Second Life: Enabling a Student Special Interest Group through Decommissioned HPC Systems

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ABSTRACT

The prevalence of High Performance Computing (HPC) in scientific research continues to grow, and with this growth, the importance of HPC education and training also increases. However, limited access to advanced research computing resources continues to impede workforce development in resource-constrained environments. In this poster, we describe our student-run HPC special interest group at the University of the Witwatersrand in South Africa, and provide an overview of the practical benefits it provides for students. Our group leverages repurposed decommissioned HPC systems to enable practical hands-on experience with HPC and computing clusters for undergraduate students at our university. We further discuss our group's approach to selecting and preparing teams for student cluster competitions, where historically we have enjoyed notable success.

KEYWORDS

Education, Workforce Development, Repurposing, Students in HPC, Student Cluster Competition, HPC Ecosystems Project, Africa

ACM Reference Format:
Michael Beukman, Sayfullah Jumoorty, Jonathan Faller, Eugene de Beste, and Bryan Johnston. 2024. Second Life: Enabling a Student Special Interest Group through Decommissioned HPC Systems. In *Practice and Experience in Advanced Research Computing (PEARC '24), July 21–25, 2024, Providence, RI, USA.* ACM, New York, NY, USA, 4 pages. https://doi.org/10.1145/3626203.3670573

1 INTRODUCTION

With ongoing global digitalisation, specialist skills in software, hardware, and High-Performance Computing (HPC) carry an ever-increasing importance [1, 3]. This being the case, several HPC workforce training initiatives have been developed [4, 9, 11, 15, 16], many catered towards students. In most cases, these initiatives are organised in a top-down fashion by a university or other institution [9, 16]. In this poster, we describe a *student-led* organisation that is dedicated to improving HPC education for undergraduate students. Our Special Interest Group (SIG) is based at the University of the Witwatersrand (colloquially referred to as Wits) in South Africa.[1] Our group serves three primary objectives:

(1) Preparation and selection of the university's teams for the annual South African Student Cluster Competition (SCC) organised by the Centre for High Performance Computing (CHPC) [9].
(2) Providing broad HPC training to the general undergraduate community at the university, focusing on practical skills not typically covered in the standard computer science curriculum.
(3) Enhancement of teaching abilities, and a deepened understanding of HPC concepts for the student organisers, through the process of assuming teaching and mentoring roles for younger peers.

In this poster, we describe the inception of our student-run SIG, its organisational structure, our training processes, and how repurposed decommissioned HPC hardware enables us to successfully achieve our training objectives. We further describe some challenges we have faced through the journey of establishing and sustaining our group. Finally, we discuss the results we have obtained to date—including training the majority of the participating members of the South African SCC teams competing internationally over the past ten years.

2 BACKGROUND

2.1 Student Cluster Competition

Since 2013, the South African CHPC has hosted an annual SCC,[2] consisting of two rounds. The first round serves as a national selection round, consisting of daily hands-on tutorials and lectures, providing students with an introduction to Linux, parallel computing fundamentals and core HPC concepts. In the second (and final) round of the national competition, teams are allocated a modest budget to design and procure a small-scale HPC cluster. These designs are assembled on the competition floor, where teams compete by running a series of benchmarks, including both synthetic and

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PEARC '24, July 21–25, 2024, Providence, RI, USA

ACM ISBN 979-8-4007-0419-2/24/07
https://doi.org/10.1145/3626203.3670573

[1] https://www.wits.ac.za
[2] https://scc.chpc.ac.za/about/

Figure 1: The decommissioned servers we use for training. These servers have DDR3 RAM and Intel XEON E5-2650 Sandy Bridge CPUs.

real-world application-based tasks.
This mirrors how the International Super-Computing (ISC) High Performance conference[3] runs its own SCC event, with the notable exception that instead of budget restrictions, a power budget is imposed for benchmarking runs. In fact, the CHPC's event leads to the selection of a South African team, which competes at the ISC event.

2.2 HPC Ecosystems Project

Around the same time, the HPC Ecosystems project (initially known as the Ranger Project) was introduced to distribute HPC resources within the African region through the repurposing of decommissioned HPC systems [9]. The Ecosystems project orchestrates the transfer of decommissioned systems to institutions in Africa—including Wits—and provides these institutions with HPC training to ensure the donated hardware can effectively be used. The project serves as a testament to the viability of older HPC systems, highlighting their continued relevance and utility, particularly in resource-constrained environments.

[3] https://www.isc-hpc.com/about-overview.html

3 THE INCEPTION OF THE WITS HPC SIG

Initially centred on participation in the cluster competition detailed in Section 2.1, the SIG operated with the following objectives:

(1) From all the eligible and interested undergraduates, select two teams of four undergraduate students to represent the university at the national selection round.
(2) After the selection round, provide training to teams qualifying for the final round.

Student cluster competitions have been shown to provide great learning opportunities to students [7, 8], but we have found that a student's experience and enjoyment are also heavily determined by their teammates. Therefore, the SIG leadership carefully selects which students to place in the nominated teams, in order to maximise the selected students' overall experience, enjoyment and skill development.

3.1 Team Selection

Our team selection process consists of all interested students writing a time-limited open-book placement test, which has general Linux-based and shell-scripting questions. The highest-scoring students are selected to represent the university. Recently, we have introduced hands-on preparation before team selections, in order to ensure equal opportunities from a greater pool of students. In doing so, we enable those who are capable but not yet familiar with specific topics to first be brought up to speed before being assessed. During this initial period, we also have regular practical tutorials that are taken into account when selecting teams. We believe that a multifaceted selection process increases the likelihood of selecting motivated and driven students. Even if some students do not achieve top scores in the placement test, they still have an opportunity in the practicals to demonstrate their willingness to learn and improve.

3.2 Team Training

After the tutorial round—which is organised by the CHPC—our SIG prepares the students for the final round by giving them hands-on access to decommissioned HPC nodes (see Figure 1), which they use to practice the skills necessary for success in the competition. These skills include, among others, operating system installation, network configuration, package installation, and basic shell usage. After the initial hardware is configured, the students learn how to compile software from source, how to run distributed HPC applications, and how to identify and control factors affecting application performance. Our SIG prioritises familiarity with a Linux-based cluster environment, advocating for extensive practice in machine deployment and software compilation. This ensures that our teams are well-versed in competition expectations and adept at executing tasks rapidly and effectively. Moreover, previous problem-solving experiences equip them to confidently handle unforeseen challenges that may crop up during the competitions. During this training phase, the mentors primarily serve as guides for the students, giving them high level objectives, and technical advice when needed.

As Alvarez et al. [5] notes, this hands-on experience is an invaluable teaching tool, and we believe it is one of the primary factors driving our success at competitions. Although the SIG does not

have access to cutting-edge and recent HPC systems, the lower-spec hardware at our disposal has served as a particularly cost-effective learning aid [2, 14].

4 MOVING BEYOND THE STUDENT CLUSTER COMPETITION

While the original focus of the SIG was the Student Cluster Competition, in 2020 the SIG was expanded to incorporate general lectures and practicals for the undergraduate community. This expansion has enabled us to reach a wider audience and to cater to more diverse interests.

The lectures cover several broad topics, including:[4]

(1) General how-to guides on Linux, Bash, and system utilities.
(2) How to compile software from source.
(3) HPC-specific skills, such as how to use containers and how to optimise HPC benchmarks.
(4) How parallel programming works, and how to write parallel programs, using e.g., OpenMP [6], MPI [13] or CUDA [17].

Most of our talks are practically focused, aiming to equip students with the necessary skills to start using a particular tool or technique immediately. We have explored various formats for our weekly sessions, including lecture-style talks, practical-focused sessions for interactive learning, and tutorial-style sessions combining lectures with practical exercises. Following research into effective practical HPC training, our more recent efforts have been focused on tutorial-style sessions, where interactive exercises enhance students' engagement and learning [10, 12].

5 RESULTS

Table 1 shows the performance of Wits participants at the national and international student cluster competitions, reflecting the effectiveness of the SIG in developing competencies in HPC administration and optimisation. Notably, from 2014 to 2023, Wits won the local SCC competition seven times in ten years, with the non-winning teams securing a further five silver and four bronze medals. In addition, over the past ten years, more than half of all members of the CHPC national teams competing in the International Student Cluster Competition have been students from our university.

Table 1: The Wits SIG group's results in the national (SCC) and international (ISC) competitions between 2013 and 2023. The ISC row counts the results of all teams with more than half of the students from Wits. We note that we usually send two teams to the national competition.

	1st	2nd	3rd	Total Events
SCC (National)	7	5	4	11
ISC (International)	2	2	1	11

The Special Interest Group uses Discord to facilitate a virtual community, and as of April 2024, membership stands at 366.

In late 2023, the SIG hosted its first hackathon event, where students were tasked with solving a highly parallelisable programming problem, aiming for the fastest runtime possible.[5] The event drew a modest turnout of around 25 students, with positive feedback from the participants.

6 CHALLENGES

Maintaining our student-run organisation has been met with several challenges:

Attrition Attendance for SIG talks typically wanes throughout the course of the year. Preliminary findings from student surveys indicate that the three primary reasons for students leaving the group are:
(1) After team selection for the student cluster competition is concluded, the students who are not placed in competition teams often lose motivation and subsequently withdraw from the group.
(2) Through the course of the year, some students shift their focus from extracurricular activities, such as interest groups, towards academic pursuits, dedicating more time to their studies.
(3) Diminished interest in the topics covered at the SIG sessions leads some students to view participation in the interest group as an additional burden.

Perpetual Succession As a student-run entity, our group lacks permanent organisers, necessitating constant recruitment of new mentors whenever existing members graduate. While we have managed to sustain sufficient volunteers thus far, ensuring continuity in leadership is anticipated to be a recurring and significant challenge.

Remote Amidst the COVID-19 pandemic, in response to the enforced lockdown measures in South Africa, all SIG activities transitioned to online platforms. While this shift enhanced accessibility, which enabled broader outreach and scalability, we observed lower engagement levels in contrast to the in-person sessions.

7 RESPONSES TO CHALLENGES AND FUTURE WORK

Noting the challenges towards sustainability and impact for the SIG, we have identified several key objectives to address these concerns.

To maintain a high attendance and consistent level of engagement from members throughout the year, we intend to organise more internal competitions. Most students have a desire to compete but it is not possible to select every participant for the SCC. By providing additional competitions, more students will be able to participate. Another idea we are considering is to have long-term projects for members to undertake. In this model, by consistently investing time throughout the year, students will incrementally build towards a concrete but ambitious end goal. The expectation is to have students feel invested in their projects, motivating them to consistently participate in the SIG's activities.

Our current approach to succession is to select a few promising and willing students every year, and have them co-organise with more senior members. This allows them to easily get started with organising while spreading the workload and providing mentorship

[4] Our talks and workshops are publicly available at https://github.com/WitsHPC/HPC-InterestGroup.

[5] The problem is provided at https://github.com/WitsHPC/HPC-InterestGroup/tree/main/assorted/competitions/2023_cuda/problem.

for the new cohort of organisers. When the more senior students graduate, the new organisers already have experience.

We have found that in-person talks have more engagement, and subsequently, we conduct most of our talks in person on campus. When the goal is to reach a wider audience, we host our talks online. In future, we hope to combine the benefits of the engagement of in-person talks and the scalability of online sessions.

Our group is currently focused exclusively on the University of the Witwatersrand. Over time, we intend to expand our scope to include other universities in South Africa. While we currently limit the use of our hardware to the SCC teams, a longer-term goal for us is to expand access to the general (non-SCC) SIG members. This would allow us to broaden the scope of research and innovation within the group, and attract alumni and staff to participate. We believe that these developments would lead to a significant improvement in HPC workforce development not only in our university, but across South Africa.

8 CONCLUSION

This poster introduces the Wits HPC interest group, a group for students, by students, that seeks to provide life-long advanced scientific computing skills to participating members. The SIG focuses on three areas: (a) exposing undergraduate students to general HPC education; (b) preparing teams for student cluster competitions; and (c) equipping students with useful technical skills for their future careers. Over the past decade, our interest group has played a pivotal role in fostering HPC knowledge and skills among students. Our success is evidenced by our achievements in both local and international student cluster competitions. Moving forward, we aspire to serve as a model for grassroots educational communities, inspiring others to take up similar initiatives and contributing to the enhancement of HPC education and workforce development. While our focus lies within the African context, we believe our efforts can resonate on a global scale, driving positive change and fostering innovation in HPC and beyond.

REFERENCES

[1] Olatunde Abiona, Clement Onime, Stefano Cozzini, and Sebsibe Hailemariam. 2011. Capacity building for HPC Infrastructure setup in Africa: The ICTP experience. In *2011 IST-Africa Conference Proceedings*. 1–8.

[2] Omar Abuzaghleh, Kathleen Goldschmidt, Yasser Elleithy, and Jeongkyu Lee. 2013. Implementing an affordable high-performance computing for teaching-oriented computer science curriculum. *ACM Transactions on Computing Education* 13, 1 (Feb. 2013), 3:1–3:14. https://doi.org/10.1145/2414446.2414449

[3] Engr Imaobong O Akpan, Mfon O Esang, Tope G Jimoh, Habeeb Ramoh Ajibola, and Engr Ekerette Dan. 2023. Accelerating Scientific Discovery Through High Performance Computing: Challenges and Opportunities for Africa Researchers. *International Journal of Diplomacy and Political Relations* 1, 1 (2023), 39–47.

[4] Nia Alexandrov and Maria-Ribera Sancho. 2017. Learning Outcomes Based Evaluation of HPC Professional Training. *Procedia Computer Science* 108 (Jan. 2017), 2141–2150. https://doi.org/10.1016/j.procs.2017.05.135

[5] Lluc Alvarez, Eduard Ayguade, and Filippo Mantovani. 2018. Teaching HPC Systems and Parallel Programming with Small-Scale Clusters. In *2018 IEEE/ACM Workshop on Education for High-Performance Computing (EduHPC)*. 1–10. https://doi.org/10.1109/EduHPC.2018.00004

[6] Leonardo Dagum and Ramesh Menon. 1998. OpenMP: an industry standard API for shared-memory programming. *IEEE computational science and engineering* 5, 1 (1998), 46–55.

[7] Stephen Lien Harrell, Hai Ah Nam, Verónica G Vergara Larrea, Kurt Keville, and Dan Kamalic. 2015. Student cluster competition: a multi-disciplinary undergraduate HPC educational tool. In *Proceedings of the Workshop on Education for High-Performance Computing*. 1–8.

[8] Stephen L Harrell, Preston M Smith, Doug Smith, Torsten Hoefler, Anna A Labutina, and Trinity Overmyer. 2011. Methods of creating student cluster competition teams. In *Proceedings of the 2011 TeraGrid Conference: Extreme Digital Discovery*. 1–6.

[9] Bryan Johnston. 2019. HPC Ecosystems Project: Facilitating Advanced Research Computing in Africa. In *Proceedings of the Practice and Experience in Advanced Research Computing on Rise of the Machines (learning)*. 1–3.

[10] Jennifer K. Knight and William B. Wood. 2005. Teaching More by Lecturing Less. *Cell Biology Education* 4, 4 (2005), 298–310. https://doi.org/10.1187/05-06-0082 arXiv:https://doi.org/10.1187/05-06-0082 PMID: 16341257.

[11] Julian Kunkel, Kai Himstedt, Nathanael Hübbe, Hinnerk Stüben, Sandra Schröer, Michael Kuhn, Matthias Riebisch, Stephan Olbrich, Thomas Ludwig, Weronika Filinger, Jean-Thomas Acquaviva, Anja Gerbes, and Lev Lafayette. 2019. Towards an HPC Certification Program. *The Journal of Computational Science Education* 10 (Jan. 2019), 88–89. Issue 1. https://doi.org/10.22369/issn.2153-4136/10/1/14

[12] Anthony McCourt and Caitriona Carr. 2010. Improving Student Engagement and Retention Through Small Group Tutorials. *Innovation in Teaching and Learning in Information and Computer Sciences* 9, 1 (2010), 61–77. https://doi.org/10.11120/ital.2010.09010061 arXiv:https://doi.org/10.11120/ital.2010.09010061

[13] Message Passing Interface Forum. 2023. *MPI: A Message-Passing Interface Standard Version 4.1*. https://www.mpi-forum.org/docs/mpi-4.1/mpi41-report.pdf

[14] Nkundwe Moses Mwasaga and Mike Joy. 2020. Implementing micro High Performance Computing (μHPC) artifact: Affordable HPC Facilities for Academia. In *2020 IEEE Frontiers in Education Conference (FIE)*. 1–9. https://doi.org/10.1109/FIE44824.2020.9273986 ISSN: 2377-634X.

[15] Belinda Mutunhu, Thambo Nyathi, and Sibusisiwe Dube. 2021. An Analysis on the Adoption of High-Performance Computing (HPC): A Case of Zimbabwe State Universities. In *2021 IST-Africa Conference (IST-Africa)*. IEEE, 1–8.

[16] Moses Nkundwe Mwasaga, Mikko Apiola, Jarkko Suhonen, and Mike Joy. 2015. Integrating high performance computing into a Tanzanian IT engineering curriculum. In *2015 IEEE International Conference on Engineering, Technology and Innovation/International Technology Management Conference (ICE/ITMC)*. IEEE, 1–9.

[17] John Nickolls, Ian Buck, Michael Garland, and Kevin Skadron. 2008. Scalable parallel programming with cuda: Is cuda the parallel programming model that application developers have been waiting for? *Queue* 6, 2 (2008), 40–53.