SPS Chapter Research Award Interim Report

Project Title	SPS @ UCA: Small Parallel Supercomputer at UCA
Name of School	University of Central Arkansas
SPS Chapter Number	Zone 10, Chapter 1059
Total Amount Awarded	$1,997.73
Project Leader	John Singel

Abstract

The Society of Physics Students at the University of Central Arkansas plans to build a small parallel supercomputer. We will use it to get hands-on experience with the tools and techniques of computational physics research. We will expand our astrophysics research, attract new SPS student research, and foster educational outreach.

Statement of Activity

Interim Assessment

This project started as an outgrowth of two students' independent research with university physics faculty in both parallel computing and astrophysics. With additional SPS volunteers, the project developed into two main thrusts. The first is to research, build, and deploy an operational small parallel supercomputer, while simultaneously developing the Python language control program to maximize parallel processing. The second main thrust will be to use this computer to process large amounts of astrophysics supernovae data.

Overall, this research project will expose all participants, particularly SPS students, to the entire life cycle of both theoretical and experimental physics. College campuses, generally, lack a dedicated supercomputer server (Adams, 2015). The benefits of a small parallel supercomputer will be especially noticed in our SPS students' computational physics and theoretical astrophysics research. When conducting student research into bolometric luminosity data of certain supernovae, the application of the Python language program SuperBol became the student focus. Telescopes cannot directly observe the bolometric luminosity of a supernova due to much of the emitted radiation falling outside of its observable wavelength range (Lusk & Baron 2017). Using SuperBol, we can simulate the luminosity of supernovae across the electromagnetic spectrum. The use of a locally built supercomputer will aid in the data processing. Also, the SPS students will come to appreciate the requirements upon the experimental physicist to build and conduct experiments to prove the validity of the theoretical physics.

We plan to disseminate our results at local meetings such as the College of Natural Sciences and Mathematics Poster Symposium at UCA and the Arkansas Academy of Science meeting; and at national meetings such as the American Astronomical Society and SPS PhysCon. The AAS also accepts submissions of papers describing research software and techniques to the Astronomical Journal.

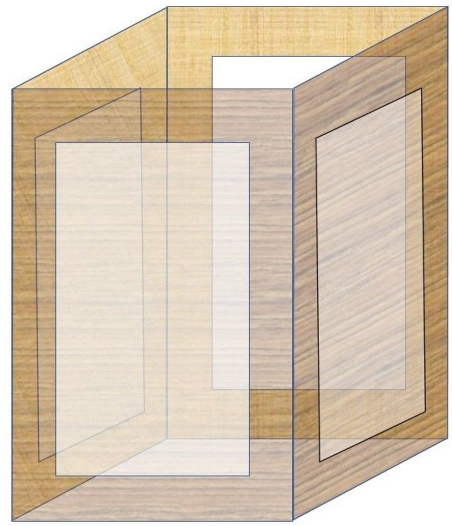
Description of Research - Methods, Design, and Procedures

The initial hurdle for us was administrative in nature. Our entire budget was dedicated to the parts required to build the supercomputer. Since the research grant was to be awarded half up front and half after the interim report, we needed the help of the UCA Research Council to provide the bridge loan to effect the necessary full budget. Once this had been secured, we finalized our research on our proposed parts list to ensure pricing compatibility with our original proposed budget. Several components, most importantly the motherboards, had decreased in price and we were able to use the same budgeted motherboard price to buy a more capable motherboard for our system. We also upgraded our wireless interface and storage drive.

The initial plan was to assemble the control motherboard with attached hard drive and wireless interface to create a working control motherboard. Then we would connect this to all five other motherboards in a temporary case (see figures 1 and 2) to ensure they were operational. Finally, the operating system (this will be LINUX based) would be downloaded and software coding for the control program would commence.

Initial Results

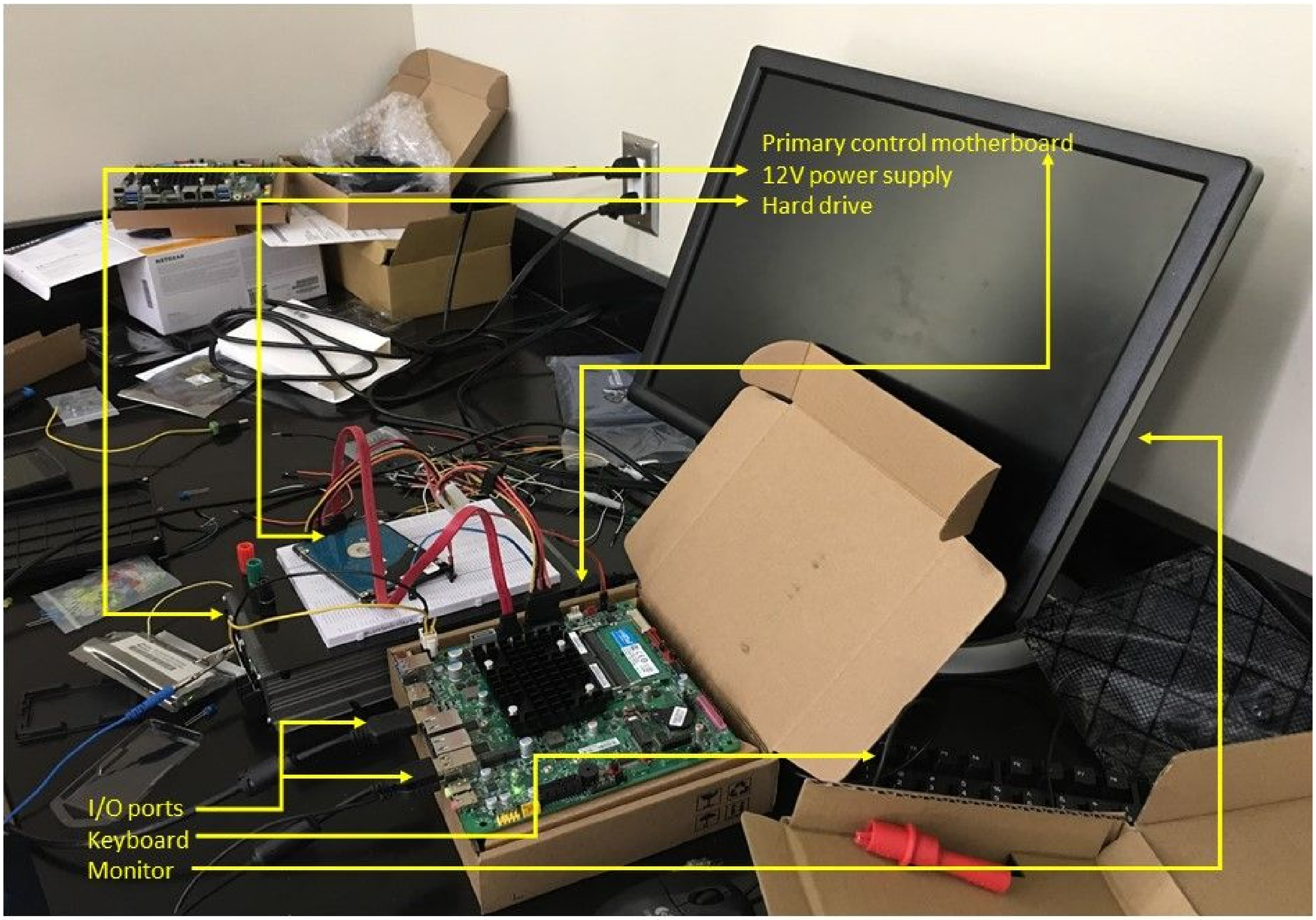
Throughout the entirety of this semester, it has become abundantly clear that obtaining viable results are only one part of the research process. As mentioned before, the task of supplementing half of the funds was our initial concern. While we waited for the funds to get approved, as well as the various parts to be shipped, we learned various skills, such as how to properly and safely utilize the 3D printer and the Epilog laser cutter that are in our lab.



A proof of concept structure, shown in figure 1, was assembled using scrap MDF in the Physics Engineering Lab. This demonstrated the woodworking concept of maximizing sheet products and was made to be easily assembled and disassembled. Note that the structure, as shown, is structurally unsound. When built with full sheets of MDF, the sides will be fully rectangular, as shown in figure 2, to effect structural soundness.

Once the various components arrived, we set out to construct a barebones apparatus to ensure that all of the motherboards and corresponding elements functioned as intended. Unfortunately, when we tried to power on a single motherboard, with RAM inserted and all the necessary cables attached, nothing displayed and neither the mouse nor the keyboard was being powered. This led us to create a "power button," fashioned out of a breadboard, button, and a small LED. After much research on how to properly wire the power button, we were met with the same results; it seemed as though some components on the motherboard were receiving power, while others were not. The hard drive would spin up while the monitor never received power from the HDMI port. The keyboard would not power up and the mouse would receive a flash of power but remain dead and unresponsive. A multimeter and a detective attitude was used to confirm these initial observations.

While experimenting, we tried powering the motherboard with no RAM inserted. A BIOS beep was emitted, indicating the initial system calls within the BIOS were working properly. We referenced the motherboard documentation, especially noting all of the jumpers placed between I/O pins on the motherboard. When changing a parameter, it was accomplished one at a time with further testing. If that test produced negative results, we returned the jumper to its original position before testing another. During all of this testing, we were particularly cautious with regard to static discharge and ensured grounding before working on any components.



We contacted the manufacturer for their assistance when we could not arrive at a solution. They believed the statistical probability all six motherboards to, coincidentally, be faulty, to be extremely unlikely. For this reason, the manufacturer suggested trying a different type of RAM, one that they specifically use for testing. We tried this, but unfortunately had no better results than before. During our communication with the manufacturer, we even received a picture that they had taken of their motherboard in their test configuration. Through this, we were able to confirm all of our jumper positions and power settings along with RAM type. Our hypothesis is that something from within the BIOS was preventing the motherboards from properly powering on. Because of this, we were forced to contact the manufacturer for replacements, requesting that they test all six motherboards before shipping. Overall, this has been a learning process filled with trial and error. Even though our main goal has not been fully accomplished yet, we gained much experience with problem solving and and the intricacies of computer hardware.

Statement of Next Steps

Plan for Carrying Out Remainder of Project (including Timeline)

Our timeline has been compressed due to the intrinsic failure of the motherboards, but we remain optimistic with high participation throughout the summer months to be able to meet the following timeline.

May 2019 - complete interim report
Summer 2019 - receive new working parts, component testing, complete build
September 2019 - implement Python control program, operational test, internal data
October 2019 - optimize software for parallel speeds and conduct operational test of hardware/software on external (to UCA) data
November 2019 - start final report, presentations to UCA physics department, and SPS PhysCon 2019
December 2019 - present final report to UCA CNSM and submit to SPS Journal of Undergraduate Reports in Physics

The two primary researchers, Doolabh and Singel continue to work with their advisor on computational and and astrophysics research. With the delay in working motherboards, they are practicing Python programming techniques to be experienced and ready when it is time to write the control program. We anticipate the replacement motherboards within several weeks and successful building to commence thereafter.

Bibliography

Adams, J. C., Caswell, J., Matthews, S. J., Peck, C., Shoop, E., & Toth, D. (2015). Budget Beowulfs: A Showcase of Inexpensive Clusters for Teaching PDC. In Proceedings of the 46th ACM Technical Symposium on Computer Science Education (pp. 344–345). New York, NY, USA: ACM. https://doi.org/10.1145/2676723.2677317

Lusk, J. A., & Baron, E. (2017). Bolometric Light Curves of Peculiar Type II-P Supernovae. Publications of the Astronomical Society of the Pacific, 129(974), 044202. https://doi.org/10.1088/1538-3873/aa5e49