, as the program requirements exceeded the hardware available in the desktop. This changed the data analysis approach to this project, students instead ran comparison tests using a reduced number of nodes on the cluster itself. Students are working on the second program over the summer, a visualization of the Ising Model which is expected to be running on the cluster by the beginning of the fall semester.

Updated Background for Proposed Project

The Tiny Titan GitHub repository contained several errors which were noted and fixed by SPS members. All programs have been thoroughly documented and made available to all parties involved.

Description of Research - Methods, Design, and Procedures

- The Raspberry Pi units were assembled individually and booted up to test their functionality.
- Once all Pi units were confirmed to work, the units were assembled in a cluster format using the Tiny Titan instructions from the ORNL GitHub repository. This required students to connect ethernet cables to each Pi and run them through an ethernet cable switch, then run a command on each Pi to allow them to function in parallel.
- To ensure that all Pi units were functioning as part of the cluster, students learned how to access each node from the boss unit and pass commands between them. This is when students realized there was a problem with the setup and eventually discovered the missing file.

- With the replacement of the missing file, the Raspberry Pi units now function as one small supercomputer, and students began assembling the ORNL fluid dynamics program. This program was prioritized over the Ising Model visualization because the computational physics professor was interested in participating in that part of the project but had schedule conflicts.
- Students attempted to run the fluid dynamics simulation on the SPS desktop and realized the computer hardware was not sufficient to run the program. They instead reduced the number of nodes in the cluster to test the effects of computational power on program efficiency.
- The end of the semester passed, and students will continue to work on the Ising Model visualization over the summer with reduced lab meetings due to availability.

Initial Results

The programs so far have followed the expected behavior, there is an increase in accuracy and efficiency of results with an increase in the number of nodes on the supercomputer. The SPS desktop was unable to run the fluid dynamics simulation, proving there is a definitive hardware constraint for new software and programs. We did not expect such a stark difference to be visible so early in the project, but it follows from previous research and comparisons of computational power. We now expect this to be more pronounced in the Ising Model visualization and estimation of π, to a degree much higher than we postulated in our project proposal. The importance of clear documentation and communication has also been emphasized for students, as the difficulty of computation increases so does the margin for error.

Project Timeline

- January 2019: The department offered financial assistance in exchange for reimbursement when the SPS awards arrived to purchase the necessary materials in bulk and the materials arrived during the first week of the spring semester. Students began working on the cluster immediately.
- February 2019: Students had assembled each Pi and began working to configure the supercomputer nodes. Aforementioned problem stalled progress for ~2 weeks.
- March 2019: Students discovered and fixed the problem; the Tiny Titan was fully functioning by March 15th. The problem was reported to the ORNL Tiny Titan GitHub and documentation for the building process was completed. Students began downloading the fluid dynamics program after deciding to wait on the Ising Model visualization for the assistance of the computational physics professor.
- April 2019: The fluid dynamics program was successfully loaded to the cluster and run. Students modified several parts of the code to increase functions of the simulation and altered the logo to a fun SPS-ORNL joint logo.
- May 2019: Students dispersed for the end of the semester and work long-distance on the Ising Model visualization. Expected to be finalized and running on the cluster by August 2019.

Statement of Next Steps

Plan for Carrying Out Remainder of Project (including Timeline)

Approximately 5 students of the original 25 graduated or left the program in Spring 2019, so the project will be continued by the remaining 20 students. However, the UK SPS chapter is well known on campus for their fall semester recruiting events and they expect to gain at least 5 new students to join the supercomputer project as well as the student organization. The computational physics professor who is also the SPS faculty advisor will be involved during the fall semester for the Ising Model visualization and estimation of π, and several mathematics and physics professors have proposed undergraduate research projects to utilize the supercomputer.

- Students will continue work on the Ising Model visualization over the summer, with plans to employ it in their fall semester recruiting efforts in August 2019.
- Professors offering undergraduate research projects will begin their programs in August 2019.
- Students will prepare a report of their work to be submitted to the University of Kentucky Office of Undergraduate Research by September 2019.
- The estimation of π program will be running on the Tiny Titan by the end of November 2019.
- The final report (due December 2019) will be prepared with a fully documented Tiny Titan build (descriptive essay with pictures), pictures and reports from all outreach events (UK freshman orientation or "K-week," Open Lab Day, game nights and physics competitions), and a GitHub repository where all programs will be stored for future use.

Bibliography

Tiny Titan Build Guide. (2015). Retrieved from http://tinytitan.github.io/downloads/TinyTitanBuildGuide.pdf